THE HASHEMITE KINGDOM OF JORDAN

Second National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

Prepared for the seventh Review Meeting

October 2020

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ACRONYMS

Acronym	Definition
ALARA	As Low As Reasonably Achievable
CAT	Category
CSF	Central Storage Facility
DAW	Dry Active Waste
DoE	Department of Energy
DSIDE	Disused Sources Integrated Decision-making Evaluation
DSRS	Disused Sealed Radioactive Source
DU	Depleted Uranium
EIA	Environmental Impact Assessment
EMRC	Energy and Minerals Regulatory Commission
ERC	Electricity Regulatory Commission
EW	Exempt Waste
FSAR	Final Safety Analysis Report
GoJ	Government of Jordan
GTRI	Global Threat Reduction Initiative
HLW	High Level Waste
HRD	Human Resources Development
HVAC	Heating Ventilation and Air Conditioning
IAEA	International Atomic Energy Agency
ILW	Intermediate Level Waste
IRRS	Integrated Regulatory Review Service
JAEC	Jordan Atomic Energy Commission
JNRC	Jordan Nuclear Regulatory Commission
JRTR	Jordan Research and Training Reactor
JSA	Jordan Subcritical Assembly
JUST	Jordan University of Science and Technology
LILW	Low and Intermediate Level Waste
LLW	Low Level Waste
LRW	Liquid Radioactive Waste
MoEnv	Ministry of Environment
MoH	Ministry of Health
NFC	Nuclear Fuel Cycle
NNSA	National Nuclear Security Administration
NORM	Naturally Occurring Radioactive Material
NPP	Nuclear Power Plant
NRA	Natural Resources Authority
PNNL	Pacific Northwest National Laboratory
PPE	Personal Protective Equipment
PSAR	Preliminary Safety Analysis Report
QA	Quality Assurance
QAP	Quality Assurance Program

QMS	Quality Management System
R&D	Research & Development
RB	Reactor Building
RDD	Radiological Dispersion Device
RI	Radioisotopes
RIPF	Radioisotope Production Facility
RMS	Radiation Monitoring System
RPO	Radiation Protection Officer
RPP	Radiation Protection Program
RS	Radiation Source
RTF	Radioactive-waste Treatment Facility
RW	Radioactive Waste
RWM	Radioactive Waste Management
SB	Service Building
SF	Spent Fuel
SFA	Spent Fuel Assembly
SFA	Spent Fuel Assembly
SMR	Small Modular Reactor
SNF	Spent Nuclear Fuel
SRS	Sealed Radioactive Source
USA	United States of America
VLLW	Very Low-Level Waste
VSLW	Very Short-Lived Waste
WAC	Waste Acceptance Criteria
WMO	Waste Management Organization

GLOSSARY

"Exempt Waste" means those radioactive materials that can be removed from the regulatory control due to its activity concentration and or total activity, after a limited storage period for decaying;

"**Historical Waste**" means those radioactive waste treated, conditioned or finally disposed applying criteria beyond the current regulatory frame and that require its re-assay;

"**License**" means any authorization, permission or certification granted by a regulatory body to carry out any activity related to Spent Fuel (SF) or radioactive waste management;

"**Nuclear Facility**" means a civilian facility and its associated land, buildings and equipment in which radioactive materials are produced, processed, used, handled, stored or disposed on such a scale that consideration of safety is required;

"**Operating Lifetime**" means the period during which a SF or a radioactive waste management facility is used for its intended purpose. In the case of a disposal facility, the period begins when SF or radioactive waste is first emplaced in the facility and ends upon closure of the facility;

"**Radioactive Waste**" means radioactive material in gaseous, liquid or solid form for which no further use is foreseen by the Contracting Party or by a natural or legal person whose decision is accepted by the Contracting Party, and which is controlled as radioactive waste by a regulatory body under the legislative and regulatory framework of the Contracting Party;

"Decommissioning" means all steps leading to the release of a nuclear facility, other than a disposal facility, from regulatory control. These steps include the processes of decontamination and dismantling;

"Discharges" means planned and controlled releases into the environment, as a legitimate practice, within limits authorized by the regulatory body, of liquid or gaseous radioactive materials that originate from regulated nuclear facilities during normal operation;

"Disposal" means the emplacement of SF or radioactive waste in an appropriate facility without the intention of retrieval;

"Radioactive Waste Management" means all activities, including decommissioning activities that relate to the handling, pre-treatment, treatment, conditioning, storage, or disposal of radioactive waste, excluding off-site transportation. It may also involve discharges;

"Radioactive" means any facility or installation whose primary purpose is radioactive waste management, including a nuclear facility in the process of being decommissioned only if it is designated by the Contracting Party as a radioactive waste management facility;

"Regulatory Body" means anybody or bodies given the legal authority by the contracting Party to regulate any aspect of the safety of SF or radioactive waste management, including the granting of licenses;

"Reprocessing" means a process or operation, the purpose of which is to extract radioactive isotopes from SF for further use;

"Sealed Source" means radioactive material that is permanently sealed in a capsule or closely bonded and in a solid form, excluding reactor fuel elements;

"Spent Fuel" (SF) means nuclear fuel that has been irradiated in and permanently removed from a reactor core;

"Spent Fuel Management" means all activities related to the handling or storage of SF, excluding off-site transportation. It may also involve discharges;

"Spent Fuel Management Facility" means any facility or installation, the primary purpose of which is SF management;

"Storage" means the holding of SF or of radioactive waste in a facility that provides for its containment, with the intention of retrieval;

"Trans-Boundary Movement" means any shipment of SF or of radioactive waste from a State of origin to a State of destination.

A. INTRODUCTION

The Hashemite Kingdom of Jordan (HKJ) became a member state of the International Atomic Energy Agency (IAEA) in April 1966, and ever since, Jordan attaches the highest importance to international efforts to harmonize and increase all aspects of nuclear and radiological safety. In this respect, Jordan has initiated projects and entered into bilateral agreements with other countries and actively participates and contributes to international activities.

Jordan has signed the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, referred to herein as the "Convention" on the 15th of April 2016. The Convention has been ratified and entered into force on the 14th of July 2016.

This is the Second National Report of the Hashemite Kingdom of Jordan (HKJ) that has been prepared in accordance with the Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management for review at the Seventh Review Meeting of the Convention to be held in May 2021. This National report describes the legislative, regulatory, and administrative measures and other measures taken by the HKJ, as a Contracting Party, to implement each obligation of the Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

Similar to the HKJ's First National Report submitted to the Sixth Review Meeting held in May 2018, this Second National Report is a collective effort of various national organizations including the Jordan Atomic Energy Commission (JAEC), the Energy and Minerals Regulatory Commission (EMRC) and other leading organizations. This report's form and structure is based on the *"Guidelines regarding the Form and Structure of National Reports*" (INFCIRC/604/Rev.3, 13 May 2014).

The HKJ appreciates the opportunity to participate in the Seventh Review Meeting of the Parties to the Convention and looks forward to contributing to the profound discussion.

In 2007, Jordan's Committee for Nuclear Strategy was formed to launch the development of nuclear energy programs in Jordan. One of this committee's goals is for Jordan to generate 30% of its electricity by nuclear power by the year 2030. To support the development of its nuclear energy program, JAEC and the Jordan Nuclear Regulatory Commission (JNRC), which later became the EMRC, were developed and that constitute the two main counter parts for the purpose of the Convention, the promoter and the regulatory, respectively.

Because Jordan has no Nuclear Power Plants (NPPs) as of yet, Spent Nuclear Fuel (SNF) management is therefore relevant only to the Jordan Research and Training Reactor (JRTR). The JRTR is owned and operated by JAEC and is located at the Jordan University of Science and Technology (JUST) campus. JRTR has reached its first criticality in April 2016 and received its operational license from the EMRC in November 2017.

Radioactive Waste (RW) in Jordan originates from medicine, education and research and training centers, industry, agriculture and Naturally Occurring Radioactive Material (NORM) activities. JAEC is responsible for the Radioactive Waste Management (RWM) and the long-term management of SNF. To fulfill its responsibilities, JAEC has established the JRTR Radioactive-waste Treatment Facility (RTF) within the JRTR site for treatment and temporary storage of RW. The RTF received its operational license from the EMRC in March 2019. The Central Storage Facility (CSF) is another facility that has been established to fulfill JAEC's responsibilities; it is located at the premises of JAEC headquarters; and is tasked with the safe and secure storage of disused sources and orphan sources, as well as other RW. Another storage facility of RW is the historical storage facility at the Sewaqa site. The licensing of the SNF and

RW Management facilities is governed by laws, regulations, and instructions issued by EMRC and other governmental authorities, such as the Ministry of Environment (MoEnv).

This report covers the legal regime concerning the management of SNF and RW of the JRTR, as well as RW arising from medical, industrial, and research institutes within Jordan. It also describes the Hashemite Kingdom of Jordan's Policy and current practices concerning the management of RW and SNF.

A.1 Progress since the Sixth Review Meeting

A.1.1 Radioactive Waste Treatment Facility

In October 2020, the Nuclear Fuel Cycle Commission at JAEC completed the final draft for the National Strategy for Radioactive Waste and Spent Nuclear Fuel Management after being reviewed and discussed by both EU and IAEA experts. Currently, JAEC staff are working with the international experts to develop the strategy action plan to be finally presented to the Board of Commissioners at JAEC for final official approval and endorsement.

Since the Sixth Review Meeting, the JRTR RTF was granted its operational license from the EMRC.

A.1.2 Regulatory Framework Progress

EMRC has also continued to focus on development of regulations and instructions for the safety of RWM and since the Sixth Review Meeting the EMRC has drafted four regulations to enhance the regulatory control over all radiation and nuclear applications, these named regulations are:

- Safety and Security of Radiation Sources.
- Radiation Protection and Safety of Working with Involving Naturally Occurring Radioactive Material.
- Radioactive Waste and Spent Nuclear Fuel Management.
- Mining and Milling of Nuclear Materials.

As well as an and an updated instruction on:

- Safety and Authorization of RW and SNF Activities.

A.1.3 Collaboration with the IAEA

The HKJ has continued to cooperate extensively with the IAEA through hosting several missions and safety services since the Sixth Review Meeting. Along with missions that have been hosted in Jordan, JAEC staff has also participated in many of the IAEA meetings, workshops and training courses to build up a competent human resources and be in line with all of the international best practices in the field of the RW and SNF management.

In October 2018, JAEC hosted an IAEA Experts mission to develop a Stakeholder Involvement Strategy and in December 2018, the strategy was finalized, reviewed and approved by JAEC Body of Commissioners. The strategy aims to stress that nuclear related information dissemination must be done in a transparent, timely, factually correct, objective manner and in plain language to:

- Inform stakeholders and maintain their trust.
- Minimize rumors and defeat myths.

In December 2018, the Nuclear Fuel Cycle Commission at JAEC in collaboration with the IAEA developed the National Policy and Strategy for Nuclear Fuel Cycle-Front End. The strategy aimed to define the acquisition, design, and management framework of the front-end

of the nuclear fuel cycle and other front-end related operational tasks required for the safe and economical operation of an NPP in Jordan. In October 2019, JAEC hosted an IAEA expert mission to update the Nuclear Fuel Cycle Strategy to highlight on the international trends and technologies for fresh and spent NF storage for Small Modular Reactors (SMRs) and to identify the key elements of the Nuclear Fuel Cycle (NFC) for SMRs.

A.1.4 Minimization of the volume of DSRSs at the Centralized Storage Facility

In Nov 2018, JAEC conducted a consolidation mission to significantly reduce the volume of the RW stored at the CSF by dismantling / removal of the radionuclides from their original shield containers or devices / equipment and placing the radioactive sources in Source Conditioning Capsules (SCCs) suitable for handling, storage and transport. In this mission more than 60% of the DSRSs inventory at the CSF, at that time, was consolidated in one storage container.

A.1.5 Future National Waste Disposal Facility

As part of JAEC efforts to set up a process and roadmap for the selection, design and realization of a national waste disposal facility needed for the future management of RW in the country and by recognizing that interim storage is not a permanent solution for long-lived Disused Sealed Radioactive Sources (DSRSs), JAEC collaborated with the IAEA, in April 2019, to pilot the Disused Sources Integrated Decision-making Evaluation (DSIDE) tool for Jordan's RW inventory to support informed decision-making on a permanent solution for its RW. DSIDE is a multi-attribute utility methodology that can be used to compare options for DSRSs disposition, combining a full range of factors, such as safety and security, costs, public acceptance and political support to indicate the preferred option. Borehole disposal approach was recommended as a preferred disposal option for current Jordan's RW inventory.

Table A.1 below presents an overview matrix for the HKJ RW and SNF management program.

Table A.1 Overview Matrix of the HKJ RW and SNF Management Program

Type of Liability	Long Term Management Policy	Funding of Liabilities	Current Practice / Facilities	Planned Facilities
Spent Fuel	• Return SNF to the country of origin for reprocessing and final disposal. • Dry storage facility in Jordan. • Disposal in national or regional repository.	Government	Research Reactor service Pool	N/A
Nuclear Fuel Cycle Waste	• Long term storage • HLW: Deep geological disposal • LILW-SL streams: Near-surface disposal. • LILW-LL streams: Deep disposal • VLLW: Clearance for re-use or disposal in engineered simple near-surface disposal facility.	Government	N/A	N/A
Application Wastes	• Treatment, conditioning, and interim long-term storage. • Disposal in near surface LILW disposal site.	Waste generator (Owner)	• CSF: operated by JAEC. • RTF: operated by JRTR.	Near surface LILW disposal site including DSRSs.

Type of Liability	Long Term Management Policy	Funding of Liabilities	Current Practice / Facilities	Planned Facilities
Decommissioning	• LILW-SL streams: Near-surface disposal. • LILW-LL streams: Deep disposal. • VLLW: Clearance for re-use or disposal in engineered simple near-surface disposal facility.	Government	N/A	Disposal facility
Disused Sealed Sources	• Return to the supplier. • Transfer to another user. • Near-surface disposal or Borehole disposal.	• Waste generator (Owner). • Government; for orphan sources.	• Repatriate to the origin suppliers (manufacturer). • Transfer to the CSF.	Disposal site for LILW including DSRSs.

B. POLICIES AND PRACTICES

Article 32. Reporting, Para 1

Jordan's policy for RW and SNF management sets out its national commitment on the development of SNF and RW management in a coordinated and cooperative manner with all related national organizations and entities. The Government of Jordan (GoJ) is also committed through its national regulatory body (EMRC), by which it operates independently from operators, licensees, and any other body or organization involved in SNF or RW, on issuing strict and comprehensive laws and regulations to manage the SNF and RW.

B.1. SNF Management Policy

The Jordan's policy related to SNF management sets out its commitment to:

- Store the SNF on an interim basis in the storage pool at the nuclear facility site until it decays to sufficient levels to allow for safe dry storage.
- Establish storage facilities near the nuclear facility for further cooling.
- Decide on the possibility of returning the SNF to the country of origin (to the supplier) for final disposal or interim storage or to remain in Jordan in interim storage for either of the two following options:
    - Considering the SNF as strategic resource that can be utilized through reprocessing (nationally or internationally) where the subsequent High Level Waste (HLW) will be sent for final disposal in a national waste disposal facility at HKJ.
    - Declare the SNF as RW thereby allowing it to be disposed of directly to a national waste disposal facility.
- Establish the national facilities for disposal of low and intermediate level waste (LILW) in the HKJ.
- Take relevant decisions for the disposal of spent nuclear fuel and HLW.

The national drafted strategy for the RW and SNF management defines the technical options for management of Spent Fuel (SF) in order to accomplish the management goals outlined in the national policy. The strategy outlines the technical options for management of SNF irradiated in RRs, subcritical assemblies, and future NPPs. All technical options include safe storage at the site of nuclear installation and the following steps in management of SNF up to the final disposal are described as shown in Figure B.1.

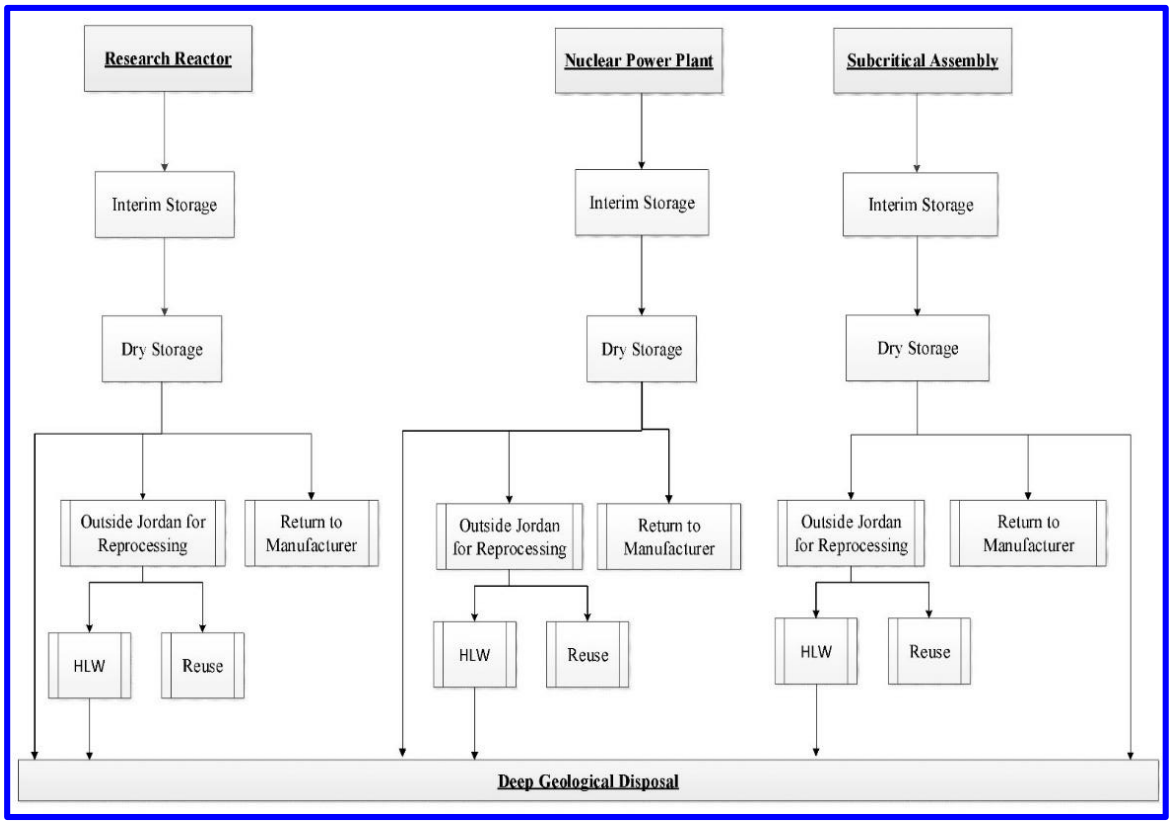


Figure B.1 Technical Options for the Management of the Spent Nuclear Fuel

B.2. Spent Fuel Management Practices

Ever since the JRTR received its operational license in November 2017, Spent Fuel Assemblies (SFAs) discharged from the reactor core are currently stored at the service pool, and current plans are to maintain their safe storage in the service pool until the end of the reactor lifetime. Storage of SFA is performed according to the relevant radiation protection and safeguards' legislation. Periodic inspections are performed by the EMRC, as well as the IAEA.

The reactor service pool is designed and constructed for safe storage of SNF assemblies and is sized-sufficiently to store all SNF assemblies produced from JRTR operations during its entire lifetime (»40 years). Figure B.2 presents a top view of the SNF storage racks inside the reactor service pool, which have a current storage capacity for 222 SNF assemblies and for 10 damaged fuel assemblies. Additional storage racks can be added to accommodate additional assemblies if the need arises.

Figure B.2 Overview of the SNF Storage Racks

B.3. Radioactive Waste Management Policy

- **Disused Sealed Radioactive Sources (DSRSs)**

The management policy for DSRSs includes:

- Return of the DSRSs to the supplier.
- Management of the DSRSs in local RWM facilities such as the national CSF at JAEC, in case the DSRS can't be returned to the supplier.
- Finding international or regional solutions for the DSRSs management and disposal options.

- **Other Types of RW**

The other main sources of RW in Jordan are:

- Liquid radioactive sources.
- JRTR operational RW (both liquid and solid).
- Contaminated materials and structures that might be found in the scrap yards, custom free zones, or other places within the territory of Jordan.

The management policy for this category of "Other Types of RW" includes:

- Return these radioactive sources to their place of origin, if possible.
- The management of the radioactive sources, contaminated materials, or the orphan sources within the territory of Jordan.

- **Naturally Occurring Radioactive Material (NORM)**

The RW & SNF management policy takes into account the NORM generated from the extraction and processing of raw materials containing NORM (including milling and mining of ores containing uranium and thorium, and their radioactive decay products) byproducts of oil and gas industries; and any other activities that contain NORM as RW. According to the national policy; JAEC is reasonable for implementing the RWM regulations issued by the EMRC for all types of RW (solid waste, by-products, tailing, … etc.) generated from the national industries relying on or using the natural uranium ores or oil and gas industries and industries for mining and milling of uranium, thorium or any other nuclear ores.

B.4. Radioactive Waste Management Practices

- **Institutional RW**

Institutional RW generated from medical, research, Jordan Subcritical Assembly (JSA), scrap, etc., in different categories, except JRTR RW with a half-live less than six months, can be stored at the RW generator facility until they decay to the levels allowing its clearance and management as non-radioactive waste. In case the RW activity remains above the clearance level, then it will be transported to JAEC's facilities for further processing followed by storage and later disposed in a national dedicated repository upon its availability. RWM practices are shown in Figure B.3.

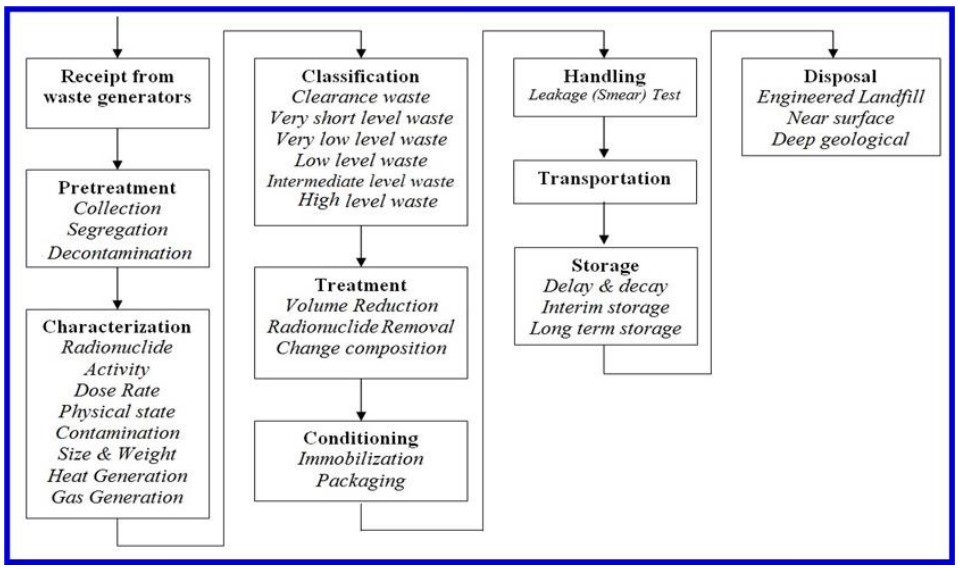


Figure B.3 Radioactive Waste Management (RWM) Process

- **JRTR RW**

The JRTR generates liquid and solid RW from its operation. The generated RW is collected, characterized, and stored for appropriate periods at JRTR temporary RW storage locations until it is either transferred to the RTF for treatment and processing or to interim storage before its final transfer to the future disposal site or be free-released as per EMRC requirements, criteria for clearance, exemption, or exclusion. The WAC for this facility was established by JAEC and was approved by EMRC. The RW generated by JRTR can be classified as follows:

1. **Exempt Waste (EW)**: The EW stream is mainly composed of non-contaminated consumables used during reactor operation, and the materials that are used in the reactor when its activity concentration is below the regulator's limits.
2. **Very Short-Lived Waste (VSLW)**: The VSLW stream is mainly composed of consumables and tools used during the production of medical and industrial radioisotopes such as I^{131}, Tc^{99m}, and Ir^{192}.
3. **Low-Intermediate Level Waste (LILW)**: This class of RW is collected, characterized, treated, conditioned, and stored at the RTF until it can be transported to a dedicated disposal facility or a long-term storage facility. The LILW stream is mainly composed of water treatment consumables (resin and SS filters), Heating Ventilation and Air Conditioning (HVAC) filters, irradiated aluminum capsules, contaminated Personal Protective Equipment (PPE) and liquid RW from drainage system.

It should be noted that the HLW is not expected to be generated from JRTR operations. However, the SNF management is covered in sections B1 and B2.

- **Disused Sealed Radioactive Sources**

The national drafted strategy for the RW and SNF management relies on DSRSs reuse, recycle and return to the manufacturer as much as possible. Otherwise, DSRSs should be managed as RW. A flow diagram for DSRSs management is shown in Figure B.4**,** the adopted management scheme is in line with the IAEA references. The implementation of the indicated scheme is being performed at the predisposal facilities for DSRSs management. All those facilities are owned and operated by JAEC.

The decision on the disposal strategy depends on the construction of disposal facilities for Intermediate Level Waste (ILW)/HLW, where adequate storage capacity for conditioned DSRSs should be considered. In May 2019 JAEC performed a multi-attribute decision making methodology to compare disposal options for DSRSs using both economic and non-economic criteria. The analysis concluded that Borehole Disposal option is a preferred option for final disposal of DSRSs in Jordan.

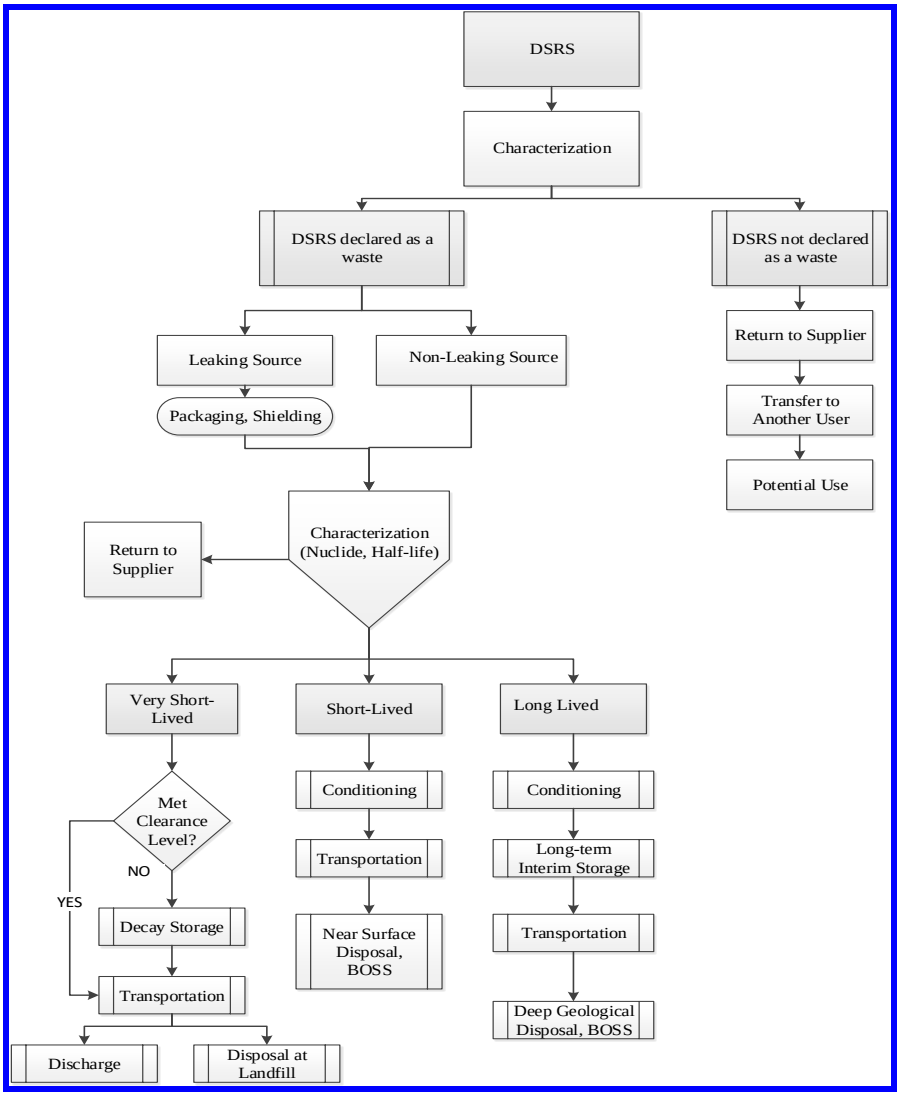


Figure B.4 Flow diagram illustrating the main steps in the management of DSRSs.

- **Naturally Occurring Radioactive Materials (NORM)**

The implementation of the national RWM strategy for NORM relies on the availability of national regulations for the management of the NORM. EMRC has drafted two regulations on *Radiation Protection and Safety of Working with involving Naturally Occurring Radioactive Material (NORM) and Mining and Milling of Nuclear Materials*. These regulations address the regulatory control, licensing requirements, radiation safety and protection, nuclear security, safeguards and emergency preparedness and response, RWM of the generated waste (radioactive and non-radioactive) and environmental requirements. NORM will be processed and disposed by their generators at or nearby the site of their generation.

B.5. Criteria Used to Define and Categorize Radioactive Waste

Upon request from the EMRC, a meeting was conducted between all national relevant parties to update the classification of the RW, these parties were mainly: EMRC, JAEC, MoEnv and the nuclear engineering department at JUST.

The main reasons for updating the classification of RW were:

- To clearly define the classes of the RW within categories.
- To define the lower and upper limits for each class in terms of activity concentrations.
- To define the disposal options for each RW class.
- To define some specific definitions related to the RW, such as: Very Short Lived Waste (VSLW), Very Low Level Waste (VLLW), Low Level Waste (LLW), Intermediate Level Waste (ILW), High Level Waste (HLW), Very Short Lived Radionuclides, Short Lived Radionuclides and Long Lived Radionuclides.

Based on the above, the classification of the RW was updated as follows:

1. Exempted waste (EW): Waste that meets the criteria for clearance from the regulatory control and can be disposed in conventional landfills.
2. Very Short Lived Waste (VSLW): Waste contains only radionuclides with half-lives of the order of 100 days or less and activity concentrations above the clearance levels, this type of waste can be stored to decay, until the activity has fallen beneath the levels for clearance, allowing for the cleared waste to be managed as conventional waste.
3. Very Low Level waste (VLLW): Waste that does not necessarily meet the criteria of exempted waste, but that does not need a high level of containment and isolation, with an average activity concentration of significant radionuclides above the clearance levels and does not exceed the value of 100 kBq/Kg. This type of waste should be disposed in engineered surface landfill type facilities.
4. Low Level Waste (LLW): Waste that is above clearance levels, but with limited amounts of long-lived radionuclides. The activity concentration of such waste is greater than 100 kBq /Kg and does not exceed the value of 1 MBq/kg. This type of waste requires robust isolation and containment for periods up to a few hundred years and should be disposed in engineered near surface facilities.
5. Intermediate Level Waste (ILW): Waste that, because of its content, particularly of long-lived radionuclides, requires a greater degree of containment and isolation than that provided by near surface disposal. ILW may contain long lived radionuclides, in particular, alpha emitting radionuclides that will not decay to a level of activity concentration acceptable for near surface disposal during the time for which institutional controls can be relied upon. The activity concentration of such waste is greater than 1

MBq/kg and does not exceed the value of 10 GBq/kg. This type of waste should be disposed in Intermediate depth facilities.

6. High level waste (HLW): Waste with levels of activity concentration high enough to generate significant quantities of heat by the radioactive decay process and contain large amounts of long-lived radionuclides. The activity concentration of such waste is more than 10 GBq/kg. This type of waste should be disposed in deep geological disposal facilities.

C. SCOPE OF APPLICATION

Article 3. Scope of Application

The scope of application for this report is:

1. **Spent Fuel**: As described in Sections A and B, currently there are no NPPs in Jordan and only a research reactor (JRTR) and a subcritical assembly are existed. Jordan is not reprocessing any SNF and the SNF of the JRTR will be kept at the reactor site for the lifetime of the reactor. JRTR SNF will then be managed in a safe manner either by returning the fuel to the vendor or be stored in a long-term storage facility in Jordan.

2. **Radioactive Waste Management**: The safe management of RW resulting from use of radioactive materials in industry, medicine, scientific research, education, other branches of national economy and civil activities within the territory of Jordan, and RW arising from operating uranium mines is discussed under the relevant articles.

3. **Military or Defense Program**: No SNF or RW within military or defense programs has been declared as SNF or RW for the purpose of the convention.

D. INVENTORIES AND LISTS

Article 32. Reporting, Para 2

D1. Spent Fuel Management Facilities
JRTR spent fuel management is described in Section B.2.

D2. Inventory of Spent Fuel
The JRTR, which is the only research reactor in Jordan (started operation in November 2017) is the only facility that produces spent fuel. Currently, three SFA have been discharged from the reactor core to the reactor service pool.

D3. Radioactive Waste Management Facilities
There are three main sites hosting RW processing and storage facilities: CSF at JAEC headquarter site, RTF at JRTR site, and the historical RW storage pit at Sewaqa site. JAEC is the operator of the CSF and the RTF and retains responsibility for RW stored at Sewaqa site while the site is formally under the management of the MoEnv. Those facilities are distributed over the territory of Jordan and are at different phases of their life cycle, have significantly different design features and achieved level of safety and security, as well differ in resourcing for RWM activities. The Sewaqa site has been used for the storage of legacy DSRSs and it is considered a closed site since 2004.

There are no radioactive waste disposal facilities in Jordan.

D4. Inventory of Radioactive Waste
As Jordan has neither NPPs nor any other nuclear fuel cycle facilities, HLW is not currently produced in Jordan. The main sources of RW in Jordan are from radioactive material used in medicine, industry, research, and orphan sources, as well as RW that is generated from JRTR operations.

Currently, EMRC requires the licensees to present a 'take-back' agreement with the supplier or manufacturer before importing radioactive sources. Only old disused sources that cannot be returned to the supplier or the manufacturer as well as orphan sources found inside the territory of Jordan are stored at the CSF. As of November 2020, the following represents the activity of RW inventory in Jordan:

- Total activity at CSF: 4.68E+13 Bq.
- Total activity at Sewaqa Storage Site: 1.32E+11 Bq.
- Total activity at the RTF: 0 (RTF received its operational license in March 2019, but is yet to process and receive any waste).

All generated RW from the operation and utilization of the JRTR is stored currently in the temporary storage areas and in Liquid Radioactive Waste (LRW) sumps at the JRTR. Based on the available capacities at the JRTR, and RW generation rates and the current reactor operation conditions, there is no need for transferring any RW to the RTF at least for the next six months. The current inventory of solid and liquid RW stored at the temporary storage areas and LRW sumps are shown in Table D.1 and Table D.2 below. More details about the current inventories at the CSF and Sewaqa Site are shown in Table D.3, Table D.4 and Table D.5 below:

Table D.1 JRTR Solid RW Inventory

Type of Waste	Volume (L)
Waste subjected to authorized free release	6000
RI Capsules	90
DAW	1500
DAW from the RIPF	600
HVAC Filters	2170
Spent Resin	690
Spent Wet Filters	300

Table D.2 JRTR liquid RW Inventory

Type of Waste	Total Activity (kBq)	Volume (L)
RB sump	14.074	4540
SB sumps	12.567	3540

Table D.3 DSRSs inventory at the CSF

No.	Radionuclide(s)	Total activity 10.2020 Bq	Total No. of source
1	Am-241	8.73E+09	275
2	Am-241, Be	2.50E+11	30
3	Ba-133	3.25E+05	2
4	Cd-109	1.37E+04	4
5	Co-57	4.71E+02	18
6	Co-60	3.66E+13	35
7	Cs-137	9.86E+12	139
8	Eu-152	2.47E+10	4
9	Fe-55	2.58E+07	4
10	Ir-192	8.14E-03	1
11	Kr-85	9.86E+10	12
12	Ni-63	2.31E+08	2
13	Pm-147	5.21E+05	2
14	Po-210	8.54E-11	4
15	Ra-226	2.00E+10	13
16	Sr-90	2.96E+09	33
Total		**4.68E+13**	**578**

Table D.4 The RW Other than DSRS Inventory at the CSF

No.	RW	Items No.
1	Ba-133	1
2	C-14	1
3	Co-57	2
4	Co-60	3
5	Contaminated (Cs-137, Am-241)	2
6	Contaminated (Cs-137), Check Source	1
7	Cs-137	3
8	Depleted U	4
9	I-125	385
10	I-131	97
11	Mo-99/Tc-99m	378
12	Pb-210	1
13	Ra-226	11
14	Tc-99m	3
15	U-238	2
16	UO2(NO3)26H2O	1
Total No.		**895**

Table D.5 Inventory of RW at Sewaqa site

Radionuclide	No. of DSRS	A (10.2020), Bq
Cs-137	32	9.55E+10
Co-60	43	2.34E+10
Presumably, Co-60	3	Unknown
Sr-90	6	1.35E+09
Cs-137 (tubes)	30	1.28E+09
Cs-137 (needles)	54	2.28E+09
Am-241	5	8.15E+09
TOTAL	**173**	**1.32E+11**

D5. Decommissioned Facilities

No nuclear facilities have been decommissioned or under decommissioning in Jordan.

E. LEGISLATIVE AND REGULATORY SYSTEM

Responsibilities

A clear distribution of responsibilities is described among the following stakeholders:

The Government of Jordan (GoJ) has to ensure and maintain the availability of the adequate resources, such as adequate human resources, financial resources and technical (Research and Development (R&D) in this regards) to facilitate the implementation of the management of SNF and RW.

In addition, the GoJ shall establish legislations on the fees needed to support the short- and long-term safe management of SNF and RW.

Energy and Minerals Regulatory Commission (EMRC) is required to ensure the implementation of SNF and RW management in a safe and secure manner. This is performed by the adequacy of national legislations issued by EMRC in a cooperative manner with other national relevant involved parties such as the MoEnv, Ministry of Health (MoH), and other relevant national entities.

EMRC has to ensure the fulfillment of requirements for public, workers and environment safety, and the nuclear safety and security for radiological and nuclear activities and facilities including safe and secure practices for RW and SNF management.

Jordan Atomic Energy Commission (JAEC) is required to fulfill national regulations and instructions issued by EMRC in the field of SNF and RW management. These responsibilities include:

- Ensuring adequate competencies and capacity within JAEC in the field of RW and SNF management.
- Fulfilling national and international obligations in terms of international agreements and conventions associated with the long-term management of SNF and RW.
- Implementing an adequate recording and reporting system for RW and SNF.
- Preparing safety, risk, and environmental impact reports for national facilities designated for management of RW and SNF, and any future disposal facility.
- Preparing and updating the national strategy for SNF & RWM emerging from the national policy.
- To setup the waste acceptance criteria for the national facilities designated for management of RWM and SNF, and any future storage and disposal facility.

Operators of SNF and RW including RW storage and treatment facilities are responsible for the technical, financial, and administrative short-term management of their waste within their facilities, and are responsible for the financial aspects of the long-term management (including disposal) of RW they generate - according to the national legislations.

Article 18. Implementing Measures

Jordan has taken legislative, regulatory, and administrative measures and other necessary steps for implementing its obligations under the Joint Convention, as described in Articles 19 and 20 below.

An Integrated Regulatory Review Service (IRRS) Mission was conducted by the IAEA in 2014, covering Jordan's regulatory framework for all nuclear activities regulated by the EMRC. The IRRS mission to Jordan examined the status of EMRC's regulations and confirmed that the regulatory framework development is appropriate for the current employed nuclear activities inside the country. The mission noted good practices in the EMRC system and also made recommendations and suggestions for the regulatory authority. A follow-up IRRS mission was conducted in 2017 to review the measures undertaken and the implementation of the recommendations and suggestions from the initial IRRS mission conducted in 2014.

The IRRS review team concluded that Jordan, through the EMRC, has been responsive to each recommendation and suggestion made in 2014, and continues to place appropriate focus on implementing a framework that provides for effective protection of public health and safety. The IRRS team determined that all of the recommendations and suggestions made by the 2014 IRRS mission had been effectively addressed and this is a significant achievement in a period of three years.

Article 19. Legislative and Regulatory Framework

Overview – Article 19 Para 1

The safety of SNF management and the safety of RWM are mainly governed by the legislation on Radiation Protection, and Nuclear Safety and Security.

Legal Framework

The following laws and regulations issued by the EMRC to govern the safety of SNF management and the safety of RWM:

- Law No. (8) for the year 2017, "*Law of Energy and Minerals Regulatory Commission.*"
- Law No. (43) for the year 2007 "*Radiation Protection, and Nuclear Safety and Security Law.*"
- Regulation No. (43) for the year (2014), "*Regulation on the Safe Use of Nuclear Energy*," and its Instructions.
- Regulation No. (108) for the year (2015), "*Regulation on Radiation Protection,*" and its Instructions.
- Regulation No. (32) for the year (2016), "*Regulation on the Transport of Radioactive Materials,*" and its Instructions.
- Regulation No. (8) for the year (2013), "*Regulation on the Basis and Conditions for Granting Licenses and Permits for the Radiation Work.*"
- Instructions on "*Management of the Radioactive Waste,*" for the year 2015.
- Instructions on "*Spent Nuclear Fuel Management*," for the year 2015.
- Instructions on "*Decommissioning of The Nuclear Facilities,*" for the year 2015.
- Instruction on "*Environmental Impact Assessment*."
- Instructions on "*The Criteria for Exemption of the Radiation Practices and Radiation Sources and Clearance of the Radiation Sources from the Regulatory Control*."

Legislations of MoEnv relevant to the safety of SNF and RW management:

- Environmental Law No. (6) for the year 2017.

- Environmental Law No. (24) for the year 2005.
- Regulation No. (68) for the year 2020; "Hazardous materials and waste management".
- Regulation No. (69) for the year 2020; "Environmental Classification and Licensing".

Other Bylaws and regulations:

- Law No. (27) for the year 2005, "*Solid Waste*."
- Regulation on "*Used Oil*," issued in 2014.
- Liquid Acid Lead Batteries requirements.
- Technical committee of Hazardous Substances and Waste Management is established by Law No. (24) for the year 2005, "*Hazardous Substances and Waste Management*."
- Law No. (37) for the year (2005), "*Environmental Impact Assessment*," governing any radioactive facility, such as NPP and mining of radioactive substances.
- "*The Protocol of Medical Waste between Ministry of Environment and Ministry of Health*," which was issued in 2017, and by this protocol the MoH is responsible for management of waste inside any healthy facility.
- "Regulation on Medical Waste Management No. (1)" for the year 2001, issued by MoH.

Radiation Safety - Article 19 Para 2 (i)

The national requirements for radiation safety are established in Law No. (43) for the year 2007 "*Radiation Protection, and Nuclear Safety and Security*" aims to protect the environment, human health and property from the hazards of contamination and exposure to ionizing radiation.

The radiation protection regulation implements the principles of justification of a practice, optimization of radiation exposure and dose limitation. Detailed radiation protection measures for management of SNF and RW are described in the instructions on "*Management of the Radioactive Waste*" and instructions on "*Spent Nuclear Fuel Management*."

Licensing System – Article 19 Para 2 (ii)

The licensing of the SNF and RW facilities is governed by the legislations mentioned above in the legal framework. Instructions on the management of SNF and RW describe the safety requirements for the management of the SNF and the RW.

Prohibition of Operation without a License – Article 19 Para 2 (iii)

According to Article 14 of Law No. (43) for the year 2007, it is prohibited for any person to carry out any of the following activities without obtaining a license:

(a) Establishing, operating, or managing any nuclear facility in the Kingdom.
(b) Circulation of any radioactive sources or any substances emitting ionizing radiation, importing, exporting, using, dealing, possessing, trafficking, operating, leasing, transferring, storing, destroying, disposing, or producing, including exploring, grinding, milling, crushing, extracting, converting, mining, or manufacturing.
(c) Using ionizing radiation or perform any work related to the ionizing radiation sources.
(d) Discharging radioactive materials into the environment in the form of gas or liquid.

(e) Management of radioactive waste.

Control, Regulatory Inspection, Documentation and Reporting - Art 19 Para 2 (iv)
All facilities, which have been licensed according to Law No. (43) for the year 2007 are monitored and inspected periodically by EMRC. In the course of these inspections, the compliance of the license holder with the applicable regulations and the terms of the licenses are verified on an annual basis. If necessary, the license holder can be requested to implement additional radiation protection measures.

The radiation protection legislation requires comprehensive documentation on the construction, modification and operation of facilities engaged in handling radioactive material. Detailed specifications on documentation and reporting are set forth in the individual issued licenses.

Enforcement – Article 19 Para 2 (v)
EMRC is in charge of enforcing the legislation and the regulations applicable to facilities for the use of radioactive material and radiation sources as well as other related obligations on the licensee. The EMRC is empowered to take necessary enforcement measures to ensure compliance by the license holder.

The different enforcement tools and authority of EMRC are described in Law No. (43) of 2007, which include:

- Warning the licensee or the authorized person to take measures to remove the violation or refrain from actions that would lead to continuation of the violation within a time period specified in the warning.
- Imposing fines in accordance with EMRC regulations.
- Amending the granted license or permit.
- Suspension of the license or the permit for a time period specified by the Board.
- Cancelling the license or the permit.

Allocation of Responsibilities – Article 19 Para 2 (vi)
JAEC was established per Law No. (42) for the Year 2007, and it has responsibility for the long-term management of SNF and RW, which includes disposal of RW. The operator has the prime responsibility for safety throughout the lifetime of the waste management facilities and activities, and this responsibility cannot be delegated.

Person generating and/or managing RW bear the responsibility for the safety of the generated RW until the RW is transferred out of that facility.

Regulating Radioactive Materials as Radioactive Waste – Article 19 Para 3
According to the instructions of the RWM, RW is defined as any unusable material in gaseous, liquid, or solid form that contains, or is contaminated with, radionuclides at concentrations or activities greater than clearance levels established by EMRC.

EMRC has issued instructions on the criteria for the exemption of and clearance of radioactive material from regulatory control, which entails the requirements and levels for the clearance of materials in solid, liquid, and gaseous forms.

Article 20. Regulatory Body

Establishment and Designation – Article 20 Para 1

As indicated previously, the regulatory authority in the HKJ is the EMRC. EMRC is a governmental body that possesses a legal personality with financial and administrative independence, which was formed by merging the Electricity Regulatory Commission (ERC), JNRC, and the Natural Resources Authority (NRA), and as such is considered to be the legal successor of these entities. The EMRC was formed per Law No. (17) for the year (2014) regarding the restructuring of institutions and governmental organizations.

According to Article 4 of Law No. (43) for the year 2007, EMRC in coordination and cooperation with relevant authorities is tasked to achieve the following:

- Regulate and control the use of nuclear energy and ionizing radiation.
- Protect the environment, human health and property from the hazards of contamination and exposure to ionizing radiation in accordance with the provisions of this law.
- Ensure the fulfillment of requirements of public safety, radiation protection, and nuclear safety and security.

According to Article 5 of Law No. (43) for the year 2007, EMRC is required to undertake the following duties and authorities:

- Grant licenses and permits for radiation institutions, nuclear facilities, and workers in the radiation and nuclear fields.
- Verify the commitment of the licensees to implement the terms of this law and any regulations and instructions issued accordingly.
- Control the implementation of the terms of this law and conduct inspection for any installation or entity for this purpose.
- Contact institutions and commissions concerned with regulating and control of nuclear energy, radiation protection, and nuclear safety and security in the Arab and foreign countries to benefit from the expertise, scientific research, and assistance in their field of work.
- Participate in Arab, regional, and international projects concerned with radiation protection, and nuclear safety and security, related to expertise or research with the consent of the cabinet.
- Regulate relations between Jordanian entities concerned with radiation protection, and nuclear safety and security; as well as with relevant international, regional, and Arab organizations and agencies.
- Implement comprehensive safeguards and create a system to account for and control of all nuclear materials subject to these safeguards.

Independence – Article 20 Para 2

According to the Article 3 of Law No. (8) for the year 2017, Law of Energy and Minerals Regulatory Commission, EMRC possess a legal personality with financial and administrative independence and reports directly to the cabinet.

F. OTHER GENERAL SAFETY PROVISIONS

Article 21. Responsibility of the License Holder

Safety Responsibility – Article 21 Para 1

Pursuant to Article 14 of the "*Radiation Protection and Nuclear Safety and Security*" law No.(43) for the year 2007" and in accordance with Article 5 (b) of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2014, SNF management and RWM can be conducted only by authorized entities after obtaining required licenses and permits.

The "*Instructions on Safety of Radioactive Waste Management*" issued by EMRC under Article 25 of the Regulation *on the Safe Use of Nuclear Energy for the year 2014* clearly defines in its Article 4 (Appendix 1) that the license holder has the prime responsibility for safety throughout the lifetime of RWM facilities and activities, and this responsibility cannot be delegated. According to Article 7 of the "*Regulation on the Safe Use of Nuclear Energy"* for the year 2014, the licensee or permit holder that is authorized by EMRC to use nuclear energy, manage RW, or manage SNF and shall, among other requirements, ensure compliance with the nuclear safety, security, safeguards, and radiation protection requirements adopted by the EMRC in performing relevant activities in their facilities and installations, and implement all measures and activities associated with the safe storage of nuclear material and management of radioactive material, SNF, and RW generated in their facilities and installations until delivered and transferred to a licensed entity to use such materials or licensed entity for RW and SNF management.

By the "*Nuclear Energy Law*" No. 42 for the year 2007 and its amendments No. 4 for the year 2008, JAEC has been assigned with the responsibility for the long-term management of SNF and RW, as well as for disposal of RW generated within the territory of the HKJ.

By the "*Instructions on Radioactive Waste Management*" and the "*Instructions on the Spent Fuel Management*"; Generators of SNF and RW shall, among other responsibilities, be responsible for the technical, financial, and administrative short-term management of the waste generated within their facilities, and for the financing of long-term management of their SNF and RW, including final disposal, which will be technically and administratively managed by JAEC. The generators are required to make arrangements and agreements with JAEC for the long-term management of SNF and RW, including storage, disposal, and all required institutional control measures.

Pursuant to Articles 4 and 5 of the "*Radiation Protection and Nuclear Safety and Security*" Law for the year 2007," and in accordance with the Merging Law No. 17 for the year 2014, EMRC performs its regulatory functions that include granting licenses and permits for radiation institutions, nuclear facilities and workers in the radiation and nuclear fields; verifying the commitment of the licensees to implement the terms of laws, regulations, and instructions, and conducting periodic inspections of any installation or body for this purpose.

No License Responsibility – Article 21 Para 2

According to Article 20 A of the "*Radiation Protection and Nuclear Safety and Security*" Law for the year 2007, pertaining to revoking the license or discovery of any unlicensed facility, activity or orphan source, the EMRC is authorized:

- To terminate operation or close the installation, facility, institution, or establishment, where radioactive sources, materials, equipment, or radiation devices are kept or used - if keeping, continuous operation, handling, or use is posing risk to human health and environment;

- To confiscate radioactive sources, materials, equipment or radiation devices that cannot be licensed to prevent its use and deposit it in the EMRC's warehouses or in any place deems appropriate until they are licensed, and if not licensed within three months of the date of seizure, to dispose of the confiscated materials in accordance with public interest, including the returning of the imported materials to the country of origin option. In this, appropriate precautionary protective measures will be taken by the EMRC.

Article 11 of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2014, defines that any RW or SNF for which the owner is unknown, shall be constituted as state property. The EMRC shall designate a licensee to which such RW and/or SNF shall be transferred to and the relevant conditions for this provision.

According to Article 21 (a) of the *Radiation Protection, and Nuclear Safety and Security Law* EMRC has the right to enter and inspect any place suspected of containing unlicensed sources, materials, equipment, or radiation devices, and to inspect any activity that is being practiced in violation to the terms of laws, regulations, or instructions.

According to the national policy on RW and SNF management, the GoJ is responsible for bearing the cost for management of orphan sources, RW and SNF of which the owner cannot be defined or no longer exist. Otherwise the occurring costs can be claimed back by recourse to the identified owner.

Article 22. Human and Financial Resources

Jordan has a well-developed academic infrastructure, providing a strong foundation in disciplines required for a nuclear power program. The country has 25 universities (10 public and 15 private) offering BSc degrees in physics, chemistry, biology, health physics, electrical, mechanical, industrial, chemical and nuclear engineering. In addition, there are 35 community colleges (15 public and 20 private). JAEC has emphasized the need for institutional collaboration in order to "establish technical training and certification" in areas such as basic nuclear principles, radiological health protection, and nuclear material handling.

Jordan has emphasized various forms of external assistance as part of its Human Resources Development (HRD) strategy. Jordan's training and education efforts include scholarship support for international education programs, international training programs, and nuclear cooperation agreements with other countries and the IAEA. JAEC has offered a master's and PhD scholarships in nuclear science and engineering in France, Russia, South Korea, China and Japan. The number of scholarships provided for Jordanians graduates is more than 150 scholarships.

The JRTR is a cornerstone of research and training in nuclear science and technology in Jordan and it plays the primary role in providing a strong platform for educating and training the upcoming generations of nuclear engineers and scientists and other nuclear sciences students, engineers, and technicians to have a solid background on the safety of nuclear and radiation protection activities and operate, maintain and develop nuclear reactors.

As a matter of strategy, JAEC is also requiring external consultants to provide training as part of their activities. This approach is included in the solicitation for the Bid Invitation Specifications.

GoJ has recruited a qualified and capable workforce in the nuclear and radiation protection field. Long-term career opportunities for Jordanians at EMRC or JAEC are achieved through focused recruitment and training and development programs.

Jordan is a member of several international networks and has signed Nuclear Cooperation Agreements with many international countries to provide support in nuclear project management, research reactor utilization, nuclear power systems, reactor safety, nuclear waste management, and nuclear fuel cycle management.

Jordan also has a longstanding relationship with the IAEA, including recent technical cooperation on various HRD issues. Jordan and the IAEA engage in specialized training courses and workshops in nuclear and radiation safety and security, nuclear and atomic physics, nuclear chemistry and radiochemistry, nuclear engineering and technology, and nuclear and radiation safety and nuclear security. Other areas of technical cooperation between Jordan and the IAEA include fellowship programs and on-the-job training, scientific visits, national consultant visits, and expert missions.

JAEC is developing a HRD plan to identify the capabilities needed to support the Jordanian nuclear power program, assess the ability of the current market to provide those capabilities, and develop the required skills and abilities within the country in order to have the required skilled local workforce available when implementing the nuclear power program and to build the human capacity to support the radiation and nuclear industry in Jordan.

Staff Qualification – Article 22 (i)

According to provisions of Jordan's national policy on RW and SNF management, the GoJ is responsible to take the appropriate steps to ensure the availability of qualified staff for the RW and SNF management, which can be achieved by recruitment of adequate human resources and ensuring allocation of financial resources for training and qualification of personnel. Article 7 D of the "*Radiation Protection and Nuclear Safety and Security*" Law for the year 2007 lays the foundation for mandating the availability of qualified personnel that are efficient in the areas of radiation protection, nuclear safety and security. Furthermore, Article 7 H of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2014 also mandates that the licensee or permit holder, authorized by the EMRC to use nuclear energy or manage RW and/or SNF, to ensure having qualified healthy fit human resources, and other mentioned conditions in "Regulation of Principles and Conditions for Granting Licenses and Permits for Radiation Work".

Article 3 of the "*Instructions on Controls of the Radiation Protection Program, Safety of Radiation Sources, the Management System, Quality of Radiation Sources and Radiological Practices, Accidents and Verification of Compliance*" defines that a licensee or permit holder shall establish a Radiation Protection Program (RPP) in proportion to the radiation risks associated with the exposure situation under their responsibility that is sufficient to ensure compliance with the safety requirements. This Article further requires that the RPP shall identify the Radiation Protection Officers (RPOs) and qualified experts, and certify their appropriateness for their assigned duties, which education, training, qualifications, and fields and years of experience. The RPO is defined as person technically competent in radiation protection matters relevant for a given type of practice, who is designated by the registrant or licensee to oversee the application of relevant requirements established in international safety standards and in accordance with their RPP.

According to Article 64 (Appendix 1) of the "*Radioactive Waste Management Instruction*," in order to control all waste management activities, the operator shall implement a management system that integrates safety, health, environmental, security, quality, and economic elements

to ensure, among other requirements, improving personnel safety culture and qualification. Article 65 further defines that the documents of the management system shall specify the organization structure of RWM activities, including facility operation, training, and qualification of the personnel.

In full compliance with the legislative requirements, JAEC has assigned RPOs and qualified experts necessary for the safe operation of its facilities. The radiation protection, maintenance, and inspection programs are developed by JAEC, and have been approved. Verification of availability of adequate human resources is part of the licensing process of any waste management facility and annual inspections are performed by the EMRC to verify compliance to licensing conditions.

Financial Resources – Article 22 (ii)

According to provisions of the Jordan national policy on RW and SNF management, the GoJ shall take the appropriate steps to ensure adequate financial resources to support the safety, security and radiation protection for SNF and RW management facilities during their operating lifetime and their decommissioning. The generators of SNF and RW are responsible for securing the adequate human resources and establishing the safe management of SNF and RW and shall be in a position to bear all the cost for the management and safe disposal, which will be carried out by JAEC. The GoJ will be responsible for bearing the cost for management of ownerless RW and orphaned sources.

JAEC's budget is set by prime ministry and the ministry of finance. Funds are made available by annual government allocation. JAEC manages its financial resources according to the applicable financial and auditing regulations within the GoJ. The overall budget provided has been adequate to enable JAEC to carry out all of its responsibilities over the reporting period.

Financial Provision – Article 22 (iii)

According to provisions of Jordan's national policy on RW and SNF management, the GoJ is required to take appropriate steps to ensure financial provisions are made available for carrying out all institutional controls and monitoring arrangements for national disposal facilities.

Article 23. Quality Assurance

It is stipulated by the national policy for RW & SNF management that generators of SNF and RW or operators or managers of RW storage and treatment facilities are responsible for establishing and implementing a Quality Assurance Program (QAP) for RW and SNF management at their facilities.

According to Article 7 of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2014, the licensee or permit holder authorized by EMRC shall maintain a high level of quality in all activities related to nuclear safety, security, and radiation protection carried out in the licensed nuclear facility.

Adhering to the requirements set forth by the national legislation, JAEC has established and implemented a management system, covering all its facilities, which is compliant with international safety standards. Programs, plans, written procedures, equipment, tools, devices for radiation protection and installed radiation monitoring system governing activities and processes that are carried out in its facilities are formulated to ensure these activities and processes are in accordance with radiation protection principles to ensure that no dose constraints or limits are being exceeded.

Quality Assurance (QA) has been considered in the design, construction, maintenance, and modification of RWM facilities owned by JAEC.

Assessment of the availability and level of implementation of an integrated management system to ensure a sustained level of safety and to verify compliance to all the established procedures during the operational phase of the facilities is regularly performed by JAEC. Records are also maintained for these assessments, as well as for activities carried by in these facilities.

The main objective of implementing a Quality Management System (QMS) for the safe, secure, and effective management of RW from their generation to their long-term storage (an ultimately disposal), is to reduce radiological risks and hazards and to protect the public health and the environment, at the present time and the future without imposing undue burden upon future generations.

All services or activities pertained to the RWM are conducted through specialized technical staff to ensure the highest level of quality. All services and activities are performed in accordance with the national requirements and regulations, international standards, and the IAEA recommendations.

Verification of the achievement of quality within RWM facilities is the responsibility of the JAEC's QA Directorate. All CSF personnel have the authority and responsibility to identify quality concerns, recommend solutions, and stop unacceptable activities or practices that may adversely affect quality or safety.

CSF Management is committed to the continual improvement of its performance by monitoring quality issues and through involvement with customers, suppliers, regulatory authorities, and community.

To assist with the above, JAEC has established a dedicated QMS based on the ISO 9001:2008 for CSF. It is the responsibility of the entire CSF team to support effective operation of the CSF Quality Management System in order to achieve the goals and the specified quality objectives. JAEC QA Directorate implements inspection tours to ensure the safe operation of JAEC's facilities.

Article 24. Operational Radiation Protection

Any SNF or RW management facility is subject to EMRC licensing under the provisions of the *"The Radiation Protection, and Nuclear Safety and Security"* Law No. (43). This gives the EMRC the authority to regulate radiation protection in the overall Nuclear Sector, which includes nuclear facilities and industrial and medical application of radioactive materials.

For all facilities operated by JAEC (the CSF and RTF), RPPs are documented and formally approved by the EMRC. The RPPs have been implemented and cover routine monitoring of the relevant facility and its environment, monitoring of specific operations such as treatment and emplacement activities, and any special monitoring that may be required from time to time. These programs make provisions to monitor occupational exposure, radiation levels, and surface contamination. Documented safety analysis is required by the EMRC for each facility, and is reviewed and audited by the EMRC, to ensure appropriateness and applicability of its RPP and that it is fully implemented by the respective facility.

In order to ensure safety for both JRTR and JAEC workers on site, as well as the safety of the general public, the following laws and regulations set out below by the EMRC are applied to the RW and SNF management facilities. *"The Radiation Protection, and Nuclear Safety and*

Security" Law No. (43) covers radiation safety and protection by providing the basis for safety requirements in matters related to radiation protection.

EMRC has developed the following regulations and instructions dealing directly with radiation protection in related facilities:

- Instruction on "*Limits of the radiation doses*".
- Regulation No. (108) on "*Radiation Protection*".
- Instruction on "*Public protection from radiation exposure*".
- Instruction on "*Personal dosimetry and area monitoring system*".
- Instructions on "*Medical protection programs for workers*".
- Instruction on "*Radiation protection for classification of areas within the institutions*".
- Regulation on "*Radioactive Material Transport*".
- Instructions on "*Radiation Dose Constraints*"
- Instructions on "*Justification of Radiation Practices, Medical Exposure Conditions and Requirements of Radiation Protection for Non-Medical Imaging of the Individual*".
- Instructions on "*Radiation Protection Equipment that shall be provided in the Facility*".
- Instructions on "*Bases and Procedures for the Tests, Periodic Calibration, Dosimetry, Quality Control Tests for Radiation Sources and Medical Radiation Practices and Bases of Radiation Safety Assessment of The Radiation Sources*".
- Instructions on "*Radiation Protection Requirements against Occupational Exposure*".
- Instructions on "*Radiation Protection Requirements for Pregnant or Breast-Feeding Female*".
- Instructions on "*Controls of the Radiation Protection Program, Safety of Radiation Sources, The Management System, Quality of Radiation Sources and Radiological Practices, Accidents and Verification of Compliance*".
- Instructions on "*Program for Workers' Health Surveillance*".
- Instructions on "*Requirements and Measures for Protecting the Public against Radiation Exposure*".
- Instructions on "*Radiation Protection Requirements for the General Use of Consumer Products that Contain Radioactive Material or Emit Ionized Radiation*".
- Instructions on "*Establishment of Reports and Records of Ionizing Radiation Sources*".
- Instructions on "*Exempted Practices from Radiation Protection Requirements and the Criteria for Clearance of Radioactive Materials*".
- Instructions on "*The Personal Training Related to Protection of the Patient*".
- Instructions on "*The Release of Patients After Radionuclide Therapy*".

Regulatory requirements have been established to ensure that radioactive discharges shall be limited and consistent with international norms and standards.

Article 25. Emergency Preparedness

Emergency Plan – Article 25 Para 1

Article 15 of the "*Radiation Protection and Nuclear Safety and Security*" Law for the year 2007 stipulates that every licensed establishment shall develop an emergency plan proportionate with the nature of the work of the establishment.

Article 14 of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2014 requires the licensees for commissioning, operation, and decommissioning of nuclear facilities and processes related to the manufacturing, transportation, and storage of nuclear material to establish measures for emergency planning and emergency preparedness for all its activities. This Law and Regulation requires the on-site emergency plan to be prepared in coordination with the off-site national emergency plan.

The EMRC coordinates with relevant governmental entities for the development of the off-site emergency plan. The off-site emergency plan is submitted by the EMRC to the Higher Civil Defense Council for official adoption.

Article 15 of the former regulation states that the licensee shall ensure the connection between on-site and off-site emergency plans with all relevant national organizations to protect the public, their properties, and environment in the event of nuclear accidents or emergencies.

Article 16 of "*The Safe Use of Nuclear Energy*" Regulation No. 43 for the year 2014 requires that six months prior to the commissioning of a nuclear facility, licensee is required to submit the on-site emergency plan to the EMRC and to other relevant national parties. Approval of the on-site emergency plan is required prior to fuel loading in any nuclear facility in accordance with the "*Instructions on Emergency Preparedness for Nuclear and Radiological Facilities*,"

It is stated in subparagraph B of Article 16 of the Regulations that the emergency plan shall be exercised in practice prior to commissioning of the nuclear facility and in the course of facility operation, and the separate parts of the plan shall be periodically tested and evaluated and the licensees or relevant permit holders are obligated to conduct special training for the employees designated to perform functions in implementing the emergency plans as required by Article 17 of "*The Safe Use of Nuclear Energy*" Regulations No. 43 for the year 2014.

Article 18 of "*The Safe Use of Nuclear Energy*" of Regulation No. 43 for the year 2014 defines that the terms and procedure for preparation of the emergency plans, the persons responsible for their implementation and their duties, the measures for mitigation and remediation of the consequences, the arrangements for warning of the public, as well as measures for conducting the emergency preparedness exercises shall be in accordance with the Instructions and Regulations issued by EMRC.

In the national policy for RW and SNF management, it is stated that SNF and RW shall be managed in accordance with national and international accepted practice principles, such as the following:

- Emergency preparedness and response: Arrangements must be made for emergency preparedness and response in case of nuclear or radiation incidents.
- Prevention of accidents: All practical efforts must be made to prevent nuclear or radiation accidents.

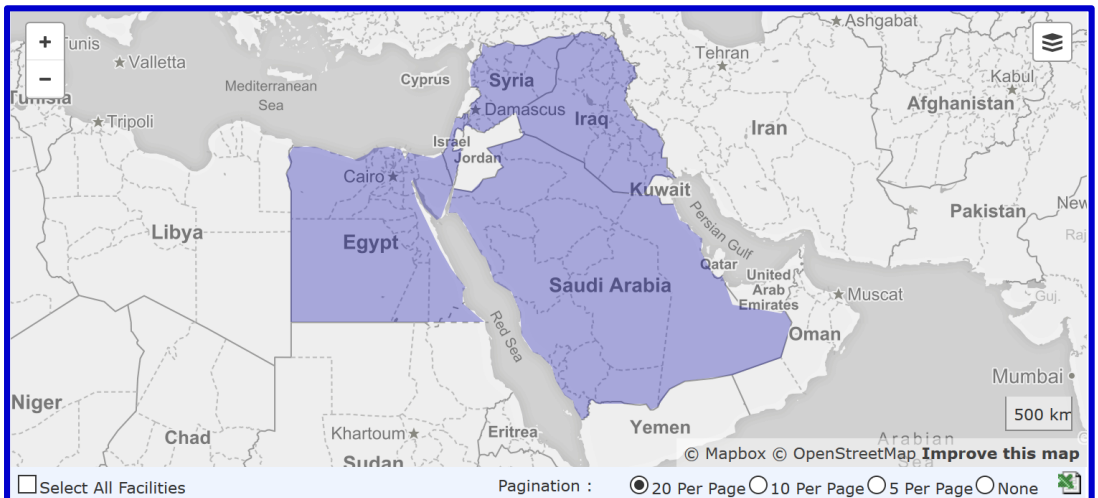
In the national regulation for SNF, particularly Articles No. 112 and 113, emphasis that the safety of the facilities for SNF management shall be ensured by the development of emergency plans and their on-site and off-site execution when necessary.

JAEC has developed an emergency plan for each of its licensed radiological facilities and activities, a drill with all concerned governmental parties has been conducted to test the emergency response of the technical team within JAEC. Off- site emergency response organizations and the technical emergency response, JAEC team has been also involved with other concerned governmental emergency response organizations in drills and exercises on the national level to examine and test the integration of overall national emergency response plan in case of radiological or nuclear emergencies.

Outside Effects – Article 25 Para 2

There is no NPP in construction or operation in the vicinity of Jordan territory. However, there are several research reactors in the neighboring regions, as shown in Figure F.1, which could raise a need for an emergency response system in place in case of any radiological emergency event at their sites.

EMRC will further study potential implications and related demands in establishing national early warning system within Jordan's territory and seek for regional cooperation with this regard.



Select All Facilities Pagination : 20 Per Page 10 Per Page 5 Per Page None

Report	Country	Facility Name	Type	Thermal Power (kW)	Status
☑	Saudi Arabia	LPRR	POOL	30.0000	UNDER CONSTRUCTION
☑	Egypt	ETRR-2	POOL	22000.0000	OPERATIONAL
☑	Israel	IRR-1	POOL	5000.0000	OPERATIONAL
☑	Israel	IRR-2	HEAVY WATER	26000.0000	OPERATIONAL
☑	Syrian Arab Republic	SRR-1	MNSR	30.0000	OPERATIONAL
☑	Egypt	ETRR-1	TANK WWR	2000.0000	EXTENDED SHUTDOWN
☑	Iraq	IRT-5000	POOL, IRT	5000.0000	PERMANENT SHUTDOWN
☑	Iraq	TAMMUZ-2	POOL	500.0000	PERMANENT SHUTDOWN

Figure F.1 Research Reactors in the Neighboring Region

Article 26. Decommissioning

There is currently no facility under decommissioning or approaching decommissioning phase in Jordan. Nevertheless, EMRC has established the relevant national legislation to cope with

decommissioning issues. There is no requirement on obtaining license for decommissioning posed by the "*Radiation Protection and Nuclear Safety and Security*" Law for the year 2007, however, according to the Article 6 (d) of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2014, the EMRC issues a permit for decommissioning of a nuclear facility under the operating license of a nuclear facility or installation. All phases of decommissioning, from the initial plan to the final release of the facility from regulatory control is to be regulated by EMRC, as set forth in Article 3 (Appendix 1) of the "*Instruction on Decommissioning of Nuclear Facilities*." Therefore, any decommissioning activity cannot be implemented without a permit issued by the EMRC. EMRC requires the decommissioning plan to be prepared and maintained by the operator throughout the lifetime of the facility, where for newly designed facilities, decommissioning planning should be considered on three stages: initial, intermediate, and final; while in the case of nuclear facilities in operation and under construction, where an initial decommissioning plan does not yet exist, an intermediate decommissioning plan reflecting the current operational status is required to be prepared as soon as possible for establishment of compliance with the Instructions.

Pursuant to Article 8 (f) (Appendix 1) of the "*Instructions on Decommissioning of Nuclear Facilities*" for sites that house more than one facility, a global decommissioning program is required to be developed for the entire site to ensure that interdependences are considered in the planning for each individual facility.

Staff Qualification – Article 26 (i)

Since the permit for decommissioning of a nuclear facility is issued by the EMRC under the license for operation of nuclear facility, Article 7 of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2014 requires provision of qualified human resources is applicable to the decommissioning phase of the facility. The "*Instructions on Radiation Protection Requirements Against Occupational Exposure*" issued by EMRC under Article 7 of "*The Radiation Protection, and Nuclear Safety and Security*" Law No. 43 for the year 2007, and by its Article 4, which stipulates that in order to guarantee the necessary level of competence for all workers engaged in activities in which they are or could be subject to occupational exposure, a registrant or licensee shall ensure suitable and adequate human resources and appropriate training in protection and safety are provided. Furthermore, Article 28 (b) of the "*Instruction on Decommissioning of Nuclear Facilities*" requires the management system to be applied throughout the entire process of decommissioning to ensure that personnel involved have appropriate qualifications and experience, and the respective training is carried out.

Article 7 of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2014 also defines that the licensee or permit holder authorized by the EMRC to use nuclear energy, manage RW, or manage SNF shall guarantee securing adequate financial resources to ensure safe shutdown and decommissioning of the nuclear facility and the relevant activities. Furthermore, Article 9 (e) (Appendix 1) of the "*Instruction on Decommissioning of Nuclear Facilities*" sets forth the obligation for the operator to ensure that sufficient funds will be available for decommissioning, where the initial decommissioning plan shall address the costs and the means of financing the decommissioning work, based on preliminary cost estimation, taking into account evaluation of accepted and applied engineering methods and technologies for decommissioning of referent nuclear facilities, and options for collection of financial resources and budgeting in accordance with the applicable national legislation.

Applying Provisions of Article 24 – Article 26 (ii)

Article 11 (a) (Appendix 1) of the "*Instruction on Decommissioning of Nuclear Facilities*" requires that the final decommissioning plan shall be submitted by the applicant for decommissioning authorization to the EMRC for approval two years before termination of the

facility operation. The final decommissioning plan is required to define safety and radiation protection measures. According to the provisions of Article 21 of this instruction, radiation protection during decommissioning of a nuclear facility is required to adhere to and be in accordance with the principles stated in the "*Radiation Protection and Nuclear Safety and Security*" Law for the year 2007.

Furthermore, Article 22 (Appendix 1) of this instruction requires the operator to develop, within the framework of the decommissioning plan, a program for radiation protection of the workers, the public, and the environment.

According to Article 9 (Appendix 1) of the EMRC instruction, technical measures and solutions that facilitate decommissioning must be considered in at the design phase of a nuclear facility. The initial decommissioning plan must be based on preliminary assessment of the planned decommissioning activities in respect to occupational exposures and potential releases of radioactive substances with resulting exposure of the public. The final decommissioning plan is required to define criteria based on the safety assessment and environmental impact assessment pertaining to such activity.

Applying Provisions of Art 25 – Article 26 (iii)
The provisions of Article 14 of the "*Regulation on the Safe Use of Nuclear Energy*" for the year 2014 related to emergency preparedness apply to all phases of nuclear facility, including decommissioning.

Records – Article 26 (iv)
According to Article 9/c/8 (Appendix 1) of the "*Instructions on Decommissioning of Nuclear Facilities*," the initial decommissioning plan is required to include nomenclature of documents and records from the sitting, design, construction, and operation relevant to decommissioning planning, which must be retained during the facility lifetime.

Article 11 (Appendix 1) of these instructions define that the final decommissioning plan shall address documentation and record keeping requirements.

Article 10 (Appendix 1) stipulates that during operation, the operator shall ensure the implementation of the plan and take general measures facilitating the decommissioning, including relevant records keeping.

As set forth by Article 34 (Appendix 1), the quality program developed by the operator as a part of final decommissioning plan is required to address the planning and implementation of all processes on decommissioning, including maintenance and archiving of related documents and records. Relevant documents and records are to be prepared and maintained during the design, construction, commissioning, operation, decommissioning phases of a nuclear facility, and after completion of decommissioning.

G. SAFETY OF SPENT FUEL MANAGEMENT

Article 4. General Safety Requirements

As explained previously, Jordan has only one research reactor (JRTR), which received its operational license in November 2017. NPPs have not yet been established.

Article 8 in appendix 1 of the instructions on "*Spent Fuel Management*" for the year 2014 issued by the EMRC provides the safety requirements for the SNF management to be guaranteed by the fulfillment of the basic safety functions which attain the following:

- Ensuring subcriticality.
- Residual heat removal.
- Confining of the radioactive products within the boundaries of the physical barriers.

Nuclear criticality safety of the SNF stored within the facility is addressed adequately in the safety documentation submitted to EMRC with the JRTR operation license.

The EMRC has issued instructions on "*Spent Fuel Management*", which provides requirements for spent fuel handling, transport, and storage in water pools.

Article 29 (b) in appendix 1 of the mentioned instructions also requires that the generation of RW including waste associated with SNF management, shall be minimal.

The national policy for RW and SNF management as well as the strategy for RW and SNF management consider the interdependencies between the RW generation and management steps.

Article 6 of Regulation on "*Radiation Protection*" for the year 2015 requires the licensee or permit holder to develop a safety and radiation protection program to be put in place commensurate with the radiological hazards associated with the licensed radiation practices for the institution to ensure that doses to workers during normal operations are controlled and that the radiation dose limits set by the EMRC are met.

The Jordan's SNF and RW management policy aims to manage SNF and RW considering the protection of present and future generations with no undue burden on future generations.

Article 5. Existing Facilities

The only SNF management facility currently in operation is the JRTR reactor service pool. All SNF resulting from JRTR's operation are stored in the service pool for the lifetime of the reactor.

Articles 6,7. Siting of Proposed Facilities, Design and Construction of Facilities,

There are no plans to design or construct new facilities in the near future.[1]

[1] *Note that siting studies are currently undergoing in support of the NPP that is under consideration in Jordan.*

Articles 8. Assessment of Safety of Facilities

The operator or the applicant for a license to construct or operate a SNF management facility will be required to submit detailed evidence of safety that would be reviewed and assessed by the EMRC.

EMRC reviews and assesses a preliminary safety analysis report at the stage of seeking a construction license followed by a final safety analysis report at the stage of the operating license.

Article 7 of instructions on "*Spent Fuel Management*" states that:

The adherence to the principles, achievement of goals and fulfillment of the safety criteria shall be substantiated by the Safety Analysis Report.

Article 9. Operation of Facilities

The operation license for a facility for handling of radioactive material, including radioactive waste management activities, is granted based on a safety analysis report demonstrating the suitability of the design, site and operational measures as well as the compliance with all legal and administrative requirements.

The RTF was licensed for operation in 2019 after submitting and demonstrating to the EMRC all required safety criteria stated in the instructions on "*Spent Fuel Management*" for the year 2015, Regulation No. (43) on "*The Safe Use of Nuclear Energy*" for the year 2014 and Instructions on "*The Procedures for Granting a Permit for Constructing a Nuclear Power Plant*" for the year 2015.

Article 10. Disposal of Spent Fuel

All SNF from JRTR is to be stored at the service pool for the lifetime of the reactor. After the interim storage at the JRTR, SNF will be either returned to the country of origin for final disposal or if declared as RW, the SNF is to be disposed of directly to national waste disposal facility. Final decision on SNF disposal would be taken once a decision on NPPs is made.

H. SAFETY OF RADIOACTIVE WASTE MANAGEMENT

Article 11. General Safety Requirements

EMRC regulations require RWM operator to apply measures that assure compliance to the general safety requirements so that:

- Effects of ionizing radiation on the workers, public, and environment are kept to a Level As Low As Reasonably Achievable (ALARA).
- Sub-critical values ($k_{eff} << 1$) are ensured.
- Removal of residual heat is ensured.

Licensed operators are to implement measures to minimize waste generation and to avoid accumulation of RW on-site. Therefore, the operator is required to apply technologies and methods suitable for keeping the generation of RW to minimum practicable levels, in terms of both activity and volume of the generated RW.

RW is characterized in terms of its physical, mechanical, chemical, radiological, and biological properties. In applying for permits and/or licenses, the operator is required to take into account the chemically or biologically hazardous substances in the safety analysis of its processes and facilities.

Addressing Criticality and Heat Removal – Article 11 (i)

JAEC is required to implement measures and demonstrate that the implemented measures are adequate to assure compliance to the general safety requirements so that removal of residual heat is ensured in all its RWM activities.

EMRC requires that the design and operation of a waste storage facility must incorporate technical features to maintain nuclear sub-criticality and residual heat removal, if necessary.

Minimizing Radioactive Waste Generation – Article 11 (ii)

One of the main objectives of Jordan's national policy for RWM is to minimiz the generation of RW to the extent possible.

Also, JAEC is keen to apply basic safety standards for RWM and will ensure that the methods applied in Jordan are in full conformance with the recommendations of the international best practices and the IAEA standards in regard with control and minimize of RW generation. EMRC, as the regulatory authority, is responsible to ensure full compliance of JAEC and its facilities to local regulations and Jordan's international commitments.

JAEC is required to apply measures to minimize waste generation and to avoid accumulation of RW on-site. In accordance with that, JAEC is required to:

- Apply technologies and methods suitable for keeping the generation of waste to the minimum practicable levels, in terms of both activity and volume.
- Reuse and recycle materials to the extent possible.
- Classify and segregate waste appropriately, depending on its properties and with account taken of the designated options for processing.
- Not allow mixing of radioactive and non-radioactive waste.
- Avoid spread of contamination in the facilities.
- Implement practices for release of materials from regulatory control

- Introduce decontamination processes following cost-benefit analysis.
- Apply processing technologies that reduce the volume of RW.
- Provide adequate storage options for the RW subject to subsequent processing, clearance, or disposal; and
- Ensure that activities and methods used to manage RW comply with the stated national policy and strategy.

In the JRTR, radioactive material control procedures are established, implemented, and maintained that ensure compliance with the regulatory requirements for minimizing volumes of RW. This can be shown in some examples in JRTR Final Safety Analysis Report (FSAR) such as:

- A pre-action sprinkler system (fire-fighting system) is used in radiation-controlled areas to minimize the discharge of RW;
- During the operation of the JRTR, considerations was given to minimize the extent of the contamination of structures and surfaces, to prevent the mixing of waste products of dissimilar categories, minimizing waste generation, and to avoid spillages and leaks.
- Minimizing the generation of radioactive materials by neutron activation was considered in the design of the JRTR; and
- JRTR RWM requires the RW to be characterized, segregated, treated, recycled/reused – when possible, conditioned, stored, and free discharged and released (when applicable) to minimize the impact of RW.

Several processes have been incorporated in the design and construction of the RTF to minimize RW, which include:

- Solidification of RW, such as cementation of concentrated radioactive liquid, radioisotope capsules, and spent HVAC and water filters.
- Compaction of dry solid RW.
- Decontamination of reusable tools and equipment; and
- Evaporation.

Interdependence – Article 11 (iii)

JAEC is keen to apply the basic safety standards for RWM and will ensure that the methods applied in Jordan are in full conformance with the recommendations of the international best practices and the IAEA standards. JAEC is obliged to ensure that generation and management of RW is interdependent.

EMRC regulations require the design, construction, operation, and decommissioning of RWM facilities take into consideration the inter-relations between all steps of RW generation and management.

At the JRTR, management of waste generation and waste minimization was considered in all the project's stages from design to decommissioning. Different options for the treatment, conditioning, storage, and disposal of RW have been considered. Furthermore, EMRC licensing procedures as well as its periodic inspections provide further assurances of the interdependencies among the different steps in RWM.

RWM, including WAC, were important documents considered during licensing of JRTR and RTF facility to ensure a proper interrelation between all steps of RWM processes up to final disposal.

Protection of Individuals, Society, and Environment – Article 11 (iv)
JAEC is keen to apply the basic safety standards for SNF and RW management and seeks to deploy and implement RWM and SNF management techniques that are in conformance with the recommendations of the international best practices and the IAEA standards.

EMRC in coordination and cooperation with relevant authorities aims to protect the environment, human health, and property from the hazards of contamination and exposure to ionizing radiation in accordance with the provisions of the "*Radiation Protection and Nuclear Safety*" Law. No. 43 for the year 2007.

Safety of RWM facilities is to be based on the concept of defense-in-depth, relying on a system of organizational and technical measures for protection of workers, members of the public, and the environment under normal and accident conditions.

During the pre-operational stages of the JRTR project, EMRC has conducted many periodical inspections including monitoring of radioactivity in the environment in order to establish a baseline. By establishing this baseline prior to the operations of the JRTR, and periodic environmental monitoring and assessment, provides assurances and verifications that releases are kept below the discharging limits and to ensure that the ALARA principle has been applied and is in compliance with the environmental legislations.

In case of the RTF, the facility is zoned to minimize the transport of contamination to other areas and to reduce the annual dose received by personnel during normal operation of the facility to minimum levels. In addition, general techniques to accomplish ALARA of operational aspects are adhered to through the design and construction features of the RTF that incorporate shielding, distance, and minimize the residence time of the RTF workers in high radiation areas.

The Radiation Monitoring System (RMS) is used to monitor, measure, indicate, and record the radiation dose rates and airborne concentrations of radioactive materials in selected areas of the RTF, as well as the radiation or radioactivity levels in the radioactive effluents released to the environment from JRTR operation. The RMS is also used to provide personnel with timely information regarding alarm and readout.

Considering Biological, Chemical, and Other Hazards – Article 11 (v)
EMRC regulations require the operator of RW storage and disposal facility to develop and apply WAC. The WAC is required to be developed based on the safety analyses report for the respective facility and is required to contain requirements (acceptance criteria) pertaining to the chemical and biological hazards of substances in the waste and waste packages.

Impacts on Future Generations – Article 11 (vi)
There are currently no final disposal facilities for RW in operation or under construction in Jordan.

Jordan's RWM policy aims to manage RW in accordance with national and international accepted practice principles, in order to protect present and future generations.

Burdens on Future Generations – Article 11 (vii)
Jordan policy includes all specific steps and stages related to the safe management of RW, starting from its generation to its final disposal, and to ensure nuclear safety and security

provisions that aims to protect human health and the environment against the radiological and nuclear contamination, currently and in the future and without imposing undue burden upon the future generations.

Currently, DSRSs are the main component of the current national RW inventory in Jordan. The management options for DSRSs include finding international or regional solutions for the DSRS management and disposal.

EMRC is aiming by implementing its legislations during licensing, that the operator has to achieve proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards.

The operator shall make suitable arrangements to ensure that maintenance, inspection, and testing appropriate to the preservation of the provisions for protection and safety can be carried out without undue occupational exposure.

JAEC is studying options for dealing with their inventory of DSRSs and other RW, including SNF that is generated from the operations of the JRTR. Options being considered by JAEC include international and/or regional solutions for the management and disposal of RW (for SNF, processing abroad is being considered).

Article 12. Existing Facilities and Past Practices

The RWM system in the HKJ has characteristics of both centralized and decentralized (distributed) management of RW. There are three main sites hosting RW processing and storage facilities (Table H.1): The CSF at JAEC headquarter site, RTF at JRTR, and the historical RW storage pit at Sewaqa. JAEC is the operator of the CSF and the RTF and retains responsibility for RW stored at Sewaqa site while the site is formally under the management of MoEnv. Those facilities are distributed over the territory of Jordan and are at different phases of their life cycle and have significantly different design features, different levels of safety and security (based on the graded-approach) and differ in resourcing for RWM activities.

Table H.1 RWM Facilities in Jordan

Name	Site	Status	Description
CSF	Amman-Shafa Badran	In operation since 2010	RWM and Storage of DSRS
RTF	Irbid-JRTR	In operation since 2019	Liquid and Solid RWM
Sewaqa	Amman-Sewaqa	Out of Use	Storage of DSRS

Radioactive waste Treatment Facility

The RTF is established at the JRTR on the campus of JUST. The facility is designed and built for the management of RW originating from the JRTR operations, scientific experiments, and medical isotopes production, as well as RW generated outside the JRTR from external facilities. RW receipt, treatment, characterization, conditioning, handling, and storage are the main processes deployed in the RTF facility.

The RTF's FSAR was submitted to EMRC in December 2016 and the RTF operating license was received in March 2019. The RTF operating license covers processing and storage of RW arising from JRTR and institutional RW (except DSRSs) from other facilities and practices within Jordan. No RW generated from external facilities is currently stored at the RTF. The RTF is equipped with internal security and access control, radiation monitoring and alarm, electric power supply, lighting, ventilation, special water collection, and treatment systems. Operational procedures related to the envisaged activities in the RTF are developed and implemented, RWM and RPP are also established.

WAC are established for processing and storage of RW at RTF. It is defined that only Dry Active Waste (DAW) forms, e.g. paper, cellulose, plastic, rubber, wood, glass, and metals, from other sites / facilities like hospitals etc. that meet the WAC for storage in RTF can be accepted at this facility. Whereas the DSRSs are not acceptable for storage at RTF. However, liquid RW from the JRTR is received and processed at the RTF.

National Centralized Storage Facility

The CSF is a national facility established in March 2010 for the safe and secure RW storage, this includes DSRSs that cannot be returned by the owner\user to the manufacturers (origin country), and until disposal facility is made available. The CSF is located at the western end of the JAEC headquarters site in Shafa Badran Complex, Amman. The CSF provides storage and predisposal management for most of the DSRSs accumulated in Jordan so far.

The CSF is licensed for processing and storage of DSRSs. In November 2018, CSF has adopted a new RWM procedure; DSRSs consolidation, through the IAEA technical support; a one-week national workshop hands on- Job training on characterization and conditioning the DSRSs with especial emphasis on DSRSs of category 3-5 and neutron sources. A consolidation operation was performed at the CSF and 184 of the DSRSs were consolidated in a special lead container within stainless steel capsules. Considerable size and volume minimization and reduction by conducting consolidation operation was achieved; about 6 tons of lead was extracted and released over 60 % of the total inventory existed at the CSF was consolidated. It has to be noted that there are up to about 1000 radioactive sources still in use in Jordan in various peaceful nuclear application in many national organizations. All the in-use Sealed Radioactive Sources (SRSs) will ultimately be transferred to the CSF upon reaching their operational lifetime (if not returned to the country of origin) for storage prior to disposal.

The CSF is designed and built meeting the requirements of modern standards for protecting human health and the environment from harmful effects of ionizing radiation caused by RW acceptable for storage in this facility. Physical protection of RW in CSF is ensured by the site and CSF design features as well as technical and administrative measures in place namely:

- Passive physical barriers.
- Site and facility video surveillance system and active intrusion alarm equipment,
- Presence of military security guards next to the CSF building on a 24/7 basis,
- Multi-level access control systems for personnel and vehicles (i.e. to the site and radiological controlled areas of the CSF).

The operation of the CSF is carried out in a systematic manner and is governed by a set of procedures that are well implemented. Figure H.1 depicts the process for RW retrieval, conditioning, and storage at the CSF.

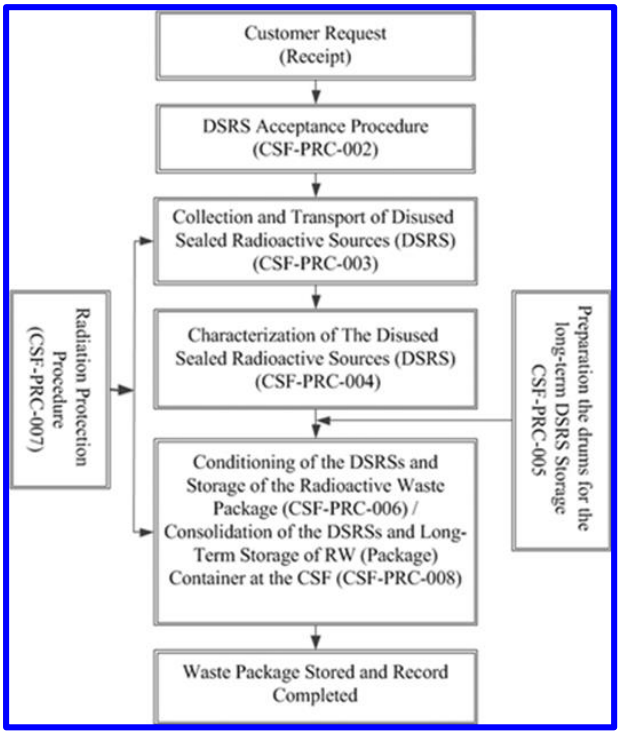


Figure H.1 DSRS Management Procedures at the CSF

Sewaqa Historical Site

Sewaqa site hosts an engineered underground well type facility in which historical RW are stored. Both the physical and radiological inventories for the RW that are currently stored at the site were established. The facility was the only facility for centralized storage of DSRSs prior to CSF which was commissioned in 2010. The conditioned DSRSs are inside 33 200L steel drums, two of them are over-packed in 1 rectangular shape metallic container. Only three DSRSs are non-conditioned DSRSs (within their original industrial shield container). All the previously mentioned radioactive sources are currently stored underground in reinforced concrete storage pit shown in Figure H.2.

Figure H.2 The rectangular underground reinforced concrete pit

The total number of DSRSs in this storage pit is 173. The majority of the RW packages contain more than one DSRS. The in-drum cementation technique was used for conditioning all the DSRSs that are currently stored in the 200L steel drums. Majority of these DSRSs were kept within their original shielding. The conditioning option of DSRSs was adopted in order to immobilize the DSRSs within type (A) package and thus to prevent non-authorized removal of

DSRSs. This is warranted by the heavy weight and robust product that is produced by the above conditioning method.

Apart from the RW that are packaged in drums, there are also DSRSs in 3 cylindrical containers (industrial shielding with adjacent metallic parts, presumably structural elements of industrial irradiators) and one rectangular metallic container with two 200L drums inside it.

The majority of the DSRSs currently stored at Sewaqa site are industrial nuclear gauges used for level, weight, thickness and density measurements, moisture and soil contents, and lightning conductors in its original shielding.

The facility does not meet the requirements of the national legislation and internationally recognized standards on safety and security of RW in particular, the RWM site and facilities at the site were not licensed, the WAC is not defined, physical security system and measures are not adequate to the level of anticipated threat.

A feasibility study to transfer the RW, represented by DSRSs, which are packaged in different types of containers and currently stored at Sewaqa historical site was developed by JAEC as a first step towards achievement of compliance with applicable regulatory requirements. Two primary options were covered by the study:

1. Retrieval of RW stored at Sewaqa site and transferring them to CSF; and
2. Continue storage of RW in underground storage pit at Sewaqa site under improved safety and security arrangements.

The feasibility study concluded that retrieval of RW stored at Sewaqa site and transfer them to CSF for processing, characterization and storage in dedicated storage facilities CSF/RTF is the most technically and economic sound option.
Analysis and comparison of the available information on radiological inventory and its comparison with radionuclide specific activity limits established for the purpose of radioactive sources categorization concluded that no DSRSs other than category 4 and 5 are stored at Sewaqa site. Inventory of the RW (DSRSs) currently stored at Sewaqa site represents only small fraction (about 16% by quantity and 0.003% by activity) of the total inventory of the DSRSs accumulated in Jordan. Most of the DSRSs are currently stored in the CSF. In recognition of the existing safety and security deficits and weaknesses at Sewaqa site, the conditioned RW stored at Sewaqa site will be transferred to CSF at JAEC.

The United States Department of Energy's National Nuclear Security Administration (NNSA) Radiological Security Program is involved in an initiative to reduce the threat of a Radiological Dispersion Device (RDD) incident. Therefore, in September 2020, a proposal submitted by JAEC was granted by the Pacific Northwest National Laboratory (PNNL) to retrieve the stored DSRSs at the Sewaqa site and transfer them to the CSF for long-term storage purposes. JAEC will be responsible for the safety and security as well as the retrieval of the DSRSs at Sewaqa Site and making the proper arrangements to transport them to the CSF.

Article 13. Siting of Proposed Facilities

Site Evaluation and Safety Impact – Article 13 Para 1 (i & ii)
Site selection of RW processing, storage, and disposal facilities is made based upon evaluation of:

1. Inventory, characteristics, and location of the existing waste, as well as the perspective for generation of RW.
2. Impact of naturally induced or man-induced initiating events on the safety of the facility.
3. Impact of the facility upon the environment.
4. Radiological impact of the facility on the public.
5. Specific characteristics of the site as it pertains to significant for migration and accumulation of radioactive substances.
6. Possibilities for application of protective measures to the public in case of an accident in the facility; and
7. Size of the special statutory areas and the emergency planning areas.

According to Article 14 of "*Radiation Protection and Nuclear Safety and Security"* Law No. 43 for the year 2007; It is prohibited for any person or entity to establish, operate or manage any nuclear facility in Jordan without obtaining a license according to the terms of this law from the EMRC. The applicant for a license to construct or operate a RWM facility will be required to submit detailed evidence of safety that will be reviewed and assessed by EMRC. The JRTR site was evaluated according to the requirements set by the EMRC laws and regulations. The FSAR submitted by JAEC to the EMRC demonstrated the characteristics of the siting, the compliance and suitability of the site selected as well as the safety impact of the JRTR and its facilities including the RTF.

The RTF has been sited after evaluation and consideration of the siting requirements stated in the EMRC instructions on "*Spent Fuel Management*" for the year 2015. The service reactor pool, used for storage of SNF, is considered in the design of the JRTR and the EMRC requirements have been addressed in the JRTR FSAR.

Information for Public – Article 13 Para 1 (iii)
According to article 73 of the instructions on "*Spent Fuel Management*" for the year 2015, the licensee, the permit holder or the operator shall establish organization for interactions with the state regulating authorities for such activities and with the public.

The licensee or permit holder authorized by the EMRC to use nuclear energy, manage RW or SNF is required to ensure:

1. Plans covering the roles and responsibilities of the relevant parties according to its competence to provide for the provision of the necessary measures to raise awareness of the dangers resulting from the use of nuclear energy, and any measures in order to inform the public and the relevant authorities for any possible effects on health and the environment, and maintain these measures transparently.
2. Make suitable arrangements to ensure that all relevant safety documentation is available in the appropriate languages understandable to users.
3. An Environmental Impact Assessment (EIA) is made per the governing requirements (set by the MoEnv) to inform the public for any possible effects or hazards that are expected from such a facility.

For the JRTR, there were scoping sessions undertaken between the applicant and in the interested parties of public. These sessions were organized by the MoEnv and observed by

EMRC. Open discussions among concerned parties and the public to answer many questions and respond to concerns were carried out. These sessions were also used to inform the public and interested parties on the expected releases from the JRTR and demonstrate that theses releases are within the allotted limits.

For the CSF, JAEC is ensuring that the required information for the public is available and JAEC is accepting visitors to tour the facility and provide access to relevant information to assure transparency and openness.

Other Parties Consultation – Article 13 Para 1 (iv)
Jordan's national policy intends to inform the public about the proposed plans for SNF and RW management, and to consult with all concerned parties and members of the public to aid in making related decisions.

In October 2018, a Stakeholder Involvement Strategy was issued. The strategy aims to stress that nuclear related information dissemination must be done in a transparent, timely, factually correct, objective manner and in plain language to inform stakeholders and maintain their trust and minimize rumors and defeat myths.

Article 14. Design and Construction of Facilities

Design Consideration – Article 14 (i)
The design, technologies, and procedures developed for RWM facilities shall ensure that radioactive substances are contained within the established boundaries under all operational conditions and design-basis accidents.

The CSF and RTF designs comply with IAEA safety standards and EMRC requirements and adhere to the established radiological protection policy and measures. The design of the RTF and its operational procedures are formulated to ensure that internal and external exposures to radiation workers and the public are within the limits stated by the EMRC instructions and applicable to recommendations of IAEA and in compliance with ALARA principle.

Decommissioning Consideration – Article 14 (ii)
Article 17 D of the EMRC instructions on the "*Spent Fuel Management*" for the year 2015 states that the design documentation of SNF management facility shall include a part for decommissioning. Article 9 of the instructions on "*Decommissioning Nuclear Installations and Facilities*" requires that the design stage of a nuclear facility must incorporate technical measures and solutions that facilitate decommissioning, which include the following:

- Lay-out of the structures, systems and components of the nuclear facilities and access routes to facilitate:
    - The dismantling and removal of large components.
    - Allowance for detachment and remote removal of significantly activated components.
    - Future mounting of decontamination and waste handling equipment.
    - Decontamination or removal of embedded components such as pipes and drains.
    - Control of radioactive material within the facility.

- Construction materials are to be selected to reduce activation and to minimize contamination, spreading of radioactive products, and the amount of generated RW.

During the design and construction stage of the JRTR, a preliminary decommissioning plan was submitted with the FSAR. The objectives of decommissioning plan are to reduce radiological exposure to workers, to minimize waste generation, reduce impacts on the environment, to simplify the dismantling procedures, and to reduce cost associated with decommissioning activities. The decommissioning plan is required to include all the necessary steps that lead to the ultimate completion of the decommissioning to the point that safety can be assured with minimal or no surveillance at the decommissioned site.

Closure Consideration – Article 14 (iii)

EMRC requirements mandate that major design characteristics of a waste disposal facility is to be determined based on the safety assessment for the operational and post-closure period. The design of a waste disposal facility is required to establish the following:

a. Waste acceptance requirements.
b. Maximum total activity of the waste disposed of on site.
c. Composition and structure of the multi-barrier system.
d. Necessary requirements to the materials of each barrier.
e. Minimum durability for each barrier.
f. Provision of sub-criticality; and
g. Maximum allowable thermal generation and required heat conductivity between the package and natural barriers.

Furthermore, EMRC requirements mandate that closure of radioactive waste disposal facilities are to be performed according to a detailed closure plan, which must be submitted to the EMRC at least three years prior to the start of its implementation. The closure plan must address the following:

1. Design of technologies and materials needed.
2. Final safety assessment following closure, using the information as result of analyses and operational experience accumulated during the previous stages.
3. Description of the control measures during closure, which include:
    a) Steps and periods of controls.
    b) Radiation monitoring program on-site and within the protected and supervised areas.
    c) Program for inspections and tests of the facility; and
    d) Records keeping system.

Proving Technology – Article 14 (iv)

JAEC, by virtue of its permits, licenses, and EMRC regulations and instructions, is required to develop and implement measures that assure compliance to general safety requirements while considering available technologies in its RW facilities. The design solutions, technologies, and procedures implemented by JAEC must be justified and compared with current achievements of science and technology and the internationally recognized operational experience. The design

of the JRTR is based on a proven technology / design of open – pool reactor, which is operated in South Korea (HANARO).

Additionally, JAEC constructed the CSF with the best international standards for protecting human health and the environment from the long-term effects of RW and to prevent the accidents associated with the DSRSs. The site characteristics were studied jointly by JAEC and the Ministry of Public Works and Housing. Characteristics such as geology and external events such as seismic events have been taken into consideration in the construction of the CSF.

Article 15. Assessment of Safety of Facilities

Preconstruction Consideration – Article 15 (i)
According to the EMRC instructions on the "*Spent Fuel Management*" for the year 2015; safety assessment is required to be developed by the operator (Licensee) for different stages of the RWM facility (design through decommissioning and closure). Assumptions employed in the safety assessment are required to be justified and implemented when performing the activities associated with the RWM facility.

Initiating events considered in the safety assessment are to be reevaluated during progress of the design and safety assessment of the facility and must be subjected to an iterative approach with feedback from the safety assessment. Compliance with the safety requirements and criteria shall be proven by safety assessment of the RWM facility.

The safety assessment is required to contain analyses for the capability of the facility to fulfill its safety functions under normal operation and anticipated occurrences conditions, as well as under accident conditions and low-probability events. For RW disposal facilities, degradation of the protective barriers as a result of human activity in the post closure period must be considered and evaluated. Furthermore, the safety assessment shall describe and justify measures for reducing the probability for propagation of radionuclides into the environment, as a result of human activity in the post closure period.

Environmental impact assessment – radiological impact deals with assessment of the future potential environmental impact of nuclear facilities and its associated waste treatment facilities based on the graded-approach. In particular, the instructions on the "*Environmental Impact Assessment, Radiological Part*" for the year 2015, and its attached documentation provides additional guidance on the scope of information required in connection with the potential radiological environmental impacts directly associated with construction, operation, and decommissioning of a facility.

Adequate information for all areas relevant to the assessment of the radiological impact on the environment of the construction of the facility, its operation under normal operational conditions as well as under accident conditions including severe accidents, and its decommissioning were covered and included in the FSAR for the JRTR. Non-radiological impacts of the facility are addressed under the MoEnv Legislative framework.

Prior to the construction of the RTF, JAEC submitted the Preliminary Safety Analysis Report (PSAR) which was evaluated by EMRC and covered a systematic safety assessment, and environmental impact assessment of the facility, covering the entire lifetime of the proposed facility.

Systematic and Environmental Safety Assessment – Article 15 (ii)

Main design characteristics of a RW disposal facility shall be determined on the basis of safety assessment for the operational and post-closure periods.

Closure of the RW disposal facility is to be performed according to a detailed closure activity plan and must be submitted to the EMRC at least three years prior to the start of its implementation. The plan must contain the final safety assessment after closure, using the information as result of analyses and operational experience, accumulated on the previous stages.

The period of the institutional post-closure controls is to be determined depending on the waste and site characteristics, the facility design, social, and other factors and must be substantiated in the safety assessment.

In Jordan, there is no disposal facility up to now.

Updating Safety Assessment before Operating – Article 15 (iii)

According to article 5 in the EMRC instructions on "*Radioactive Waste Management*" for the year 2015; the operator of the RWM facility shall perform safety assessment throughout all the stages of the facility lifetime. The assumptions adopted when carrying out the safety assessment are reflected when performing the activities, for which the respective assessment was prepared.

For the RTF, FSAR summarizes the updated version of the safety assessment necessary for obtaining the operating license. The safety assessment contained analyses of the capability of the facility to fulfill its safety functions under normal operation and anticipated occurrences conditions, as well as in cases of accidents and low-probability events. The RTF has its own safety case for each stage of the facility lifetime which demonstrate that all steps of RWM are carried out in a safe, secure and effective manner in line with the regulatory requirements. The safety case is updated periodically or when the need arises. Safety assessment is included in the facility safety case document. The EIA for the RTF was developed and submitted to the EMRC along with the application for operational license. The RTF obtained its operational license in March 2019.

The CSF safety case and associated safety assessment for RWM including DSRSs take into consideration the IAEA requirements for predisposal management of RW. The safety criteria are drawn from the "*Radiation Protection, and Nuclear Safety and Security."* Law No.43 and international best practices and the IAEA GSG-3 the Safety Case and Safety Assessment for the Predisposal Management of Radioactive Waste. These criteria are used as a basis for the evaluation of the safety and radiation protection. The safety assessment is updated within appropriate intervals (at least before the beginning of each stage, or as required by the regulatory body), considering new information, such as feedback from operating experiences. The safety case is reviewed and updated throughout the lifetime of the facility in subsequent phases of commissioning (active and non-active), operation, decommissioning and termination of the license in accordance with regulatory requirements, or when any new technology for RWM is adopted. The CSF safety case and safety assessment are reviewed every five years (or at the end year of the termination of the CSF license) as well.

As for the future disposal facility a safety assessment will be developed addressing the degradation of the protective barriers as a result of human activity in the post closure period and other related safety aspects.

Article 16. Operation of Facilities

All the requirements stated in article 16 of this report are covered in the EMRC regulations dealing with Nuclear Facilities (including RWM facilities) and are applied on the existing RWM facilities in Jordan. It is required by the operator of RW processing, treatment, and/or storage facilities to develop and apply facility specific operational limits, conditions, and controls for all operations and activities important to safety, assuring compliance of the facility operation with the design safety requirements. During the operation of RW processing, treatment, and/or storage facility, the operator is required to perform analyses and submit a report to the EMRC on operational events that are significant to safety.

The CSF at JAEC has been issued an operational license by the EMRC after submitting a safety assessment of all the general and specific safety requirements including radiation protection for all stages of radioactive waste management in the RWM facilities as mentioned in Article 15 of this report. The RTF has been issued an operational license as well in March 2019.

The application for obtaining an operational license for the Nuclear Facility shall comply with the requirements of the instructions on "*the procedures for issuing site, construction and commissioning permits for nuclear power plant*". This include operation, maintenance, monitoring, inspection, and testing programs that must be developed and maintained by the facility operator, as well as relevant reports that must be submitted to the EMRC for review. Engineering and technical support must be made available over the operating life of RWM facilities. All radiation protection requirements including incidents reporting and emergency planning and preparedness, and general and specific safety requirements including segregation and characterization of the generated waste, decommissioning and closure plans are outlined in the EMRC instructions on the "*Radioactive Waste Management*" and regulation on "*the safe use of nuclear energy*" and instructions on "*licensing nuclear facilities*".

Article 17. Institutional Measures after Closure

Preserving Records – Article 17 Para 1

Closure of RW disposal facilities shall be performed in accordance with detailed closure activities plan, which must be submitted to EMRC at least three years prior to the start of its implementation. The plan must address the Records Keeping System.

Any person or entity that possess, manufacture, process, store, use nuclear materials, or manage SNF and RW, shall maintain physical inventory and keep records of all nuclear and radioactive material, as well as for SNF.

The responsibilities for the management of SNF and RW in Jordan are distributed over the following main pillars: JAEC, Generators, and Operators, which are obliged for keeping record of RW and SNF.

There is no disposal facility under construction or in operation in Jordan. Nevertheless, the Jordanian legislation does contain legal requirements for closure of a disposal facility. There are currently no structured plans for closure of the existing storage facilities in Jordan.

Institutional Controls – Article 17 Para 2

An institution authorized by EMRC shall perform post-closure control of the RW repository site. Controls may include:

Active Controls by carrying out monitoring, access control, maintenance of the facility's systems and infrastructure.

Passive Controls by implementation of administrative measures for control over land-use.

JAEC is required to implement provisions of institutional control over the closure of disposal facilities for RW and storage and processing facilities during operations and decommissioning stages. The waste generator is administratively, technically, and financially responsible for the short-term safe management of the RW and SNF in accordance with the national and international principle mentioned in the national policy, and is responsible for ensuring the availability of financial resources for the long-term management of its RW and SNF. Furthermore, JAEC is responsible for the long-term management of RW and SNF at the national level. Therefore, the GoJ must take the appropriate steps to ensure the availability of financial provisions required for the institutional controls and monitoring arrangements for national nuclear decommissioning facilities and activities and disposal facilities related to the RW and SNF.

Unplanned Release – Article 17 Para 3

The estimated average effective dose to the relevant critical groups of members of the public as a result of a RW disposal facility after its closure must not exceed 0.15 mSv in a given year. This criterion is to be used in assessing the post-closure safety of the disposal facility in case of anticipated events (normal evolution of the disposal system). The intervention levels, as established by the EMRC, serves as safety criteria in case of low-probability events and human activity on-site in the post closure period.

Jordan legislation requires the implementation of radiation monitoring system to guard against the release of radioactive material to the environment that may result in doses or levels of contamination that exceed international intervention levels or action levels for protective actions.

I. TRANSBOUNDARY MOVEMENT

Article 27. Transboundary Movement

The Jordanian laws and regulations used to control the import and export of radioactive materials are:

- Law No. (43) for the year 2007 "*Radiation Protection, and Nuclear Safety and Security Law*''
- Regulation No. (43) For the year (2014), "*Regulation on the Safe Use of Nuclear Energy*", and its Instructions.
- Regulation No. (108) for the year (2015), "*Regulation on Radiation Protection*" and its Instructions.
- Regulation No. (32) For the year (2016), "*Regulation on the Transport of Radioactive Sources*" and its Instructions.
- Regulation No. (8) for the year (2013), "*Regulation on the Basis and Conditions for Granting Licenses and Permits for the Radiation Work*."

As per the national policy for RW and SNF management; it is prohibited to enter or import any radioactive materials classified as RW or SNF that is produced abroad to the Kingdom of Jordan. With an exception to re-export the SNF, generated inside Jordan, abroad to its country of origin (the manufacturer) for further treatment or reprocessing and to permit the import (enter) of the resultant HLW of the processing and treatment of the exported Jordanian SNF back into the country.

The transport of radioactive materials, RW and SNF is governed by regulation No. (32) for the year 2016, "*The Transport of Radioactive Material*" and is subject for authorization by EMRC. Each consignment is to be licensed (permitted) separately. It is prohibited to execute transport of radioactive material in import, export, transit through the border crossing points, from customs bonded yard or to clear it from customs, without the prior approval of EMRC.

Article No. (17) of the "*Radiation Protection, and Nuclear Safety and Security*," Law No. (43) for the year 2007 states that it is prohibited for any person to bring any radioactive material classified as RW to the territory of Jordan, or use, handle, transport, store, dispose of or bury it in the territory of Jordan.

Regulation No. (32) "*The Transport of Radioactive Sources*" For the year 2016, and its instructions, which regulate and control the transport of the radioactive materials including the contaminated objects, are in compliance with the IAEA safety standards and security recommendations.

According to Article No. (21) from the "*Basis and Conditions Regulation for Granting Licenses and Permits for the Radiation Work*" No. (8) for the Year 2013, it is required to have a prior permission from the EMRC to import, export, re-export, transit, transport, distribute, or temporary store of the radioactive materials with short half-life that are used in medical fields at least seventy-two hours before receiving.

The permit for transport of nuclear material is issued to a License Holder if the License Holder has performed the following:

1. Ensured that transportation will occur with a packaging and by means of transport as specified in the relevant regulation for transportation.

2. Has provided for physical protection of the nuclear material; and
3. Has submitted to EMRC a document ensuring nuclear safety applied to transportation activities, interim storage, and other on-site activities connected to the nuclear material handling before final disposal.

Jordan imported the fresh (unirradiated) nuclear fuel for the JRTR from France in accordance with the prevailing international and national regulations. No shipments of SNF have been carried out in Jordan. All the generated SNF from the JRTR operation are stored in the reactor service pool.

J. DISUSED SEALED SOURCES

Article 28. Disused Sealed Sources

According to Article (16/O) from the "*Basis and Conditions Regulation for Granting Licenses and Permits for the Radiation Work*" No. (8) for the year 2013, applicants for radiation work authorization should submit to EMRC a non-objection certificate from the manufacturing company to re-export the radioactive source after the end of its use.

EMRC has a national inventory for all SRSs that are at the user's premises, including an inventory of DSRSs stored within the CSF at JAEC. As stated previously, JAEC is responsible to collect DSRSs from local institutions after they have been declared as RW and were unable to return them to their place of origin. Once JAEC receives an official request to retrieve the DSRS, JAEC provides for a secure transport to the CSF where the DSRS is conditioned for storage at the CSF, where they remain there until a final disposal path is made available.

The national policy for the RW and SNF management states clearly that DSRSs are the main component of the current national RW inventory in Jordan. The management options for DSRSs include:

- Return to the supplier, if possible.
- Long-term storage at CSF; and
- Finding international or regional solutions for DSRSs management and disposal.

JAEC is responsible for the safe management of the DSRSs of foreign origin, which had been used in Jordan and cannot be returned to their manufacturer.

K. GENERAL EFFORTS TO IMPROVE SAFETY

Efforts related to improvement of the safety of RW and SNF management can be summarized as follows:

K.1 Jordan Atomic Energy Commission (JAEC)

1. Continue research and investigation in identifying disposal options for RW.
2. Implement the RW recover/retrieval stored at Sewaqa historical site and transport them to the CSF at JAEC for conditioning and long-term storage.
3. Continue, in cooperation with the IAEA, efforts to enable repatriation of DSRSs of category 1-2 to the country of origin.
4. Complete the national strategy for the RW and SNF management (including those from the JRTR and future NPPs).
5. Build up the capacity and capabilities of the national RWM organization and strengthening the resources for safe and effective management of RW and SNF.
6. Seek regional solutions for RW and SNF management, including potential for shared regional deep repository site.
7. Establish strong cooperation with international community in the field of RW and SNF management.

K.2 Energy and Minerals Regulatory Commission (EMRC)

1. Continue with developing national legislation striving towards safe and efficient management of RW and SNF in Jordan.
2. Continue work on licensing the removal of the DSRSs stored at the Sewaqa site.
3. Continue work on achieving the commitment to the international conventions and treaties related to nuclear application, such as:
    a. Treaty on the Non-Proliferation of Nuclear Weapons.
    b. The Convention on Nuclear Safeguards and Additional Protocol.
    c. The Convention on Nuclear Safety.
    d. The Convention on Physical Protection of Nuclear Material.
    e. The Convention on Civil Liability for Nuclear Damages.
    f. The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

L. REFERENCES

1. National Policy for Radioactive Waste & Spent Nuclear Fuel Management, 2015, Rev. 1
2. Law of Radiation Protection, & Nuclear Safety & Security No. (43), 2007
3. Law of Energy and Minerals Regulatory Commission No. (8), 2017
4. Regulation of Radiation Protection No. (108) and its Instructions, 2015
5. Regulation of Safe Use of Nuclear Energy No. (43) and its Instructions, 2014
6. Instructions of Environmental Impact Assessment No. (37), 2015
7. Regulations on the Transport of Radioactive Materials, No. (32) and its Instructions, 2016
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9. Instructions on the Management of Radioactive Waste, 2015
10. Instructions on the Management of Spent Nuclear Fuel, 2015
11. Instructions on the Decommissioning of Nuclear Facilities, 2015
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13. Instructions on the Criteria for Exemption of the Radiation Practices and Radiation Sources and Clearance of the Radiation Sources from the Regulatory Control.
14. The Safety Case for the Management of the Disused Sealed Radioactive Sources (DSRS) at the Central Storage Facility (CSF) at JAEC, CSF-PRT-002/ NFC-TR-2016-257