October 2017

United States of America

Sixth National Report

for the

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

U.S. Department of Energy

In Cooperation with the
U.S. Nuclear Regulatory Commission
U.S. Environmental Protection Agency
U.S. Department of State

This page intentionally left blank.

ABSTRACT AND ACKNOWLEDGEMENT

The United States of America (U.S.) ratified the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention) on April 9, 2003. The Joint Convention establishes an international peer review process among Contracting Parties and provides incentives for nations to take appropriate steps to bring their spent fuel and radioactive waste management activities into compliance with general safety standards and practices. The U.S. participated in Review Meetings of the Contracting Parties to the Joint Convention in November 2003, May 2006, May 2009, May 2012 and May 2015 in Vienna, Austria. This Sixth National Report, an update of the U.S. Fifth National Report prepared under the Joint Convention in September 2014, documents spent fuel and radioactive waste management safety in the U.S. under the terms of the Joint Convention. The U.S. Government prepared this report for review by the Contracting Parties.

The U.S. complies with the terms of the Joint Convention. An extensive U.S. legal and regulatory structure ensures the safety of spent fuel and radioactive waste management. This report describes radioactive waste management in the U.S. in both the commercial and government sectors, and provides annexes with information on spent fuel and waste management facilities, inventories, and ongoing decommissioning projects. It also provides detailed information on spent fuel and radioactive waste management safety, as well as transboundary movements (imports/exports) and disused sealed sources, as required by the Joint Convention.

The Department of Energy acknowledges the support and cooperation of the Environmental Protection Agency, Nuclear Regulatory Commission, and Department of State in preparation of this report through the Joint Convention Interagency Executive Steering Committee and Working Group. The information in this report was extracted from publicly available information sources, including regulations and internet web sites of these agencies.

Copies of this report are available from:

Mr. Douglas Tonkay
Director, Office of Waste Disposal
U.S. Department of Energy
Mailstop: EM-4.22/270 Corporate Center
1000 Independence Avenue, SW
Washington, DC 20585
Email: douglas.tonkay@em.doe.gov

TABLE OF CONTENTS

LIST OF TABLES, FIGURES, AND ANNEXES

A. INTRODUCTION

This United States of America (U.S.) Sixth National Report updates the Fifth National Report published in September 2014, under the terms of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management[1] (Joint Convention). This report reflects developments in the U.S. through June 2017.

A.1. Purpose and Structure

This report satisfies the requirements of the Joint Convention for reporting on the status of safety at spent fuel and radioactive waste management facilities within the U.S.[2]

This Department of Energy (DOE) report was prepared by a working group composed of staff from DOE, the Department of State, Environmental Protection Agency (EPA), and Nuclear Regulatory Commission (NRC).

The report format and content follow guidelines as agreed by the Contracting Parties to the Joint Convention. Sections and annexes (or appendices) in this report have the same titles as in these guidelines, facilitating review by other Contracting Parties. Table A-1 provides a cross-reference between the sections in this report and the specific reporting provisions in the Joint

Table A-1. Joint Convention Reporting Provisions

National Report Section	Joint Convention Section
A. Introduction	
B. Policies and Practices	Article 32, Paragraph 1
C. Scope of Application	Article 3
D. Inventories and Lists	Article 32, Paragraph 2
E. Legislative and Regulatory Systems	Article 18; Article 19; and Article 20
F. Other General Safety Provisions	Articles 4-9; Articles 11-16; Articles 21-26
G. Safety of Spent Fuel Management	Articles 4-10
H. Safety of Radioactive Waste Management	Articles 11-17
I. Transboundary Movement	Article 27
J. Disused Sealed Sources	Article 28
K. General Efforts to Improve Safety	Multiple Articles
L. Annexes	Multiple Articles

[1] International Atomic Energy Agency, *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, INFCIRC/546, December 24, 1997.

[2] The U.S. ratified the Joint Convention on April 9, 2003.

Convention. Section A.3 and Section K provide a concise summary of important changes since the U.S. Fifth National Report.

Information in this report is derived from publicly available information sources. See the internet web sites listed in Table A-2 for more detailed information. The internet references provided in this report were available to the public and are accurate as of June 2017. These uniform resource locators (URLs) may change over time or may no longer be active.

Table A-2. Key Sources of Information Available on the Internet

Code of Federal Regulations
Access to all regulations: https://www.gpo.gov/fdsys/browse/collectionCfr.action?collectionCode=CFR
Energy, Title 10: (Includes DOE and NRC regulations): https://www.gpo.gov/fdsys/pkg/CFR-2016-title10-vol1/pdf/CFR-2016-title10-vol1.pdf https://www.gpo.gov/fdsys/pkg/CFR-2016-title10-vol2/pdf/CFR-2016-title10-vol2.pdf https://www.gpo.gov/fdsys/pkg/CFR-2016-title10-vol3/pdf/CFR-2016-title10-vol3.pdf https://www.gpo.gov/fdsys/pkg/CFR-2016-title10-vol4/pdf/CFR-2016-title10-vol4.pdf
Protection of the Environment, Title 40: https://www.gpo.gov/fdsys/pkg/CFR-2016-title40-vol2/pdf/CFR-2016-title40-vol2-chapI.pdf https://www.gpo.gov/fdsys/pkg/CFR-2016-title40-vol7/pdf/CFR-2016-title40-vol7-chapI.pdf https://www.gpo.gov/fdsys/pkg/CFR-2016-title40-vol30/pdf/CFR-2016-title40-vol30-chapI.pdf https://www.gpo.gov/fdsys/pkg/CFR-2016-title40-vol34/pdf/CFR-2016-title40-vol34-chapI.pdf https://www.gpo.gov/fdsys/pkg/CFR-2016-title40-vol36/pdf/CFR-2016-title40-vol36-chapI.pdf
U.S. Department of Energy
Homepage: https://www.energy.gov
Office of Environment, Health, Safety and Security: https://energy.gov/ehss/environment-health-safety-security
Office of Environmental Management: https://energy.gov/em/office-environmental-management
Office of Nuclear Energy: https://www.energy.gov/ne/office-nuclear-energy
Office of Legacy Management: https://energy.gov/lm/office-legacy-management
Energy Information Administration: https://www.eia.gov/nuclear/
National Nuclear Security Administration: https://nnsa.energy.gov/
Orders and directives: https://www.directives.doe.gov
Waste Isolation Pilot Plant: http://www.wipp.energy.gov/
Off-Site Source Recovery Project: http://osrp.lanl.gov
U.S. Nuclear Regulatory Commission
Homepage: https://www.nrc.gov/

Table A-2. Key Sources of Information Available on the Internet
Regulations: https://www.nrc.gov/reading-rm/doc-collections/cfr/
Regulatory guides: https://www.nrc.gov/reading-rm/doc-collections/reg-guides/
Statutes and legislation: https://www.nrc.gov/about-nrc/governing-laws.html
Radioactive waste: https://www.nrc.gov/waste.html
Nuclear materials: https://www.nrc.gov/materials.html
Nuclear decommissioning (reactor and materials): https://www.nrc.gov/waste/decommissioning.html
Sealed sources and devices: http://www.nrc.gov/materials/miau/sealed-source.html
Spent fuel storage: https://www.nrc.gov/waste/spent-fuel-storage.html
NARM toolbox: https://scp.nrc.gov/narmtoolbox.html
Radium: https://www.nrc.gov/materials/radium.html
High-level waste: https://www.nrc.gov/waste/high-level-waste.html
Emergency preparedness and response: https://www.nrc.gov/about-nrc/emerg-preparedness.html
Export/import: https://www.nrc.gov/about-nrc/ip/export-import.html
Japan Lessons Learned: https://www.nrc.gov/reactors/operating/ops-experience/japan-dashboard.html
U.S. Environmental Protection Agency
Homepage: https://www.epa.gov/
Laws and Regulations: https://www.epa.gov/laws-regulations/regulations
Office of Air and Radiation: https://www.epa.gov/aboutepa/about-office-air-and-radiation-oar
Office of Resource Conservation and Recovery: https://www.epa.gov/aboutepa/about-office-land-and-emergency-management
Radiation Program: https://www.epa.gov/radiation/
Waste Isolation Pilot Plant oversight: https://www.epa.gov/radiation/epas-role-waste-isolation-pilot-plant-wipp
Environmental monitoring related to Fukushima accident: https://www.epa.gov/radnet/2011-japanese-nuclear-incident
Other
U.S. Department of State: Bureau of International Security and Nonproliferation (ISN): https://www.state.gov/t/isn
U.S. Defense Nuclear Facilities Safety Board: https://www.dnfsb.gov/
National Academies: http://www.nationalacademies.org/
National Council on Radiation Protection and Measurements: http://www.ncrponline.org/
U.S. Nuclear Waste Technical Review Board (NWTRB): http://www.nwtrb.gov/

Table A-2. Key Sources of Information Available on the Internet
Conference of Radiation Control Program Directors, Inc.: http://www.crcpd.org/
U.S. Customs and Border Protection: https://www.cbp.gov/
U.S. Customs and Border Protection - International Initiatives: https://www.cbp.gov/border-security/international-initiatives
U.S. Department of Homeland Security: https://www.dhs.gov/
U.S. Public Health Service: https://www.usphs.gov/
U.S. Army Corps of Engineers Formerly Utilized Sites Remedial Action Program: http://www.usace.army.mil/Media/FactSheets/FactSheetArticleView/tabid/219/Article/816/formerly-utilized-sites-remedial-action-program.aspx
Organization of Agreement States: http://agreementstates.org/
Interagency Steering Committee on Radiation Standards (ISCORS): http://www.iscors.org/
Radiation Source Protection and Security Task Force Report: https://www.nrc.gov/security/byproduct/task-force.html

A.2. Generic Issues Identified in the Fifth Review Meeting Summary Report

The following four issues were identified for all Contracting Parties to address in their Sixth National Report:

- Staffing, staff development, reliability of funding, and other human resource areas;
- Maintaining or increasing public involvement and engagement on waste management, to provide public confidence and acceptance;
- Developing and implementing a holistic and sustainable management strategy for radioactive waste and spent fuel at an early stage; and
- Management of disused sealed sources.

A.2.1. Staffing, Staff Development, Reliability of Funding, and Other Human Resources Areas

The U.S. understands the need to retain institutional knowledge and operational experience in fields impacting spent fuel and radioactive waste management. Workforce retention and succession plans are used to maintain core competencies. With numerous options for obtaining advanced levels of education, the U.S. provides development and training opportunities for government staff who support spent fuel and radioactive waste management activities. The U.S. uses centralized knowledge management and informational tools to support technical training and educational opportunities. Section F.2 provides information about funding for human resources and specific information on education, recruitment, training, and development within the U.S.

A.2.2. Maintaining or Increasing Public Involvement and Engagement on Waste Management, to Provide Public Confidence and Acceptance

The U.S. has an extensive statutory and regulatory system to ensure that the public and other affected stakeholders are fully informed of and have the opportunity to comment on proposed actions related to spent fuel and radioactive waste management. In addition, Federal and state agencies with responsibilities in these areas make additional efforts to raise awareness through public meetings, web sites, distribution lists, and written materials. Key activities of this nature since the U.S. Fifth National Report include DOE's "town hall" meetings related to the Waste Isolation Pilot Plant (WIPP) incidents and recovery, and NRC's public meetings related to supplementing the environmental impact statement (EIS) that DOE prepared on the proposed geological repository at Yucca Mountain. Section K.1.4 of this report provides more information on public information efforts related to the WIPP incidents. Section F.6.1.1 discusses public involvement related to decommissioning, Section F.7.8 discusses public and stakeholder involvement with respect to general safety.

A.2.3. Developing and Implementing a Holistic and Sustainable Management Strategy for Radioactive Waste and Spent Fuel at an Early Stage

The U.S. has decades of experience in managing radioactive waste and spent fuel and understands the importance of early and sustainable management strategies. The U.S. develops strategies for radioactive waste and spent fuel management at an early stage before the physical construction of a nuclear facility. For example, a license application for a nuclear reactor must address storage of spent fuel at reactor (see Section B.3.3 for additional information). In addition, the U.S. has a policy in place to minimize the generation of waste that does not have a known disposal path. When developing a radioactive waste and spent fuel strategy, the U.S. considers several factors including: safety; environmental protection; emergency preparedness; justification of facility need; cost; and schedule.

A.2.4. Management of Disused Sealed Sources

The U.S. has a mature, integrated and well-established regulatory framework for sealed source management. In the legislative or regulatory framework, disused sources are not distinguished from sources in use. The U.S. allows for manufacturers and distributors of sealed sources to accept return of disused sealed sources from their customers as they determine appropriate. Disused sealed sources that remain with the owner of record are required to be stored safely and securely. Within the U.S., the management may include reuse, recycling, disposal, or storage for any sources that do not have a disposition path. Section J of this report provides an overview of the programs in place to manage such sources domestically and internationally. Section A.3.4.2 discusses activities related to financial assurance for sealed sources.

A.3. What is New Since Last Report

The following sections summarize progress made in several important areas since the previous report.

A.3.1. Spent Fuel and HLW Disposition

A.3.1.1 Yucca Mountain Repository

See the U.S. Fourth and Fifth National Reports for background and history on the Yucca Mountain program and the license application for a repository.

In August 2013, the U.S. Court of Appeals for the District of Columbia Circuit ordered NRC to continue with the licensing process for DOE's Yucca Mountain construction authorization application, until Congress directs otherwise or there are no appropriated funds remaining. After the court's decision, NRC completed the Safety Evaluation Report (SER). In addition, NRC staff developed a supplement to DOE's EIS to address groundwater impacts previously identified by NRC staff as requiring additional analysis.

In January 2015, in its SER, NRC staff found that DOE's license application met the regulatory requirements for the proposed repository, with two exceptions: DOE had not obtained certain land withdrawal and water rights necessary for construction and operation of the repository.

The fiscal year 2018 Budget Request for DOE includes $120 million to accelerate progress on fulfilling the Federal Government's obligations to address nuclear waste by requesting funding of licensing activities for the Yucca Mountain nuclear waste repository and to establish a robust interim storage program to develop a capability for earlier acceptance of spent fuel. The Budget Request for NRC includes $30 million for Yucca Mountain licensing activities.

A.3.1.2 DOE Research and Development Activities for Spent Fuel and HLW

The objectives of the U.S. R&D program are to develop and initiate activities to improve the overall integration of storage as a planned part of the waste management system, and develop information, resources, and capabilities to assist future disposal implementation decisions and actions. DOE is performing R&D regarding the long-term management of spent fuel to ensure any potential concerns are identified and addressed before safety is compromised.

The principal focus of DOE's R&D activities is to develop a suite of options that will enable future decision makers to make informed choices about how to safely manage the spent fuel from nuclear reactors. An additional objective is to demonstrate technologies to allow commercial deployment of solutions for spent fuel management that are safe, economic, and secure.

A sound technical basis for evaluating multiple viable disposal options will increase confidence in the robustness of generic disposal concepts and support development of the science and engineering tools needed to support disposal concept implementation. Significant testing, modeling, and demonstration activities will be conducted to enhance and confirm the technical basis for safe storage and disposal of spent fuel, particularly as spent fuel discharge burn-up is increased and as storage times extend beyond what was originally intended.

Other R&D focuses on identifying multiple viable geologic disposal options and concepts in various host media (e.g., mined repositories in salt, clay/shale, and granitic rocks). R&D will transition to site-specific challenges as national policy advances. R&D goals at this stage are to identify generic issues that may need to be addressed in site-specific investigations to increase confidence in the robustness of a site-specific disposal concept.

DOE is actively involved in international and bilateral R&D activities, in order to provide the U.S. with an understanding of the fuel cycle activities of other countries. This involvement allows the participants to leverage their expertise and gain cost benefits in conducting technical assessments for different geologic media and waste forms. The U.S. will also collaborate with other countries to conduct joint experiments or data exchanges associated with underground research laboratories. Active collaboration with international programs, initiatives, or projects is beneficial to the U.S. disposal research program, providing access to decades of experience gained in various disposal environments. See Section K.1.2.

As part of this international coordination, the Extended Storage Collaboration Program (ESCP) is a consortium of organizations coordinated by the Electric Power Research Institute (EPRI) to investigate aging effects and mitigation options for the extended storage of spent fuel, followed by transportation. In December 2015, EPRI convened a workshop of over 40 representatives from the nuclear industry, Federal Government, regulatory agencies, national laboratories, and suppliers and international organizations associated with spent fuel dry storage systems. The topic of discussion was identification of potential concerns associated with extended dry storage of spent fuel, i.e., storage for periods that involve multiple renewals for term periods in current NRC regulations.

ESCP meets twice a year to: review and develop consensus on specific data that is needed to enhance and confirm the safety of spent fuel storage; present the work of individual organizations that have common interest to the group; and discuss future efforts. DOE is active in this program, and uses it as an effective way to collaborate with industry, regulators, and international organizations dealing with similar topics to enhance the technical basis for extended storage and subsequent transportation of spent fuel.

A.3.1.3 Continued Storage of Spent Fuel at Reactors

On September 13, 2013, NRC proposed revising its generic determination on the environmental impacts of the continued storage of spent fuel.[3] On September 19, 2014, NRC published an announcement of the final rule and the completion of the final generic EIS in the *Federal Register*.[4] The generic EIS is published as NUREG-2157, *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel*. This rule is referred to as "Continued Storage of Spent Nuclear Fuel," which was previously referred to as "Waste Confidence Rule."

Continued Storage of Spent Nuclear Fuel adopts the findings of the generic EIS regarding the environmental impacts of storing spent fuel at any reactor site after the reactor's licensed period of operations. The generic EIS analyzes the environmental impact of storing spent fuel beyond the licensed operating life of reactors over three timeframes: for 60 years (short term), 100 years after the short-term scenario (long-term) and indefinitely. See Section B.3.3 for additional information.

A.3.1.4 Consolidated Interim Storage of Spent Fuel and Reactor-Related GTCC LLW

On April 28, 2016, NRC received an application from Waste Control Specialists LLC (WCS), to construct and operate a consolidated interim storage facility for the storage of spent fuel and reactor-related greater-than-Class C (GTCC) low-level waste (LLW) at its site in Andrews,

[3] See *Waste Confidence – Continued Storage of Spent Nuclear Fuel, Proposed Rule*, 78 FR 56776 (September 13, 2013).
[4] See *Continued Storage of Spent Nuclear Fuel*, *Final Rule*, 79 FR 56238 (September 19, 2014).

Texas. NRC issued a notice of its intent to prepare the EIS and requested comments on the scope of its environmental review. NRC also held public meetings on the scope of the environmental review.

In addition, on January 26, 2017, NRC issued a letter to WCS accepting the application for technical review. NRC also issued a notice of docketing of the application and informed the public of the opportunity to file a written request for a hearing. On March 16, 2017, WCS submitted a consolidated revision of its original application and supplements. NRC started its technical and environmental review of the license application. On April 18, 2017, WCS requested that NRC temporarily suspend all safety and environmental reviews, as well as public participation activities associated with the license application, until the completion of the sale of WCS to Energy*Solutions.*

On November 16, 2016, Department of Justice filed a civil antitrust lawsuit seeking to block Energy*Solutions*' acquisition of WCS.[5] On June 21, 2017, the United States District Court for the District of Delaware issued a Judgment and Order in a civil antitrust lawsuit blocking the proposed $367 million acquisition of WCS by Energy*Solutions.*

By letter dated March 30, 2017, Holtec International submitted an application for a site-specific independent spent fuel storage installation license to construct and operate the HI-STORE Consolidated Interim Storage Facility, to be located in Lea County, New Mexico. Holtec's license application seeks authorization to store up to 5000 metric tons uranium of commercial spent fuel in the HI-STORM UMAX Canister Storage System. NRC is reviewing the application to determine whether it contains sufficient information to perform a technical and environmental review.

A.3.1.5 Processing of Department of Energy's Aluminum-Clad Spent Fuel Inventory

The amended decision based on the *Supplement Analysis for the Savannah River Site Spent Nuclear Fuel Management* (DOE/EIS-0279-SA-01 and DOE/EIS-0218-SA-06, March 2013) authorizes processing of approximately 1000 bundles of aluminum-clad spent fuel; 200 cores from the High Flux Isotope Reactor at Oak Ridge National Laboratory; and target residue materials containing highly-enriched uranium (HEU) (including target residue materials containing liquid HEU from Canada).

A.3.2. Commercial LLW Disposal

The following are some issues government, industry, and others are addressing:

A.3.2.1 Concentration Averaging

NRC regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 61 provide requirements for land disposal of radioactive waste and allow for concentration averaging of waste. The term, "concentration averaging," means averaging of the radionuclide activities in waste over its volume or over its mass. The regulations in 10 CFR 61.55(a)(8) allow averaging radionuclide concentrations in waste in determining waste classification. The regulations in 10

[5] See https://www.justice.gov/opa/pr/justice-department-sues-block-energysolutions-acquisition-waste-control-specialists.

CFR Part 61 do not provide specific limitations on concentration averaging. NRC developed guidance in the Concentration Averaging and Encapsulation Branch Technical Position (CA BTP) Vols. 1 and 2, which was recently updated.[6] The CA BTP provides guidance on appropriate volumes and masses to use in calculating average concentrations.

In addition to using mathematical averaging, licensees may physically mix some types of LLW. This type of physical mixing is referred to as "blending." For example, licensees may mix higher activity LLW (Class B and C concentrations) with lower activity waste (Class A) to form a Class A mixture, meeting waste acceptance criteria (WAC) of a commercial facility accepting Class A waste (see Section B.2.3.2 on classification of LLW in the commercial sector). The approach involves mixing materials such as ion exchange resins that have different radionuclide concentrations at the point of origin (or a commercial LLW processing facility), resulting in an essentially homogeneous mixture; the average concentration of the final mixture is used for waste classification purposes. The CA BTP provides guidance on blending and how to demonstrate that waste is adequately blended. The CA BTP also recommends constraints for discrete items based on their size and the amount or concentration of radioactivity they contain. The size, amount of radioactivity, and/or concentration helps define the hazard to an inadvertent intruder who might directly handle the discrete item.

A.3.2.2 Depleted Uranium Disposal

Depleted uranium (DU) is a source material as defined by the Atomic Energy Act of 1954, as amended (AEA), and, when declared a waste, would be considered LLW.

One of NRC's responsibilities is to ensure safe disposal of commercially generated LLW. When NRC regulations (10 CFR Part 61) on LLW disposal were developed, there were no commercial facilities generating significant quantities of DU waste. Consequently, the impacts from the disposal of large amounts of DU were not considered in the development of 10 CFR Part 61. DU is Class A LLW under 10 CFR 61.55(a)(6). NRC issued licenses for four commercial uranium enrichment facilities (although only one facility is currently operating). These facilities could generate quantities of DU significantly larger than considered during the development of 10 CFR Part 61.

To address this issue, NRC is proposing revisions to 10 CFR Part 61. The proposed rule was published on March 26, 2015.[7] The rule, if approved, would specify the requirements for an acceptable site-specific performance assessment (PA). NRC is also proposing guidance with the rule that, when combined with existing guidance, would provide acceptable methods for demonstrating that the PA requirements in the revised rule are met. Under the revised provisions, a disposal facility licensee, with NRC or NRC Agreement State approval, could develop site-specific WAC from the results of the site-specific PA. AEA provides a statutory basis under which NRC discontinues and the State (i.e., Agreement State) assumes portions of its regulatory authority. See Section K.1.3 for additional information.

In addition, DOE has a DU inventory and operates facilities to convert DU to a DU oxide conversion product for disposal. DOE's recent efforts on disposition of DU oxide includes the

[6] The updated guidance is available at NRC's Agencywide Documents Access and Management System (ADAMS), under ML12254B065 and ML12326A611, respectively.
[7] See *Low-Level Radioactive Waste Disposal, Proposed Rule*, 80 FR 16082 (March 26, 2015).

August 2016 (with a correction in September 2016) Notice of Intent to prepare a Supplemental EIS to propose disposition alternatives for DU oxide conversion product from its depleted uranium hexafluoride conversion facilities at the Paducah, Kentucky and Portsmouth, Ohio, sites.[8] The proposed scope of the draft Supplemental EIS includes an analysis of three proposed disposal locations: the DOE-owned LLW disposal facility at the Nevada National Security Site in Nye County, Nevada; the Energy*Solutions* LLW disposal facility in Clive, Utah; and the WCS LLW disposal facility in Andrews, Texas.

A.3.2.3 VLLW Scoping Study

NRC is conducting a scoping study to address Very Low-Level Waste (VLLW) Management (see Section H.3.1). The purpose of the scoping study is to identify the actions that NRC should take to strengthen its regulatory framework for VLLW (also known as "low-activity waste"). 10 CFR Part 61 classifies LLW in the commercial sector as Class A, Class B, and Class C (see Section B.2.3.2).

The lowest portion of Class A waste has been referred to as VLLW. In general, VLLW contains some residual radioactivity, including naturally occurring radionuclides, which may be safely disposed of in hazardous waste or municipal solid waste landfills. Such waste possesses a small fraction of the hazard of waste at the Class A limits in 10 CFR Part 61. Current disposal options for VLLW are at a 10 CFR Part 61 disposal facility or alternate disposal facility that complies with the process outlined in 10 CFR 20.2002, *Method for obtaining approval of proposed disposal procedures,* and 10 CFR 20.2003, *Disposal by release into sanitary sewerage*.

The regulatory focus of the scoping study is to develop a framework for accommodating the large volumes of VLLW associated with decommissioning of nuclear power plants (NPPs). The scoping study will also consider the impact of large quantities of VLLW that would result from cleanup if a radiological dispersal device or similar device were used in the U.S. In February 2017, NRC held a public meeting to receive initial stakeholder comments. NRC plans to hold additional public meetings to obtain stakeholder comments on the VLLW scoping study.[9]

A.3.3. Federal LLW Disposal

Currently, six DOE sites are operating LLW disposal facilities: the Hanford site, the Idaho National Laboratory, the Nevada National Security Site, the Los Alamos National Laboratory, the Oak Ridge Reservation, and the Savannah River Site. Also, the Portsmouth site is in the process of constructing a disposal facility. The record of decision for site-wide waste disposition at Portsmouth was approved in 2015.[10] Oak Ridge is designing another LLW disposal facility because the current one is nearing capacity.

[8] See *Notice of Intent To Prepare a Supplemental Environmental Impact Statement for Disposition of Depleted Uranium Oxide Conversion Product Generated From DOE's Inventory of Depleted Uranium Hexafluoride; Correction*, 81 FR 61674 (September 7, 2016).
[9] Additional information is available at: https://www.nrc.gov/waste/llw-disposal/very-llw.html. The site will be updated with future outreach efforts.
[10] See https://energy.gov/pppo/downloads/portsmouth-waste-disposition-record-decision.

A.3.4. Sealed Source Disposition

A.3.4.1 Sealed Source Recovery

Since initiation of the Off-Site Source Recovery Program (OSRP), the DOE/National Nuclear Security Administration (NNSA) has recovered over 39000 sources consisting of over 4.49E+16 Bq of radioactive material that represented threats to national security and/or public health and safety. Additionally, DOE/NNSA has facilitated the recovery of 22000 sources consisting of over 9.21E+12 Bq of radioactive material by working with non-government partners. In total, DOE/NNSA in conjunction with non-government partners has recovered more than 61000 radioactive sealed sources from more than 1,300 sites in the U.S., and over 3000 U.S. origin legacy sources have been repatriated from 48 sites in 25 other countries.

Since September 2012, 139 recovery shipments of Category 1 and 2 sources have been made with 13 additional shipments scheduled by October 2017. In addition, DOE/NNSA continues to support states in a nationwide program to recover and commercially dispose disused sealed sources that are determined to be Class A, B, and C LLW.

DOE/NNSA also developed two new Type B container designs to support the government's efforts to recover and transport high-activity sealed sources. The container designs will be provided to qualified commercial entities interested in fabricating containers for commercial use. The 435-B container design was certified by NRC and the first two units were delivered in April 2017. The 380-B container design is currently under review by NRC, and the certification is anticipated by December 2017.

A.3.4.2 Financial Assurance for Disposition of Sealed Sources

NRC regulations in 10 CFR 30.35, *Financial Assurance and Recordkeeping for Decommissioning*, provide financial assurance requirements for licensees possessing byproduct material, including sealed sources with a half-life greater than 120 days and at activity levels above certain thresholds. However, the thresholds are such that many licensees possessing Category 1 and 2 byproduct material sealed sources are not required to provide financial assurance for disposition of these sources.

Financial assurance requirements can help ensure that licensees are prepared for the costs of end-of-life management, and may help facilitate timely disposition when sealed sources become disused or unwanted. In April 2016, NRC staff completed a review to determine whether additional financial assurance requirements for end-of-life management of certain radioactive byproduct material, particularly sealed sources, were needed. Based on the results of this review, which is documented in SECY-16-0046, *Radioactive Byproduct Material Financial Scoping Study*,[11] NRC is considering rulemaking to expand the financial assurance requirements in 10 CFR 30.35 to include a broader range of byproduct material sealed sources.

A.3.5. Nuclear Material Return to the U.S. and Russia

DOE/NNSA works in partnership with the International Atomic Energy Agency, the Russian Federation, and other nations to remove and protect vulnerable nuclear material located at civilian sites worldwide. Since the last report, all HEU has been removed from Argentina,

[11] The document is available at NRC's ADAMS, under ML16067A367.

Indonesia, Poland, Switzerland, and Uzbekistan. As a result, 31 countries plus Taiwan are considered HEU-free (defined as less than 1 kg remaining per country): Argentina, Austria, Brazil, Bulgaria, Chile, Colombia, Czech Republic, Denmark, Georgia, Greece, Hungary, Indonesia, Iraq, Latvia, Libya, Mexico, Philippines, Poland, Portugal, Romania, Serbia, Slovenia, South Korea, Spain, Sweden, Switzerland, Thailand, Turkey, Ukraine, Uzbekistan, and Vietnam.

A.3.6. Waste Disposition for Commercial Medical Isotope Production

DOE is working to accelerate the establishment of reliable commercial production of the medical isotope molybdenum-99 (^{99}Mo) in the U.S., without the use of HEU. DOE is supporting the U.S. private sector to accelerate independent, non-HEU-based technical pathways to produce ^{99}Mo in the U.S. in cooperation with commercial partners and the U.S. national laboratories. NRC or an Agreement State will be responsible for the licensing of any new medical isotope facility used for the production of ^{99}Mo.

The American Medical Isotopes Production Act of 2012 (AMIPA), enacted on January 2, 2013, directs DOE to establish a Uranium Lease and Take-Back (ULTB) Program to make low-enriched uranium (LEU) available through lease contracts for the production of ^{99}Mo for medical uses. AMIPA further specifies that DOE will retain responsibility for the final disposition of spent fuel created by the irradiation, processing or purification of the leased LEU. AMIPA also specifies DOE will take title to and be responsible for the final disposition of radioactive waste created by the irradiation, processing, or purification of the leased LEU for which DOE determines the producer does not have access to a disposal path. DOE established the ^{99}Mo ULTB Program in January 2016 in accordance with AMIPA and utilizes cost recovery principles, consistent with AMIPA. At the time this report was written, U.S. production of ^{99}Mo has not yet commenced.

On February 29, 2016, NRC issued a construction permit to SHINE Medical Technologies, Inc. for a medical radioisotope facility that will produce waste. In addition, in 2015, NRC received an application for a construction permit for a medical radioisotope facility from Northwest Medical Isotopes, LLC, which is undergoing review.

A.3.7. Decommissioning Activities

A.3.7.1 Potential Rulemaking on Regulatory Improvements for Nuclear Power Plants (NPPs) Transitioning to Decommissioning

In 2015, NRC initiated rulemaking with the objectives of providing a more efficient and predictable decommissioning transition process, as well as to address other issues deemed relevant by NRC staff or as directed by the Commission. For example, NRC staff is considering whether changes are needed regarding public and stakeholder involvement in the decommissioning process, the level of NRC review of the Post-Shutdown Decommissioning Activity Report (PSDAR), and the required timeframes. A number of U.S. NPPs announced the transition to a decommissioned status earlier than the expected end of operational life of the plant. On November 19, 2015, NRC published an advance notice of proposed rulemaking to obtain stakeholder feedback regarding the scope of the regulatory issues that are being considered for this potential rulemaking.[12] In response to several requests, NRC extended the

[12] See *Regulatory Improvements for Decommissioning Power Reactors*, 80 FR 72358 (November 19, 2015).

public comment period through March 18, 2016, and received 162 public comment submissions.[13]

On March 15, 2017, NRC published the draft regulatory basis for public comment.[14] NRC staff concluded that there is sufficient justification to proceed with rulemaking in areas including emergency preparedness, physical security, and decommissioning trust funds. NRC staff also concluded that regulatory activities other than rulemaking, such as guidance development, should be used to address the appropriate role of state and local governments in the decommissioning process, additional details that can be added to the PSDAR to address stakeholder comments on the level of NRC's review of the PSDAR, and additional detail on the rationale for the decommissioning method chosen by licensees.

In the *Federal Register* notice of the draft regulatory basis,[15] NRC included questions in certain areas that are being considered for inclusion in the rule. Some of the areas are site-specific cost estimates and primary liability insurance. NRC requested comments in all of the areas addressed in the *Federal Register* notice and draft regulatory basis during the public comment period. A total of 40 public comment submissions were received on the draft regulatory basis. After publishing its final regulatory basis, which is expected in late 2017, NRC staff will submit a proposed rule for Commission review and approval. Should the Commission decide to proceed with this rulemaking, NRC staff will provide the draft final rule to the Commission for approval in the fall of 2019.

A.3.7.2 Radium Contamination at Military Sites and Non-Military Sites

The Energy Policy Act of 2005 (EPAct05) provided NRC with regulatory authority over discrete sources of radium-226 (^{226}Ra) and accelerator-produced radioactive material used in commercial activities, including some military ^{226}Ra contamination. NRC has jurisdiction only over discrete sources of ^{226}Ra used by the military in medical or research activities or in a manner similar to a commercial activity. NRC does not have jurisdiction over ^{226}Ra used by the military in military operations. Department of Defense (DoD) is actively cleaning up radium contamination, contamination involving other unlicensed radioactive material, and non-radioactive contamination at several sites under the Comprehensive Environmental Response, Compensation, and Liability Act. To avoid overlapping regulatory oversight at these sites, in 2016 NRC entered into a Memorandum of Understanding[16] with DoD under which NRC will monitor the status of cleanup of these sites to ensure that these cleanup efforts also meet NRC's site release dose requirements.

NRC completed an effort to identify and prioritize non-military sites with potential ^{226}Ra contamination that may have resulted from historical manufacturing of consumer products. As a result of this effort, NRC identified 29 sites in non-Agreement States with potential contamination. NRC has also started initial site visits to confirm whether contamination is present at the identified sites and, if so, to work with site owners to address it. To date, all owners associated with the 29 sites have been contacted. See Section B.2.3.3.

[13] The comment submissions are available at NRC's ADAMS, under ML16229A277.
[14] The document is available at NRC's ADAMS, under ML17047A413.
[15] See *Regulatory Improvements for Decommissioning Power Reactors Transitioning to Decommissioning*, 82 FR 13778 (March 15, 2017).
[16] The document is available at NRC's ADAMS, under ML16092A294.

A.3.8. GTCC LLW Disposal

In February 2016, DOE issued the *Final Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste*.[17] The Final EIS contains an analysis of alternatives for the disposal of GTCC LLW generated by NRC or Agreement States licensees and for DOE owned or generated GTCC-like waste. The preferred alternative in the Final EIS is land disposal at generic commercial facilities and/or disposal at the WIPP geological repository (see Section D.2.2.1). The Final EIS does not constitute a decision on GTCC LLW disposal. As required by EPAct05, DOE will submit a report to the U.S. Congress and await Congressional action before making a final decision on disposal for GTCC LLW. The report to Congress is in progress.

On January 30, 2015, the Texas Commission on Environmental Quality sent a letter[18] to NRC with questions concerning its authority as an Agreement State to license a disposal cell for GTCC LLW, GTCC-like waste, and transuranic (TRU) waste. NRC staff analyzed the questions Texas posed and developed three options, outlined in SECY-15-0094.[19] On December 22, 2015, the Commission in SRM-SECY-15-0094[20] directed NRC staff to draft a response to the Texas inquiry; to prepare a regulatory basis for the disposal of GTCC LLW and TRU waste six months after the publication of the supplemental proposed 10 CFR Part 61 rule; to conduct a public workshop during the development of the regulatory basis to receive input from stakeholders; and to address TRU waste in 10 CFR Part 61.

A.3.9. Waste Isolation Pilot Plant Recovery Update

On January 4, 2017, WIPP completed the first waste emplacement since two events in February 2014 temporarily impacted the ability to dispose of defense-generated TRU wastes (i.e., TRU wastes generated by atomic energy defense activities) at WIPP. A fire occurred on February 5, 2014, when an underground vehicle used to transport salt caught fire. All personnel safely evacuated. A second incident occurred on February 14, 2014, when a continuous air monitor detected a radiological release underground. High efficiency particle air filters onsite immediately engaged and minimized releases to the environment. Radiological releases and resultant doses during the incident and its aftermath were well below safety limits or levels of health concern; sampling confirmed these findings. Some workers onsite on February 14 and February 15 were exposed to extremely low levels of americium and plutonium.

Both incidents were investigated thoroughly. An investigation team was deployed to determine the cause of the fire and released its findings on March 13, 2014.[21] Additional experts assessed the radiological incident. Phase I and Phase 2 of the report were released on April 24, 2014, and April 16, 2015, respectively.[22] The report identified the cause of the release as an exothermic reaction of incompatible materials resulting in over-pressurization and breach of the waste container, releasing a portion of the container's contents into the WIPP underground mine

[17] See http://www.gtcceis.anl.gov/documents/index.cfm.
[18] The document is available at NRC's ADAMS, under ML15034A181.
[19] The document is available at NRC's ADAMS, under ML15162A849.
[20] The document is available at NRC's ADAMS, under ML15356A623.
[21] The report is available at https://energy.gov/em/downloads/accident-investigation-report.
[22] http://www.wipp.energy.gov/pr/2014/Radiological_Event_Report.pdf. The results of that investigation were released in April 2014 (Phase I, http://www.wipp.energy.gov/pr/2014/Radiological_Event_Report.pdf) and April 2015 (Phase II, https://energy.gov/em/downloads/accident-investigation-report-radiological-release).

and subsequently to the environment. The investigation reports also identified several weaknesses in the safety basis and safety management programs at WIPP.

Improvements in the management of TRU waste programs have been made, and are ongoing, in order to prevent a reoccurrence of a radiological event at WIPP. DOE has reestablished the safety management programs and updated the documented safety analysis.[23] Updated WIPP Waste Acceptance Criteria[24] require more detailed documentation on the source of, and the types of materials in, the waste; an expanded review of procedures (and control of any changes); more thorough chemical compatibility evaluations of TRU waste destined for WIPP; and on-site reviews of waste generator activities. WIPP has implemented procedures and training to enhance emergency management practices and to protect workers and the public from any potential events in the future.

A.3.10. U.S. Review Matrix

During the review meeting, a summary matrix is prepared for each Contracting Party by the country group rapporteur. To provide continuity from the Fifth Review Meeting and facilitate review, the U.S. revised its rapporteur's matrix with citations to explanatory sections of the U.S. National Report. Table A-3 presents the revised matrix with an overview of the U.S. program.

[23] *The Waste Isolation Pilot Plant Documented Safety Analysis*, Rev. 5b was implemented on May 29, 2016. See http://www.wipp.energy.gov/Special/DSA_Rev_5_Chapters_0-18.pdf.
[24] DOE, *Transuranic Waste Acceptance Criteria for Waste Isolation Pilot Plant*, Rev. 8.0, July 2016. See http://www.wipp.energy.gov/library/wac/WAC.pdf.

Table A-3. Overview of U.S. Spent Fuel and Radioactive Waste Management[25]

Type of Liability	Long-term Management Policy	Funding of Liabilities	Current Practice/Facilities	Future Facilities
Spent fuel	Disposal in a geologic repository in compliance with the NWPA. See Sections A.2.3, A.3.1, B.3.1, B.3.2, B.3.3, G.1, G.3, G.7, K.1.	The Standard Contract between utilities and DOE for the disposal of spent fuel requires utilities to pay fees into the Nuclear Waste Fund sufficient to cover the costs associated with disposal activities for spent fuel. In compliance with a November 2013 court ruling, the fee was adjusted to zero and payment of fees by utilities were suspended in May 2014. See Section F.2.3.2.	Onsite and away from reactors wet and dry interim storage (commercial & government property). NRC completed a rulemaking on Continued Storage of Spent Fuel and prepared a supporting EIS; integrated spent fuel regulatory strategy. Acceptance of foreign research reactor fuel. See Sections B.3, C.1, D.1, G, Annex D-1.	A license application was filed by DOE with the Commission in 2008, but adjudicatory proceedings before NRC in which the application has been challenged have been suspended. Interim storage facility applications were received by NRC. See Sections A.3.1, A.3.1.4, B.3.1, B.3.2, B.3.3, D.1.2, G, K.1.
Nuclear fuel cycle wastes (all LLW included in Non-Nuclear fuel cycle wastes for brevity)	HLW: See above. Uranium & Thorium (U&Th) recovery sites: Near-surface disposal. See Sections B.3.1, B.4, E.2.2.4, K.1.	All: Producer pays. U&Th recovery sites: Long Term Surveillance Fund. Financial assurance required by license. See Section F.2.3.3.	HLW: Interim storage. U&Th recovery sites: Surface disposal locally. See Sections B.2.3.2, B.4, D.2.2.3, E.2.1.2, E.2.2.4, F.4.2.5, H.4, Annexes D-2A (HLW), D-3 (U&Th).	HLW: See above. U&Th recovery sites: additional license applications expected. See Sections B.3.1, B.4., D.2.2.3.

[25] Refer to LIST OF ACRONYMS AND ABBREVIATIONS at the end of the report.

Table A-3. Overview of U.S. Spent Fuel and Radioactive Waste Management[25]

Type of Liability	Long-term Management Policy	Funding of Liabilities	Current Practice/Facilities	Future Facilities
Non-Nuclear fuel cycle wastes	Defense HLW: See above. Defense TRU waste: disposal at WIPP. LLW: Near-surface disposal Class A, B and C; GTCC LLW disposal path to be determined. See Sections A.3.2, A.3.9, B.1., B.2.3.2, B.4, K.1, K.2.	All: Producer pays. Defense HLW and TRU waste: Public funds. LLW: Licensees required to demonstrate financial qualifications. See Section F.2.3.1.	Defense HLW: Interim storage. Defense TRU waste: Disposal at WIPP. LLW: 4 commercial sites plus multiple government (DOE) facilities. Storage of GTCC LLW pending disposal availability. See Sections B.2.3.2, B.4, D.2.1, D.2.2.1, D.2.2.2, E.2.1.3, H.1, H.2.5, K.2.1, Annexes D-2A and D-2B.	Defense HLW Disposal: See above. Additional Defense HLW Treatment Facilities. GTCC LLW final EIS completed; by law DOE to report to Congress and await Congressional action prior to implementation of a Record of Decision for GTCC LLW Disposal. See Sections A.3.8, D.2.1.
Decommissioning liabilities	NPPs: Decontamination & Decommissioning (D&D) to be completed within 60 years. Defense, U&Th recovery and other sites: Based on risk. See Sections B.5, D.3, E.2.1.4, F.6, F.7.2, H.3.2.	NPPs: D&D fund required by law. Non-legacy Sites: Producer pays. Defense sites: Public funds for defense liabilities. See Section F.2.3.4.	Large number of facilities undergoing decommissioning/ remediation. See Sections D.3, E.2.1.4, F.6, Annexes D-4, D-5, D-6.	Large number of facilities planned for decommissioning/ remediation. See Annexes D-4, D-5, and D-6.

Table A-3. Overview of U.S. Spent Fuel and Radioactive Waste Management[25]

Type of Liability	Long-term Management Policy	Funding of Liabilities	Current Practice/Facilities	Future Facilities
Disused Sealed Sources	Return to manufacturers and distributors. Disposal, reuse or recycle. See Sections A.3.4, B.1, J.	Licensee or government, if disposed by government in support of public health, safety or national security. See Section J.	Disposal at commercial disposal sites and government sites. Storage of sources onsite by licensees pending disposal. Off-site Source Recovery Project Source Collection and Threat Reduction Program. See Sections B.2.2, D.2.2, I.1, J.	GTCC LLW disposal EIS completed; by law DOE to report to Congress and await Congressional action prior to implementation. NRC is considering a rulemaking to expand financial assurance requirements for sealed sources. See Sections A.3.4.2, D.2.2.

B. POLICIES AND PRACTICES

This section summarizes United States of America (U.S.) policies and practices for spent fuel and radioactive waste management and related nuclear activities.

B.1. U.S. National Nuclear Activities Policy

The U.S. Government promotes the development of commercial nuclear power and nuclear technology for beneficial uses in medicine, industry, and research. The promotional and regulatory duties for commercial activities are assigned to different agencies.

Nuclear Regulatory Commission (NRC) is an independent agency authorized to regulate the commercial sector and certain government nuclear facilities, regulating the possession and use of nuclear materials, as well as the siting, construction, and operation of nuclear facilities. NRC performs its mission by issuing regulations, licensing commercial nuclear reactor construction and operation, licensing the possession of and use of nuclear materials and wastes, safeguarding nuclear materials and facilities from theft and radiological sabotage, inspecting nuclear facilities, and enforcing regulations. NRC regulates commercial nuclear fuel cycle materials and facilities and commercial sealed sources, including disused sealed sources. Three types of commercial nuclear materials are regulated: source material, special nuclear material, and byproduct material.[26]

NRC is also responsible for licensing commercial nuclear waste management facilities, independent spent fuel storage facilities, and disposal facilities for high-level waste (HLW) and spent fuel. Under the Atomic Energy Act of 1954, as amended (AEA), NRC can discontinue portions of its regulatory authority over certain types of radioactive material and allow individual states to assume this authority; this is known as the Agreement State Program. However, Agreement States cannot regulate storage or disposal of HLW (including spent fuel). See Section E.2.4.2 for further information.

Department of Energy (DOE) has responsibility for, among other matters, nuclear energy development and promotion, nuclear weapons programs, nuclear and radiological weapons nonproliferation, radioactive waste management, and environmental remediation of certain contaminated sites and surplus facilities. DOE has regulatory authority over its nuclear activities and facilities, and those operated or conducted on its behalf, except where NRC or Environmental Protection Agency (EPA) is specifically authorized by statute to regulate certain DOE facilities and activities.

Although NRC and DOE use different regulatory schemes for regulating the management of radioactive materials, the criteria for safe management are generally consistent.

EPA establishes generally applicable environmental standards to protect the environment from hazardous materials and certain radioactive materials. EPA has the authority to establish standards for remediating active and inactive uranium milling sites and other properties contaminated with radioactive materials from the milling sites, for the uranium fuel cycle, and for environmental radiation protection related to management and disposal of spent fuel, HLW, and transuranic (TRU) waste. EPA promulgates standards for and certifies compliance at the Waste Isolation Pilot Plant (WIPP) for disposal of defense-generated TRU waste. EPA standards,

[26] For definition, see https://www.nrc.gov/materials.html.

under the Clean Air Act, limit airborne emissions of radionuclides from DOE sites. Section E describes the regulatory roles of U.S. agencies for nuclear activities.

B.2. Government and Commercial Entities

B.2.1. Commercial Sector

Owners and operators of nuclear power plants (NPPs) and other types of facilities that generate radioactive waste manage their spent fuel and radioactive waste prior to disposal generally under their NRC operating license. The U.S. Federal Government or state governments (as Agreement States) regulate waste disposal sites. Government custody of radioactive waste and disposal facilities can occur at different stages of the waste management scheme depending on the type of radioactive waste and generating activity. Section F.7.3 addresses the interdependencies between the steps in spent fuel and radioactive waste management. See Sections G and H for additional information on commercial spent fuel and radioactive waste management, respectively. Decommissioning activities generate radioactive waste in both the commercial and government sectors. Section F.6 describes decommissioning activities.

B.2.2. Government Sector

DOE is responsible for and performs most of the spent fuel and radioactive waste management activities for government-owned and generated radioactive waste and materials, which are mostly located on government-owned sites. These activities include managing spent fuel from defense reactors, and the waste from reprocessing spent fuel from defense reactors as well as the spent fuel generated from a number of research and test reactors. DOE, under NRC licenses, also provides safe storage for spent fuel from the decommissioned Fort St. Vrain gas-cooled reactor and spent fuel from the Three Mile Island Unit 2 reactor damaged in a 1979 accident.

DOE has a system for managing government spent fuel and radioactive waste that includes numerous storage facilities and processing facilities (treatment and conditioning). For details on treatment and conditioning, see Section D.2.1. Operating disposal facilities for low-level waste (LLW) and TRU waste are further described in Section D.2.2 of this report. Other waste management treatment and disposal systems support cleanup and closure of facilities that no longer serve a DOE mission. See Section D for more information on spent fuel and radioactive waste facilities in the government sector.

The U.S. also continues activities to remove and/or secure high-risk nuclear and radiological materials both domestically and internationally. Part of this initiative is continuing the program of accepting U.S. origin foreign research reactor spent fuel back into the U.S. for safekeeping and also the recovery of disused sealed sources.

B.2.3. Spent Fuel and Radioactive Waste Classification

Regulations addressing various aspects of the generation and control of radioactive wastes and other nuclear activities are in the U.S. *Code of Federal Regulations* (CFR), specifically Title 10 (Energy) and Title 40 (Protection of the Environment) of the CFR. These regulations address the storage, treatment, possession, use and disposal of spent fuel and radioactive waste. Section E discusses various regulations. The following subsections describe classification of spent fuel and radioactive waste.

B.2.3.1 Spent Fuel

The U.S. defines “spent nuclear fuel” (spent fuel) as fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements that have not been separated by reprocessing. For purposes of this report, “spent nuclear fuel” is referred to as “spent fuel” in accordance with the Joint Convention terminology.

B.2.3.2 Radioactive Waste

Radioactive wastes in the U.S. have many designations depending on their hazards and the circumstances and processes creating them. NRC and Agreement States regulate most, but not all, sources of radioactivity, including LLW and HLW disposal, and residues from the milling of uranium and thorium.[27] Uranium mill tailings are tailings or wastes produced by extraction or concentration of uranium or thorium from any ore processed primarily for its source material content and are considered radioactive wastes. NRC and Agreement States, also have jurisdiction over certain categories of naturally occurring radioactive materials (NORM) and technologically enhanced NORM. Radioactivity in these wastes can range from just above background to very high levels. The day-to-day waste generated in applications such as medical laboratories and hospitals and research and industrial activities, is also designated as radioactive waste.

NRC regulations in 10 CFR Part 61, and compatible regulations adopted by Agreement States, classify LLW in the commercial sector as Class A, Class B, and Class C.[28] This classification is based on potential LLW hazards, and its associated disposal and waste form requirements. Class A LLW contains lower concentrations of radioactive material than Class B LLW, which has lower concentrations than Class C LLW. Table B-1 below, provides the commercial waste classes.

Table B-1. U.S. Commercial Radioactive Waste Classification

Waste Class	Description
HLW	The highly radioactive material resulting from the reprocessing of spent fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations, and other highly radioactive material that NRC determines by rule requires permanent isolation.
Class A LLW	Class A waste is determined by characteristics listed in 10 CFR 61.55(a)(2)(i) and physical form requirements in 10 CFR 61.56(a). (U.S. does not have a minimum threshold for Class A waste).
Class B LLW	Waste that must meet more rigorous requirements on waste form than Class A waste to ensure stability. The physical form and characteristics of Class B waste must meet both the minimum and stability requirements set forth in 10 CFR 61.56.

[27] Referred to in Section 11(e).2 of the AEA as byproduct material.

[28] This classification system is primarily based on protection of the inadvertent intruder. Waste that exceeds the specific activity of Class C LLW [referred to as greater-than-Class C (GTCC) LLW] is considered generally unacceptable for near-surface disposal unless a proposal for disposal in a 10 CFR Part 61 facility is approved by the Commission.

Table B-1. U.S. Commercial Radioactive Waste Classification	
Waste Class	**Description**
Class C LLW	Waste that not only must meet more rigorous requirements on waste form than Class B waste to ensure stability but also requires additional measures at the disposal facility to protect against inadvertent intrusion, such as engineered barriers or greater depth of burial. The physical form and characteristics of Class C waste must meet both the minimum and stability requirements set forth in 10 CFR 61.56.
GTCC LLW	LLW that exceeds Class C concentrations.
AEA Section 11e.(2) Byproduct Material	Tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Underground ore bodies depleted by such solution extraction operations do not constitute "byproduct material" within this definition.[29]

The AEA defines TRU waste as: "material contaminated with elements that have an atomic number greater than 92, including neptunium, plutonium, americium, and curium, and that are in concentrations greater than [370 Bq/g], or in such other concentrations as NRC may prescribe to protect the public health and safety." The AEA definition differs slightly from DOE's definition of TRU waste which is derived from the WIPP Land Withdrawal Act, as amended (WIPP LWA) states "waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years, except for: (A) high-level radioactive waste; (B) waste that the Secretary has determined, with the concurrence of the Administrator, does not need the degree of isolation required by the disposal regulations; or. (C) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with part 61 of title 10, Code of Federal Regulations." In NRC's regulations, at 10 CFR 61.2, the definition of LLW specifically excludes TRU waste.[30] However, in SRM-SECY-15-0094, the Commission directed NRC staff to undertake a rulemaking to address TRU waste in 10 CFR 61 (see Section A.3.8). NRC is in the process of revising its regulations in 10 CFR Part 61 to recognize current International Commission on Radiological Protection recommendations, to allow for site-specific analyses, and to accommodate disposal of previously unanticipated waste streams.

Radioactive waste owned or generated by DOE is classified as HLW, TRU waste, or LLW. In addition, DOE manages large quantities of uranium mill tailings and other residual radioactive material.[31] Waste may also contain a hazardous waste component subject to Resource Conservation and Recovery Act (RCRA). Waste with both a radioactive and hazardous component in the U.S. is called "mixed" waste (mixed LLW or mixed TRU waste). DOE also manages spent fuel, but, considers spent fuel to be nuclear material, and not a waste.

HLW results from reprocessing spent fuel. TRU waste typically consists of protective clothing,

[29] 10 CFR Part 40, *Domestic Licensing of Source Material* (Section 40.4).

[30] Although TRU is not included in the definition of LLW in 10 CFR 61.2, a limited set of TRU may be disposed of in a LLW facility pursuant to Table 1 in 10 CFR 61.55

[31] This residual radioactive material was the result of the Manhattan Project and the Nation's early atomic energy program and is managed under the Uranium Mill Tailings Radiation Control (UMTRCA) Title I. See Section D.2.2.3.

tools, glassware, equipment, soils, and sludge contaminated with man-made radioisotopes beyond or "heavier" than uranium on the periodic table of the elements (long-lived alpha-emitting waste with concentrations greater than 3700 Bq/g).[32]

B.2.3.3 Other Regulated Radioactive Materials

NRC regulates other radioactive materials, but does not designate them as waste in the context of the AEA. The definition of byproduct material was expanded by the Energy Policy Act of 2005 (EPAct05) to include discrete sources of radium-226 (^{226}Ra), accelerator-produced radioactive material, and certain NORM as described in 11e.(3)[33] and 11e.(4). These materials are not defined as LLW, and may be disposed of in accordance with any Federal or state solid or hazardous waste laws.

NRC has jurisdiction over discrete sources of ^{226}Ra used by the military in medical or research activities or in a manner similar to a commercial activity. NRC does not have jurisdiction over ^{226}Ra used by the military in activities that are part of the military's primary mission for national defense such as warfare, combat, battlefield missions, and training for such missions.

NRC and the Department of Defense entered into a Memorandum of Understanding (MOU) in 2016.[34] The MOU is intended to minimize the dual regulation of military environmental remediation sites under both the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (see Section D.3.4) and AEA, while ensuring protection of public health, safety, and the environment. When the military undertakes CERCLA response actions at sites where there is confirmed byproduct, source, or special nuclear material contamination, the MOU applies. The two levels of NRC involvement under the MOU are "stay informed" and "monitoring." NRC involvement does not involve licensing, and accordingly, NRC does not conduct licensing reviews. At sites under EPA's regulatory authority, e.g., sites listed on the National Priorities List (NPL), NRC stays informed of the radiological aspects of remediation activities, but relies on the CERCLA process and EPA's regulatory oversight for remediation. NRC monitors sites where EPA has no regulatory authority or oversight, e.g., sites not listed on the NPL, but that are remediated by the military under the Defense Environmental Restoration Program, 10 U.S.C. 2700 et seq., as amended. Site remediation under this statute follows the CERCLA remediation process.

NRC completed the identification and prioritization of non-military sites with potential radium contamination. In November 2016, NRC initiated visits to 29 sites with potential radium contamination. A site can consist of multiple property owners. From these 29 historic sites, there are 47 unique site owners. To date, 33 of the 47 site visits have been completed. Of the 33 sites visited, 14 sites have been identified with radium above background. NRC will be working with the site owners to ensure appropriate cleanup. The AEA provides for the transfer

[32] DOE considers LLW to be radioactive waste that is not spent fuel, HLW, TRU waste, or byproduct material as defined in Section 11e.(2),(3),or (4) of the AEA.
[33] The nomenclature 11e.(3) refers to the citation in the AEA; i.e. Section11; paragraph e; subparagraph (3).
[34] The document is available at NRC's Agencywide Documents Access and Management System (ADAMS), under ML16092A294.

of regulatory authority to individual states[35] to regulate these radioactive materials[36] under specific conditions (see Section E.2.4.2).

NRC excludes from the regulatory definition of radioactive waste any radioactive material of U.S. origin contained in a disused sealed source that is imported to be returned to a manufacturer, distributor or other entity authorized to receive and possess the disused sealed source. Such imports are therefore permitted to be made under general license. Non-U.S. origin disused sealed sources do fall within the regulatory definition of radioactive waste. Accordingly, import into the U.S. of foreign-origin disused sealed sources can only be accomplished by a specific license. See Section I for further information.

The Office of Surface Mining of the Department of Interior and the individual states regulate uranium ore mining. If there are elevated levels of diffuse radium or other NORM, then EPA and individual states have jurisdiction. Other extraction mining and refinement operations for metals, phosphates, etc., may concentrate naturally occurring radionuclides in these tailings materials. For example, NRC licenses some mineral extraction processes (e.g., rare earth processers) when the process results in the use, or concentration of material above 0.05 percent by weight of source material. Identified processors are required to obtain an NRC license. Additionally, although NRC does not regulate uranium ore mining, it does regulate the milling of uranium ore and the process of in-situ recovery (ISR) where uranium is extracted from ore underground before being brought to the surface.

B.3. Spent Fuel Management Policies and Practices

This subsection provides information on spent fuel storage and disposal practices in the U.S.

B.3.1. Spent Fuel Storage

The U.S. produces spent fuel in commercial NPPs and research reactors. Currently, 99 licensed NPPs provide about 20 percent of U.S. electricity. Information on U.S. NPPs is provided in the Convention on Nuclear Safety U.S. National Report.[37] All operating NPPs are storing spent fuel in NRC-licensed onsite spent fuel pools and over half are storing spent fuel in NRC-licensed independent spent fuel storage installations (ISFSIs) located onsite (see Annex D-1D).

Most NPPs that have been decommissioned or are undergoing decommissioning also have spent fuel stored onsite pending disposal. Most permanently-shutdown commercial NPPs currently have, or are planning to have, their spent fuel stored at onsite ISFSIs. NRC amended its regulations in 1990 to allow licensees to store spent fuel in NRC-certified dry storage casks at licensed power reactor sites, under either a site-specific license or a general license tied to the reactor license. In the most commonly used cask designs, spent fuel is loaded in canisters with inert gas and welded closed. The canisters are then placed in storage casks or vaults/bunkers. Some cask designs can be used for both storage and transportation. Sections D.1.1 and G provide additional information on spent fuel storage. Spent fuel is also stored at

[35] In this context, “states” within the U.S. are similar to provinces or departments indicating the next level of government below the Federal level. See Section 274b. of the AEA, Agreement with States.
[36] See NRC’s naturally-occurring and accelerator-produced radioactive materials toolbox at https://scp.nrc.gov/narmtoolbox.html.
[37] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1650.

several research reactor sites licensed by NRC.

NRC is considering technical issues related to the long-term management of spent fuel, and remains focused on its regulatory responsibilities for the safety and security for continued onsite storage of spent fuel. NRC's ongoing review of its spent fuel programs will help maintain the safety and security of continued interim storage of spent fuel. In the past 3 years, no new specific licenses for ISFSIs have been issued; however, there are three new general licensees authorized for storing spent fuel in dry casks at current or former NPP sites:

- Beaver Valley in March 2015
- Callaway in September 2015, and
- VC Summer in March 2016.

As of April 2017, two renewal applications for dry cask storage certificates of compliance are under review: Standardized NUHOMS® and VSC-24. At present, there are a total of 71 separate ISFSIs, including four that have both general and site-specific licenses. Thirty-four states have at least one ISFSI.

DOE manages spent fuel from defense activities and domestic and foreign research reactors, and limited quantities of spent fuel from commercial activities. Most of this spent fuel is stored at DOE's Savannah River Site (SRS), Hanford site, Idaho National Laboratory (INL), and Fort St. Vrain prior to further disposition. DOE continues to receive spent fuel from foreign and domestic research reactors. The program for receipt of foreign research reactor spent fuel is planned to be completed in 2019. No date has been set for completing receipt of spent fuel from domestic research reactors.

B.3.2. Spent Fuel Disposal

The Nuclear Waste Policy Act of 1982 (NWPA), as amended, establishes the Federal responsibility for the disposal of spent fuel and HLW. The NWPA assigns responsibilities for the disposal of spent fuel and HLW to three Federal agencies:

- DOE for developing permanent disposal capability for spent fuel and HLW;
- EPA for developing generally applicable environmental protection standards; and
- NRC for developing regulations to implement EPA standards, deciding whether or not to license construction, operation, decommissioning and closure of the repositories, and certifying packages used to transport spent fuel and HLW to the licensed repositories.

B.3.2.1 Current Status of Nuclear Waste Disposal

See Section A.3.1 for the current status of U.S. spent fuel and HLW disposition.

B.3.2.2 Current Status of the Yucca Mountain Application Review

The FY 2018 Budget Request includes $120 million for DOE and $30 million for NRC to restart NRC licensing activities for the Yucca Mountain nuclear waste repository.

NRC in July 2017, directed agency staff to spend previously appropriated Nuclear Waste Funds on information-gathering activities that would allow the Commission to make efficient, informed

decisions in support of executing any appropriated funds for the High-Level Waste Program. Activities to be undertaken include a virtual meeting of an advisory panel and initial steps to identify potential hearing sites.

In 2008, NRC determined that DOE's Environmental Impact Statement (EIS) for Yucca Mountain needed supplementation in limited areas. In February 2014, DOE advised NRC that it would not prepare a supplemental EIS, but would provide an updated version of a July 2009 technical report on potential post-closure groundwater impacts of a geologic repository in the vicinity of Yucca Mountain. The updated report provided NRC with technical information to prepare a supplement to the EIS. NRC published a supplement to DOE's EIS in May 2016, *Supplement to the Department of Energy's Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* that evaluates the potential environmental impacts on groundwater and potential impacts associated with the discharge of any contaminated groundwater to the ground surface due to potential releases from a geologic repository for spent fuel and HLW at Yucca Mountain.[38]

The Licensing Support Network (LSN)[39] was an electronic system established by NRC to provide access to documents relevant to NRC's Yucca Mountain licensing proceeding. However, the LSN ceased operation in 2011. Prior to the LSN shut down, parties to the adjudication provided copies of their LSN document collections to NRC. The LSN document collections from all parties have been preserved and are publicly accessible in NRC's ADAMS.

B.3.3. Continued Storage of Spent Fuel

In September 2014, NRC issued a revised rule at 10 CFR 51.23 and its associated NUREG-2157, *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel*, Vols. 1 and 2.[40] The revised rule adopts the generic impact determinations made in NUREG-2157 and codifies NRC's generic determinations regarding the environmental impacts of continued storage of spent fuel beyond a reactor's operating license. Additionally, NRC adopted the new name, "Continued Storage of Spent Nuclear Fuel." This name change reflects the fact that the analysis considers the storage of spent fuel under three separate scenarios: (1) the short-term timeframe considers 60 years beyond the reactor's license term (including two renewal terms); (2) the long-term timeframe considers an additional 100 years; and (3) the indefinite timeframe assumes that no repository becomes available.

In 2014, the Continued Storage of Spent Nuclear Fuel final rule was challenged in the U.S. Court of Appeals for the District of Columbia. The court upheld NRC's final rule.

B.3.4. Reprocessing in the U.S.

Commercial reprocessing is a process by which plutonium, uranium, or both are recovered from spent fuel to be used again in a reactor, was abandoned in the U.S. in the 1970s because of nuclear proliferation concerns. Prior to this decision to abandon commercial reprocessing, several reprocessing ventures were considered in the 1960s and early 1970s, including General Electric Company's planned construction of a commercial reprocessing facility near Morris,

[38] The document is available at NRC's ADAMS, under ML16125A032.
[39] The document is available at NRC's ADAMS, under ML041760035.
[40] The document is available at NRC's ADAMS, under ML14196A105 and ML14196A107, respectively.

Illinois, in the late 1960s. However, only the spent fuel storage facility was completed and remains in operation today

Nuclear Fuel Services operated a reprocessing facility at West Valley, New York, from 1966 to 1972. This facility processed 640 metric tons of heavy metal from government and commercial NPPs, resulting in 2.3 million liters of liquid HLW. This was the only commercial reprocessing plant operated in the U.S. Several reprocessing ventures were considered in the 1960s and early 1970s, including General Electric Company's planned construction of a commercial reprocessing facility near Morris, Illinois, in the late 1960s. However, only the spent fuel storage facility was completed and remains in operation today.

The U.S. declared a moratorium on domestic spent fuel reprocessing in 1977. The moratorium was rescinded in 1981, but commercial reprocessing never resumed in the U.S.

DOE recognizes that research and development (R&D) of sustainable fuel cycles and waste management activities are important to support the expansion of nuclear energy.[41] DOE is conducting R&D in nuclear fuel and waste management technologies that will enable a safe, secure, and economic fuel cycle. The long-term R&D strategy is to investigate the technical challenges in developing sustainable systems and develop solutions that reduce waste while improving resource utilization and safety.

B.4. Radioactive Waste Management Policies and Practices

Commercial generators of LLW in the U.S. must treat these wastes to remove free liquids and stabilize or destroy other hazardous components contained in the waste. Wastes are also often treated to reduce the final disposal volume through compaction and incineration. In the U.S., hazardous materials are required to be treated to reduce the hazard prior to disposal. If the waste is being disposed in a LLW disposal facility, it would need to be properly treated to reduce to the maximum extent practicable the potential hazard from the non-radiological materials in accordance with 10 CFR 61.56(a)(8). Commercial companies provide processing (e.g., packaging and treatment) and brokerage services to facilitate safe storage, transportation and, ultimately, disposal of LLW at one of four commercial LLW disposal facilities.

Commercial LLW is disposed in near-surface facilities (i.e., a land disposal facility where radioactive waste is disposed within the upper 30 meters of the earth's surface). These facilities are operated under licenses issued by either NRC or an Agreement State, based on NRC health and safety regulations governing waste disposal quantities, forms, and activity levels found in 10 CFR Part 61. See Sections E.2.1.3 and H.1.1 for additional information on LLW management. Section D.2.1 provides additional information on waste storage and treatment.

GTCC LLW is generated by NRC and Agreement State licensees and contains higher concentrations of long-and short-lived radionuclides than other classes of LLW.[42] GTCC LLW is generally grouped into the following three types: sealed sources, activated metals, and other waste. (Other waste includes contaminated equipment, debris, filters, resins, and scrap metal from miscellaneous activities, such as production of molybdenum-99 (^{99}Mo)).

[41] See https://energy.gov/ne/fuel-cycle-technologies.
[42] In the context of the National Report, GTCC LLW requires a greater degree of isolation, durability, and performance than is associated with near-surface disposal for other classes of LLW. This could include intermediate level waste as defined by some nations.

The Low-Level Radioactive Waste Policy Amendments Act of 1985 assigned responsibility for disposal of GTCC LLW to the Federal government. Currently, there are no facilities authorized to dispose of GTCC LLW.

The EPAct05 requires DOE to complete several actions related to the preparation of an EIS and Record of Decision for the disposal of GTCC LLW. After considering the comments received on the Draft EIS, DOE issued the *Final Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste* in February 2016. The Final EIS contains an analysis of alternatives for the disposal of GTCC LLW and DOE owned or generated GTCC-like waste. The Final EIS considered alternatives for disposal in a geologic repository (WIPP), intermediate-depth boreholes, enhanced near-surface trenches, and above-grade vaults. The Final EIS also considered multiple DOE sites and generic commercial disposal sites in four regions of the U.S. The preferred alternative in the Final EIS is land disposal at generic commercial facilities and/or disposal at the WIPP geological repository (see Section D.2.2.1). The Final EIS does not constitute a decision on GTCC LLW disposal. Section 631 of EPAct05 directs DOE to submit a Report to Congress regarding the disposal alternatives considered in the EIS and to await Congressional action before making a final decision on the disposal alternative(s) to be implemented. The Report to Congress is in progress.

DOE manages TRU waste from former weapons production and R&D activities. TRU waste from atomic energy defense activities is disposed in the WIPP geologic repository. Section D.2.2.1 provides information on TRU waste disposal. Section D.2.1 provides additional information on TRU waste and defense HLW treatment.

HLW from commercial reprocessing activities was vitrified and is stored at the former reprocessing plant in West Valley, New York. Defense waste from reprocessing is managed, at three DOE sites (SRS, Hanford site, and INL). The HLW from commercial and defense activities is planned to be disposed in a Federal repository.

UMTRCA classified the tailings from processing of uranium ore either as residual radioactive material or AEA Section 11e.(2) byproduct material depending on the status of the facility at the time UMTRCA was passed in 1978. UMTRCA Title I applies to facilities that were closed or abandoned prior to 1978. Since the passage of UMTRCA, activities at Title I sites were largely focused on decommissioning and cleanup of residual radioactive material by U.S. governmental entities. UMTRCA Title II applies to sites under an active license in or after 1978. Tailings at Title II sites are designated as 11e.(2) byproduct material.

Uranium recovery is the extraction or concentration of uranium from any ore processed primarily for its source material content.[43] The uranium recovery processes result in wastes that typically contain relatively low concentrations of radioactive materials associated with the natural uranium decay chain. The wastes, in both solid and liquid forms, are classified as AEA Section 11e.(2) byproduct material. See Table B-1 for information on classification of radioactive waste. For conventional mills, the waste is primarily the onsite disposal of tailings (residual ore after the uranium was leached).

EPA sets generally applicable standards for uranium recovery facilities. NRC develops conforming standards. These standards need to be met prior to NRC's termination of a license

[43] Similarly, thorium was also extracted or processed in the past.

for a specific facility. The requirements include long-term stability of uranium mill tailings disposal piles, radon emissions control, water quality protection and cleanup, and remediation of land and buildings. Once a license is terminated, ownership of the land and AEA Section 11e.(2) byproduct material is transferred to a governmental entity for long-term care. For ISR facilities, no tailings are generated; no permanent surface disposal options are licensed. The subsurface ore zones that were subjected to the leaching process do not constitute AEA Section 11e.(2) byproduct material and are exempt from protections of the Safe Drinking Water Act by EPA. Groundwater restoration requirements for the ore zones following termination of mineral extraction are specified in 10 CFR Part 40. Any remaining liquid or solid residues from evaporation ponds are collected and disposed of at an AEA Section 11e.(2) byproduct material licensed off-site waste disposal facility. Alternatively, recovered injection liquid and groundwater that have been processed to remove uranium are now considered AEA Section 11e.(2) byproduct material wastes and can be disposed of by deep well injection at the site of ISR operations.[44]

Depleted Uranium Tailings

The product from uranium recovery facilities is processed to enrich the fissile content. Tailings containing depleted uranium (DU) are a byproduct of the uranium enrichment process. Depending on available quantities, long-term and short-term needs, and cost/benefit analysis of potential uses, DU could be a resource for a variety of applications and uses. If DU is not considered a resource and is declared waste, it is categorized as LLW. When 10 CFR Part 61 was developed, the disposal of large quantities of DU as LLW was not anticipated, so by default it is classified by NRC as Class A LLW. However, with the licensing of new uranium enrichment facilities, which will produce large quantities of DU that may be declared waste, concerns have been raised about whether it is appropriate to dispose of this waste in near-surface facilities without further restrictions. NRC initiated a rulemaking to require site-specific analyses for disposal of large quantities of DU waste and refine the technical requirements for such analyses. As an interim measure, NRC has issued interim guidance to Agreement States that regulate the disposal of large quantities of DU at LLW disposal facilities.[45]

Currently, DOE and commercial corporations (e.g., Centrus Energy and Louisiana Energy Services) process and store DU. This DU continues to be managed as source material available for reuse. If a decision is made to declare the DU waste, it can be disposed in DOE or commercial LLW disposal facilities, provided the waste meets the facilities' waste acceptance requirements.

B.5. Decommissioning

Decommissioning generally happens at the end of operation of commercial and governmental nuclear facilities. Governmental agencies' recommendations, and in some cases, requirements, include provisions for decommissioning planning in the pre-operational design and strategy. Waste from decommissioning is managed within the waste classes previously described. See Section F.6 for additional information.

[44] For general information on uranium recovery in the U.S., refer to the backgrounder at: https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/uranium-recovery-bg.html.
[45] The document is available at NRC's ADAMS, under ML100250501.

Applicants for licenses are required to describe how facility design and procedures will facilitate eventual decommissioning.[46] NRC has published regulatory guidance in Regulatory Guide 4.21, *Minimization of Contamination and Radioactive Waste Generation: Life Cycle Planning*, June 2008, for implementing this requirement.[47] U.S. Governmental agencies work closely with industry, stakeholders, and members of the public to ensure lessons learned from decommissioning are appropriately factored into the next generation of nuclear facilities (e.g., NPPs, uranium mill facilities, and enrichment facilities).

Decommissioning activities at conventional uranium mills include mill demolition, groundwater cleanup, soil cleanup, and closure of tailings impoundment. Decommissioning activities at ISR facilities are focused on restoring groundwater quality to pre-operational conditions or limits established by NRC, soil cleanup, and building demolition.

NRC regulates the decontamination and decommissioning of materials and fuel cycle facilities, power reactors, research and test reactors, and uranium recovery facilities to ensure that NRC-licensed sites, and sites that were, or could be, licensed by NRC, will be decommissioned in a safe, timely, and effective manner. NRC regulates and oversees these processes to ensure that stakeholders are informed and involved in the process. Each year, NRC terminates approximately 125 materials licenses. Most of these license terminations are routine, and the sites require little, if any, remediation to meet NRC's unrestricted release criteria. However, some sites may require significant remedial activities and may pose technical or policy challenges that must be addressed in order to ensure that the sites are decommissioned safely. These include complex materials sites, power, test and research reactors, fuel cycle facilities, and uranium recovery facilities (see Section D.3.3 for additional information).

[46] Regulations are stipulated in 10 CFR 20.1406.
[47] The document is available at NRC's ADAMS, under ML080500187.

C. SCOPE OF APPLICATION

This section covers the application of the Joint Convention in the United States of America (U.S.), (Article 3) of the Joint Convention, as well as the U.S. position on the application of the Joint Convention to reprocessing of spent fuel, naturally occurring radioactive material (NORM), and defense/military programs. This section also provides a definition of what the U.S. considers spent fuel and waste management facilities under the provisions of the Joint Convention.

C.1. Spent Fuel Reprocessing

The U.S. has no commercial reprocessing facilities; therefore, no declaration is needed under Article 3.1. If a decision is made in the future to proceed with construction of a reprocessing facility, the U.S. will make a declaration under Article 3.1 at that time.

C.2. Naturally Occurring Radioactive Materials

The U.S. does not consider NORM outside the nuclear fuel cycle to be within the scope of its Joint Convention obligations as permitted by Article 3, paragraph 2, except for those classes of byproduct material [designated as 11e.(3) and 11e.(4) byproduct material] regulated under the aegis of the Atomic Energy Act of 1954, as amended. Nuclear Regulatory Commission (NRC) regulates 11e.(3) and 11e.(4) byproduct material under Title 10 of the *Code of Federal Regulations* Part 30. These materials include discrete sources of radium-226 (^{226}Ra) and other NORM, as well as accelerator-produced material. Certain concentrations and quantities are exempt from the regulations.[48] NRC does not regulate the movement or concentration of diffuse NORM such as scale from pipes used in the fossil fuel industry, fly ash from coal power plants, or phosphate fertilizers.

C.3. Defense Activities

The Joint Convention does not apply to the safety of spent fuel or waste within defense or military programs unless declared specifically (Article 3.3). The U.S. Government has determined the Joint Convention does not apply to spent fuel or waste managed within the military programs in the U.S., but spent fuel and radioactive waste from military programs fall within the Joint Convention when transferred for permanent disposal in facilities operated by Department of Energy (DOE).

U.S. military programs are primarily in Department of Defense and the DOE/National Nuclear Security Administration (DOE/NNSA). DOE/NNSA is a separately organized agency within DOE, overseeing the military application of nuclear energy; maintaining and enhancing the safety, security, reliability, and performance of the U.S. nuclear weapons stockpile; improving nuclear security through its defense nuclear nonproliferation programs; and developing naval propulsion plants for the U.S. Navy, among other functions. The amount of spent fuel and radioactive waste from military programs is relatively small compared to the commercial nuclear power sector. NRC has authority to regulate military ^{226}Ra contamination resulting from discrete sources of ^{226}Ra, if ^{226}Ra is no longer used or intended for use in military operations. Spent fuel and radioactive waste in military programs are managed; however, in accordance with the

[48] See https://www.nrc.gov/materials/byproduct-mat.html.

objectives stated in Article 1 of the Joint Convention.

C.4. Radioactive Waste and Spent Fuel Management Facilities

The Joint Convention defines radioactive waste management as all activities, including decommissioning, handling, pretreatment, treatment, conditioning, storage, and disposal (excluding off-site transportation). The U.S. has both commercial and government radioactive waste management facilities under the Joint Convention.

The Joint Convention defines storage as holding radioactive waste in a facility for containment, with the intention of retrieval. The U.S. does not consider facilities to be radioactive waste storage facilities where, for a short period of time (generally less than a year), a waste generator collects radioactive waste for shipment or processing before sending it to a treatment or disposal facility. This distinction excludes low-level waste inventories at nuclear power plants, hospitals, universities, research facilities, industries, and other facilities where radioactive waste is generated and shipped to disposal sites. These facilities are subject to the regulations under licenses to possess nuclear materials. All such facilities, though not reported, subscribe to the same objectives of Article 1 of the Joint Convention.

Article 3 of the Joint Convention allows Contracting Parties to declare facilities undergoing decommissioning as radioactive waste management facilities. The U.S. has some onsite disposal facilities for radioactive waste being generated during cleanup. This report further discusses ongoing decommissioning (including site remediation) activities in Sections D.3 and F.6.

D. INVENTORIES AND LISTS

Radioactive waste inventories reported in this section are classified according to the waste classification definitions described in Section B of this report.

D.1. Spent Fuel Management

The United States of America (U.S.) nuclear power industry has generated approximately 77900 metric tons (MT) heavy metal (MTHM) of spent fuel as of the end of 2016. Of this, 27000 MTHM is in dry storage at nuclear power plant (NPP) sites. Most U.S. commercial spent fuel will remain stored at NPPs until a disposition path is identified. Some spent fuel is also being stored away from NPPs. Department of Energy (DOE) spent fuel storage facilities include those used to store foreign research reactor and U.S. research reactor spent fuel transferred to DOE. See Table D-1. Spent fuel management practices are discussed in Sections F and G.

D.1.1. Spent Fuel Storage

As previously noted, spent fuel in the U.S. is stored either in wet (pool) or dry storage. Dry storage systems include both bolted-lid steel and concrete casks and welded canister-based designs. There are two primary canister-based dry cask storage systems for spent fuel.[49] One system design involves placing canisters vertically or horizontally in a concrete vault used for radiation shielding and protection of the canister. The other design places canisters vertically on a concrete pad and uses both metal and concrete storage overpacks for radiation shielding and canister protection.[50] Spent fuel storage cask designers, manufacturers, and licensees must comply with the quality assurance (QA) requirements in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 72, Subpart G. Nuclear Regulatory Commission (NRC) inspects storage designers, manufacturers, and licensees to verify QA procedures comply with their approved QA plan, and fabrication and use are done according to their QA program. See Section F.3 for additional information.

Table D-1 summarizes the types and numbers of U.S. spent fuel storage facilities and complete lists of spent fuel storage facilities are provided in Annexes D-1A–D-1D. Figure D-1 shows the location of independent spent fuel storage installations (ISFSI) and high-level waste (HLW) storage facilities.

NRC regulations in 10 CFR Part 72 provide a general license to store spent fuel in dry storage systems to a licensee that is authorized to operate or possess fuel for a nuclear power reactor under 10 CFR Parts 50 or 52. NRC has already approved a variety of dry storage systems potential licensees may consider. These systems have Certificates of Compliance and are listed in NRC regulations at 10 CFR 72.214. General licensees are not required to submit an application or Safety Analysis Report before using these NRC-approved designs.

[49] See https://www.nrc.gov/waste/spent-fuel-storage/diagram-typical-dry-cask-system.html.
[50] See https://www.nrc.gov/waste/spent-fuel-storage/designs.html.

D.1.2. Spent Fuel Disposal

The U.S. currently has no facility for spent fuel disposal. An application for a construction authorization for a geologic repository at Yucca Mountain, Nevada, for the disposal for spent fuel and HLW was filed before NRC by DOE in 2008; however, the adjudication on the application is suspended.

Table D-1. Spent Fuel Storage Facilities

Function	Number of Facilities[51]	Inventory[52]	Units[53]	Annex
Government				
Wet Storage	8	34	MTHM	D-1A
Dry Storage[54]	7	2420	MTHM	D-1A
University Research Facilities				
Wet Storage	21	1042	kgU	D-1B
Dry Storage	0	0	kgU	D-1B
Other Research and Nuclear Fuel Cycle Facilities				
Wet Storage	3	36	kgU	D-1C
Dry Storage	1	43	kgU	D-1C
Onsite Storage at NPPs[55]				
Wet Storage	66	50871	MTHM	D-1D
Dry Storage	66	26971	MTHM	D-1D

[51] In some instances, multiple facilities at a given installation are counted as a single facility such as in the case of shared storage pools or ISFSIs.
[52] Reflects inventory as of December 2010 for government, university, and other research reactors, and as of June 2013 at NPPs.
[53] kgU = kilogram of Uranium.
[54] This includes NRC-licensed facilities at DOE's Idaho Site and Fort St. Vrain in Colorado.
[55] This includes GE Morris and Utah Private Fuel Storage, LLC, which are not located at a nuclear power plant.

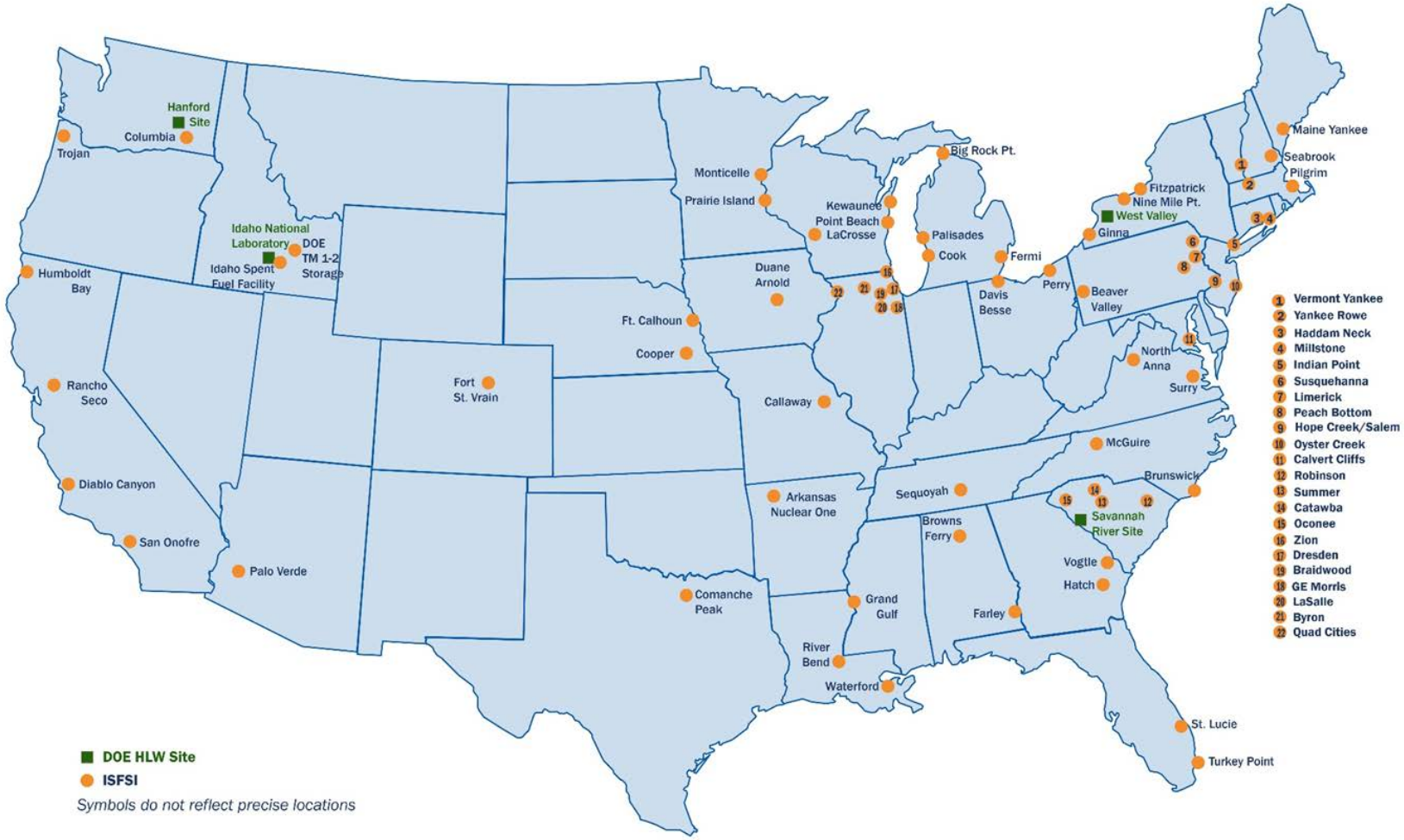

Figure D-1. U.S. Spent Fuel and High-Level Waste Storage Facilities

D.2. Radioactive Waste Management

Section D.2.1 describes waste storage and treatment facilities and their associated inventories. Section D.2.2 describes disposal facilities in the U.S.

D.2.1. Radioactive Waste Storage and Treatment

Radioactive wastes are treated primarily to produce a structurally stable, final waste form and to minimize the release of radioactive and hazardous components to the environment. The U.S. does not commonly make a distinction between the terms treatment and conditioning, although the distinction is made between the terms by the international community. Conditioning is defined in the international community as an operation producing a waste form suitable for handling, such as conversion of a liquid to a solid, enclosure of the waste in containers, or over packing. Treatment is defined as those operations intended to improve the safety and/or cost efficiency of waste management by changing the characteristics of the waste through volume reduction, removal of radionuclides, and change in composition. U.S. terminology covering both conditioning and treatment is generally referred to as treatment or processing. Treatment is used in this broader context in this report.

Table D-2 summarizes the U.S. radioactive waste treatment and storage facilities and the inventory in storage.[56] Annexes D-2A and D-2B provide a list of government and commercial facilities, their location, main purpose, and essential features. The following sections provide a brief description of the major types of radioactive waste management facilities.[57] Annex D-2B also includes a listing of waste processors.[58]

Table D-2. Radioactive Waste Storage and Treatment Facilities

Sector	Function	Material Type	Number[59]	Inventory	Units	Annex
Government	Storage/ Treatment	HLW	6	3.48E+05	m^3	D-2A
		TRU	11	4.51E+04	m^3	D-2A
		LLW[60]	17	3.31E+04	m^3	D-2A
		11e.(2)	1	1.99E+05	m^3	D-2A
		Sealed Sources	2	1.96E+03	Containers /Sources	D-2A

[56] Stored inventories for low-level waste/mixed low-level waste (LLW/MLLW) are as of 9/30/2013 per DOE's Fiscal Year (FY) 2014 Baseline Disposition Data (BLDD). Stored inventories for transuranic (TRU) waste are as of 12/31/2012 per the Annual Transuranic Waste Inventory Report - 2013. Disposed inventories for LLW/MLLW in active facilities are as of 9/30/2013 per DOE's FY 2014 BLDD. Disposed TRU inventory Waste Isolation Pilot Plant (WIPP) is as of 12/31/2013.

[57] There is no requirement in the U.S. for radioactive waste incineration for volume reduction. Incinerators are uncommon. Incineration is one of several thermal technologies employed by a few U.S. companies for some LLW streams that require treatment to destroy hazardous chemicals in the waste (mixed waste). DOE has no incinerators for radioactive waste and utilizes these commercial firms.

[58] D-2A Government, D-2B Commercial.

[59] In some instances, multiple facilities at a given installation are counted as a single facility.

[60] This includes MLLW.

Table D-2. Radioactive Waste Storage and Treatment Facilities						
Sector	**Function**	**Material Type**	**Number[59]**	**Inventory**	**Units**	**Annex**
Commercial/ Other	Treatment/ Processing	LLW	72	Small volumes for collection		D-2B
	Storage	GTCC LLW	Multiple ISFSIs	1.30E+02	m^3	D-2B
	Storage	11e.(2)	1	2.12E+04	m^3	D-2B

Treatment facilities for defense waste are among the largest and most complex radioactive waste facilities in the U.S. Hundreds of millions of liters of waste remain stored in tanks from decades of defense materials production activities.

DOE is building the world's largest radioactive waste treatment plant, the Waste Treatment and Immobilization Plant, at the Hanford Site in southeastern Washington State to treat defense waste from reprocessing stored for decades in 177 large underground tanks. The waste will be vitrified and poured into stainless steel canisters for disposal. The plant is designed to operate for 40 years. This has been a challenging and complex project due to its size and technical scope. See additional information in the U.S. Fourth National Report.

DOE also has managed or is constructing large treatment facilities for tank waste at the Idaho Site and Savannah River Site (SRS). At the Idaho Site, where most of the legacy tank waste has been treated and is stored as calcine, a new Sodium Bearing Waste Treatment Plant (known as the Integrated Waste Treatment Unit) for treatment of remaining tank waste has been constructed and is in the commissioning process. This first-of-a-kind facility will treat 3.4 million liters of the remaining tank waste at the Idaho Site, allowing closure of the four remaining underground tanks.

Tank waste continues to be treated at SRS. As part of the treatment process, the waste is separated into two fractions—a high-activity/low-volume stream and a low-activity/high-volume stream. The high-activity fraction is sent to the Defense Waste Processing Facility where it is vitrified for eventual geologic disposal. The low-activity fraction is disposed onsite in a grout (cement-like) waste form. In order to expedite the treatment process a new separations facility has been constructed—the Salt Waste Processing Facility (SWPF). The SWPF will greatly increase the separations capacity of the process thereby accelerating the life-cycle treatment schedule.

In addition, treatment and certification of TRU waste continues at multiple DOE sites in preparation for disposal. Large treatment facilities are operating at the Idaho Site (Advanced Mixed Waste Treatment Facility) and Oak Ridge Reservation (Transuranic Waste Processing Center). Some of the other sites processing TRU waste are Argonne National Laboratory, Los Alamos National Laboratory, Hanford Site, and SRS. The legacy inventory of TRU waste continues to decrease as waste is retrieved and processed for disposal.

D.2.2. Radioactive Waste Disposal

The cumulative inventory of disposed radioactive waste[61] is shown in Table D-3. Annexes D-2A, 2B, and D-3 provide detailed information on the quantities of material for each disposal facility.

Table D-3 Radioactive Waste Disposal Facilities

Sector	Facility Type	Waste Type	Number	Inventory	Units	Annex
Government	Geologic Repository (WIPP)	TRU	1	9.10E+04	m^3	D-2A
	Closed Nevada National Security Site Greater Confinement Disposal (boreholes)	TRU	1	2.00E+02	m^3	D-2A
	Near-Surface Disposal	LLW[62]	18	1.70E+07	m^3	D-2A
				1.29E+02	Reactor Compartments	D-2A
Commercial	Operating Near-Surface Disposal	LLW (Class A, B, C)	4	4.84E+06	m^3	D-2B
		Atomic Energy Act of 1954 (AEA) Section 11e.(2)	1	1.46E+06	m^3	D-2B
	Closed Near-Surface Disposal	LLW	4	4.38E+05	m^3	D-2B
Government/ Commercial	Title I Uranium Mill Tailings Remediation Control Act (UMTRCA) Disposal	Residual Radioactive Material (tailings)	21	2.28E+08	Dry MT[63]	D-3
Government/ Commercial	Title II UMTRCA Disposal[64]	AEA Section 11e.(2)	45			D-3

[61] Disposed inventories for LLW/MLLW in active facilities are as of 9/30/2013 per DOE's FY 2014 BLDD. Disposed TRU inventory (WIPP) is as of 12/31/2013.
[62] This includes mixed LLW (MLLW).
[63] Annex D-3 has additional quantities reported in units other than dry metric tons.
[64] This includes 17 in-situ recovery (ISR) and resin recovery facilities.

Table D-3 Radioactive Waste Disposal Facilities						
Sector	**Facility Type**	**Waste Type**	**Number**	**Inventory**	**Units**	**Annex**
Government	Other Closed Disposal Cells (Weldon Spring Site and Monticello)	Residual Radioactive Material (tailings)	2	3.03E+06	m^3	D-2A

D.2.2.1 Transuranic Waste Disposal

WIPP is a geologic repository to dispose TRU waste generated by atomic energy defense activities safely and permanently.[65] WIPP began operations on March 26, 1999, after more than 20 years of scientific study, public input, and regulatory review of the facility.

WIPP is located in southeastern New Mexico, about 80 kilometers from Carlsbad. The repository consists of disposal rooms mined 655 meters underground in a 600-meter thick salt formation. This formation has been stable for more than 200 million years. WIPP-bound TRU waste is currently stored at multiple locations nationwide (see Annex D-2A).

Over 91003 m^3 of defense-generated TRU waste was emplaced as of the end of February 2017. The disposal limit, as defined in the WIPP Land Withdrawal Act (LWA), is 175500 m^3. On January 4, 2017, WIPP completed the first waste emplacement after having recovered from an underground vehicle fire and a subsequent unrelated radiological event in February 2014. See Section A.3.9.

WIPP is authorized to only receive TRU waste generated by atomic energy defense activities.

D.2.2.2 Low-Level Waste (Near-Surface) Disposal

Commercial LLW is disposed in near-surface facilities that are operated under licenses issued by either NRC or an Agreement State (see Section B.4). Currently, all operating and closed LLW disposal sites are in Agreement States and are subject to their state's regulatory programs. The following are the four active, licensed commercial LLW disposal sites:

- Energy*Solutions* (near Barnwell, South Carolina) – limits disposal access to LLW generators within three states composing the Atlantic Compact (South Carolina, Connecticut, and New Jersey). Barnwell disposes of Class A, B, and C LLW up to 0.37 TBq (which excludes many higher activity sealed sources).
- US Ecology (on DOE's Hanford Site near Richland, Washington) – restricts access to only LLW generators within the Northwest and Rocky Mountain Compacts. See Figure H.1 for states in these compacts. US Ecology disposes of Class A, B, and C LLW. The US Ecology site can also accept radium and other naturally occurring radioactive materials (NORM) and accelerator-produced radioactive waste without compact restrictions.
- Energy*Solutions* (Clive, Utah) – with some restrictions, accepts Class A LLW and MLLW from LLW generators throughout the country. For example, Class A LLW from the

[65] More information on WIPP can be found at http://www.wipp.energy.gov/wipprecovery/recovery.html.

Northwest and Rocky Mountain Compact states can only be accepted with Compact approval.

- Waste Control Specialists LLC (WCS) (near Andrews, Texas) – accepts Class A, B, and C LLW from generators within the Texas Compact (Texas and Vermont).[66] LLW from generators outside the Texas Compact is accepted for disposal by approval of the Compact. At this site, WCS also operates the Federal Waste Facility (FWF), which accepts certain DOE LLW and MLLW.[67]

Commercial LLW sites now closed are: Beatty, Nevada (closed 1993); Maxey Flats, Kentucky (closed 1977); Sheffield, Illinois (closed 1978), and West Valley, New York (closed 1975). Post-closure activities at the four closed sites are performed in accordance with site-specific closure plans required by the state regulatory authorities.[68]

Commercial LLW remains within NRC's regulatory authority regardless of the radioactive waste concentrations. However, NRC regulations provide alternative waste disposal approval processes that allow for the disposal of some low-activity LLW in landfills designed and regulated for other purposes (e.g., hazardous waste disposal or industrial debris disposal). See Section H.3.1 for additional information on management strategies for these types of low-activity wastes. Figure D-2 depicts the location of U.S. LLW and MLLW disposal sites. MLLW is LLW that also contains hazardous (non-radiological) waste constituents.

[66] The site is subject to the Texas Low-Level Radioactive Waste Disposal Compact Consent Act.
[67] While in operation, the FWF is under the regulatory authority of the State of Texas. However, following decommissioning of the facility, the FWF can revert to the regulatory control of the Federal Government, as provided by the Nuclear Waste Policy Act of 1982, Subtitle D.
[68] For additional detail on commercially-disposed LLW, refer to the following web site http://mims.doe.gov/.

Figure D-2. Location of U.S. Low-Level Waste/Mixed Low-Level Waste Disposal Sites

D.2.2.3 Uranium Mill Tailings Disposal

DOE completed surface remediation at the listed UMTRCA Title I inactive uranium milling sites where uranium was processed solely for sale to the U.S. Government. Groundwater remediation is ongoing at several UMTRCA Title I sites. Residual radioactive material is the term used to describe radioactive uranium mill tailings from the original operations at Title I sites. This material was not regulated as radioactive waste prior to 1978. It consists of the tailings and any windblown contamination resulting from the tailings. This material was collected under the Title I cleanups and stabilized in one or more cells on-site or transported and consolidated in another location because of site conditions. This remediation was handled in a site-specific manner by DOE with NRC concurrence on the remedial action. These cells are under long-term management by DOE and are generally licensed by NRC under provisions in 10 CFR 40.27. DOE performs annual site inspections as part of the long-term surveillance program at Title I disposal sites. See Annex D-3 for a list of sites.

Forty-five UMTRCA Title II facilities are or have been licensed and consist of conventional uranium and thorium mills and other related facilities. Nineteen facilities are located within and regulated by Agreement States.[69] Five Agreement States (Colorado, Illinois, Texas, Utah, and Washington) license AEA Section 11e.(2) byproduct material. NRC regulates the remaining 26 facilities, which are located in Nebraska, New Mexico, South Dakota, and Wyoming.[70] Annex D-3 lists both NRC- and Agreement State-regulated uranium recovery facilities. The White Mesa facility in Utah also accepts material from other uranium recovery sites. Once the private licensee completes decommissioning activities, these Title II sites are transferred to DOE or the state for long-term care and maintenance.

Additional commercial AEA Section 11e.(2) byproduct material disposal cells include the Energy*Solutions* facilities located in Utah and the WCS facility located in Texas. These facilities are regulated under Agreement State authority. Additional information regarding these facilities is presented in Annex D-2B. Section B.4 describes uranium recovery facilities in the U.S.

D.2.2.4 Mine Overburden Remediation

Mine overburden is not classified as radioactive waste requiring restricted disposal, but an estimate of mine overburden is provided at the request of other Contracting Parties to the Joint Convention.[71] Although there are about 4000 mines with documented production, a database compiled by Environmental Protection Agency (EPA) with information from other Federal, state, and tribal governmental lands, includes 15000 mine locations, mostly in 14 western states.[72]

Most of these locations are in Colorado, Utah, New Mexico, Arizona, and Wyoming, with about 75 percent of those on Federal and tribal lands. The majority of these sites were conventional (open pit and underground) mines. With the drop in market price of uranium beginning in the 1980s, U.S. producers turned to ISR operations as a principal means of extracting uranium from

[69] NRC is required to determine applicable standards and requirements have been met before termination of the licenses at sites located in Agreement States.
[70] The WNI Sherwood site in the State of Washington is regulated under NRC general license to DOE for long-term surveillance.
[71] Unless otherwise noted, this information can be found at https://www.epa.gov/radiation/tenorm-uranium-mining-wastes.
[72] EPA, *Uranium Location Database Compilation*, EPA 402-R-05-009, August 2006.

ore bodies. There were seven uranium mines operating in 2016 according to DOE's Energy Information Administration.[73] Mining of uranium ores by surface and underground methods produces large amounts of radioactive waste material classified as NORM or technologically enhanced NORM, including overburden, un-reclaimed sub-economic ores (protore),[74] "barren" rock, and drill cuttings. The volume of waste produced by surface, open-pit mining is a factor of approximately 45 times greater than for underground mining, based on their respective averages. Thus, the amount of overburden generated from open-pit mines far exceeds underground mine overburden. The U.S. Geological Survey, in an estimate for EPA, found the amount of waste rock generated by approximately 4000 conventional mines in their data files, ranged from one billion to nine billion MT of waste, with a likely estimate of three billion MT.[75] Given the larger number of mine locations identified by EPA, the amount of waste rock is likely to be higher. See additional historical information in the U.S. Third National Report.

D.3. Nuclear Facility Decommissioning

Table D-4 summarizes ongoing U.S. decommissioning activities within the scope of the Joint Convention. See Table D-4 for more information provided in the subsections corresponding to each of the entries.

Table D-4. Summary of Decommissioning Activities in Progress

Sector	Type	Number
Government	DOE Nuclear/Radioactive Facilities for which Decommissioning is Ongoing or Pending	716
Government/ Commercial	Formerly Utilized Sites Remedial Action Program (FUSRAP)	25[76]
	Decommissioning Materials Sites Regulated by NRC	13
	Decommissioning Material Sites in NRC Agreement States	34
Commercial	NPPs	20
	Other Non-Power Reactor Facilities	4
	Uranium Recovery Facilities (NRC)	11
	Uranium Recovery Facilities (Agreement States)	11

[73] Energy Information Administration, *2016 Domestic Uranium Production Report*, 2017. See https://www.eia.gov/uranium/production/annual/pdf/dupr.pdf.
[74] Protore is material containing uranium that cannot be produced at a profit under existing conditions but may become profitable with technological advances or price increases; protore is mineralized material too low in concentration to constitute ore, but from which ore may be formed through secondary enrichment.
[75] EPA, *Technologically Enhanced Naturally Occurring Radioactive Materials from Uranium Mining; Vol. 1: Mining and Reclamation Background*, EPA 402-R-08-005, Rev., April 2008. https://www.epa.gov/sites/production/files/2015-05/documents/402-r-08-005-v1.pdf.
[76] U.S. Army Corps of Engineers, *Formerly Utilized Sites Remedial Action Program Update*, January 2014.

D.3.1. Department of Energy Sites with Decommissioning/Remediation Projects

The U.S. has a legacy of radioactive waste from past government activities spanning five decades. A total of 107 sites covering more than 0.8 million hectares of land have been used by the U.S. Government for nuclear research and development and nuclear weapons production activities. Most of the land at these sites is not contaminated. Within the boundaries of these sites are numerous radiological-controlled areas with thousands of individual facilities, encompassing 10874 discrete contaminated locations ("release sites"). Over 8047 of these release sites have been cleaned up. Full remediation is complete at 91 of 107 DOE sites,[77] and 716 nuclear or radiological facilities are being decommissioned.

The U.S. Government continues to safeguard its nuclear materials, dispose of radioactive waste, remediate extensive surface water and groundwater contamination, and deactivate and decommission thousands of excess contaminated facilities.

DOE's Office of Legacy Management's mission is to fulfill DOE's post-closure responsibilities and ensure the future protection of human health and the environment. Legacy Management protects human health and the environment through effective and efficient long-term surveillance and maintenance of legacy sites; and preserves, protects, and makes accessible to the public legacy records and information. Legacy Management has control and custody of legacy land, structures, and facilities and is responsible for maintaining them at levels consistent with DOE's long-term plans.

D.3.2. Formerly Utilized Sites Remedial Action Program

The FUSRAP began in 1974 to identify, investigate, and cleanup or control sites where the Manhattan Engineer District and later, the Atomic Energy Commission, conducted defense and energy research activities in the early days of the nation's atomic energy program (generally the 1940s - 1960s). Congress transferred FUSRAP management to the U.S. Army Corps of Engineers (USACE) in 1997. USACE continues to clean up sites started by or newly identified by DOE, or assigned by Congress. FUSRAP sites are distinct from the formerly licensed facilities, addressed in Section H.1.2.[78] FUSRAP sites are returned to DOE for long-term stewardship when remediation is completed. DOE's Office of Legacy Management has responsibility for all FUSRAP sites remediated by DOE and those transferred back to DOE by USACE.[79] The contaminants at FUSRAP sites are primarily low levels of uranium, thorium, and radium, with their associated decay products. Materials containing low levels of radioactive residues are excavated, packaged, and transported for disposal at licensed commercial disposal sites, or to hazardous waste landfills, as appropriate. Annex D-4 lists FUSRAP sites with ongoing remediation activities. In some cases, the FUSRAP sites are also considered as complex material decommissioning sites, and are listed in Annex D-5.

[77] See https://energy.gov/em/cleanup-sites.
[78] Additional FUSRAP information can be found at: http://www.usace.army.mil/Missions/Environmental/FUSRAP/.
[79] Extensive FUSRAP-related information (including information on specific sites) is available on the Legacy Management web page at https://www.lm.doe.gov. Legacy Management has also developed the Considered Sites Database (CSD) to provide public information documenting site eligibility and characterization, remediation, verification, and certification for all FUSRAP sites. CSD is available at https://www.lm.doe.gov/Considered_Sites/.

D.3.3. Nuclear Regulatory Commission Facility Decommissioning

NRC regards complex materials sites as those that are required to provide a decommissioning plan or sites that require formal NRC or State approval prior to being decommissioned. NRC has taken a comprehensive approach to its decommissioning program. Of the 47 complex materials sites that are currently undergoing decommissioning in the U.S., NRC currently regulates 13 sites, located in nine states, overseen by NRC's four regional offices. See Section F.6.1 for additional information.

As of April 2017, 20 nuclear power and early demonstration reactors, 4 research and test reactors, 13 complex materials sites, 2 fuel cycle facilities and 11 Title II uranium recovery facilities are undergoing non-routine decommissioning. In addition, 21 UMTRCA Title I and 6 Title II sites are in long-term care and maintenance by DOE, under NRC jurisdiction. Annex D-5 provides a list of these 13 "complex materials sites" undergoing decommissioning. Annex D-3 includes the uranium recovery sites undergoing decommissioning and those that have been transferred to DOE. Additional specific information on the decommissioning status of NRC regulated sites can be found at NRC's web site,[80] including specific status information for each complex site.

Under the provisions of the AEA, NRC can discontinue portions of its regulatory authority and allow individual states (Agreement States) to assume this authority, including regulation of decommissioning material sites in those states. Currently, 12 of the 37 Agreement States are regulating the decommissioning of 34 complex materials sites, with technical support from NRC's regional offices, as needed.[81] See Section E.2.4.2 for additional information. Annex D-5 also lists those facilities undergoing decommissioning in the Agreement States. NRC also provides oversight for decommissioning of research and test reactors. The four research and test reactors identified in Annex D-6 are undergoing decommissioning.

NRC provides project management and technical review for decommissioning and reclamation of facilities regulated in 10 CFR Part 40, Appendix A (under the UMTRCA Title II). These licensees include conventional uranium mills, heap leach facilities, and ISR facilities. Annex D-3 shows these sites. NRC also provides licensing oversight and decommissioning project management for fuel cycle facilities, including conversion plants, enrichment plants, and fuel manufacturing plants. NRC continues to work closely with the states and EPA to regulate remediation of unused portions of fuel cycle facilities. There are two fuel cycle facilities undergoing partial decommissioning: the Nuclear Fuels Services site in Erwin, Tennessee, and the Honeywell Metropolis Works facility located in Metropolis, Illinois.

In fiscal year 2016, NRC terminated materials licenses at the Mallinckrodt site in St. Louis, Missouri, and the Stepan Company site in Maywood, New Jersey. NRC also terminated the operating license for the U.S. Department of Veterans Affairs research reactor in Omaha, Nebraska. See Section D for additional radioactive waste and spent fuel management specific information.

[80] See https://www.nrc.gov/waste/decommissioning.html.
[81] See https://www.nrc.gov/about-nrc/state-tribal/agreement-states.html.

D.3.4. Environmental Protection Agency Site Remediation

EPA remediates radiologically-contaminated sites using its Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) authority or can under the same authority require "potentially responsible parties" to clean up those sites. Since the passage of CERCLA in 1980, 59 radiologically-contaminated sites have been placed on the National Priorities List (NPL) for CERCLA (out of 1729 sites listed, 1337 sites are currently on the NPL). Cleanup has been completed or the selected remedy implemented (e.g., construction of a groundwater treatment system that may operate over a number of years) at 39 of the radiologically-contaminated sites. Radiologically-contaminated NPL sites have included uranium mines, DOE facilities, NRC licensees, and sites being addressed through FUSRAP.

E. LEGISLATIVE & REGULATORY SYSTEMS

E.1. Legislative System

The policy on regulatory control of radioactive waste management in the United States of America (U.S.) has evolved through a series of laws establishing Federal Government agencies responsible for the safety of radioactive materials. Federal legislation is first passed by Congress and then signed into law by the President. U.S. laws apply to all 50 states (including the District of Columbia) and its territories. Laws on the safety of spent fuel and radioactive waste can be traced back for many decades. Table E-1 in the U.S. Fourth National Report,[82] identifies key U.S. laws governing radioactive waste management.

E.2. Regulatory System

The regulatory system for spent fuel and radioactive waste management in the U.S. involves several agencies: Nuclear Regulatory Commission (NRC), regulating the commercial nuclear sector; Environmental Protection Agency (EPA), establishing environmental standards; and Department of Energy (DOE), regulating its own government programs. NRC maintains regulatory authority over spent fuel, special nuclear material sufficient to form a critical mass, and high-level waste (HLW). Section 274 of the Atomic Energy Act of 1954, as amended (AEA), permits NRC to discontinue its authority and the states to assume regulatory authority over byproduct, source, and special nuclear materials to the states, U.S. territories; and the District of Columbia, through the NRC's Agreement State Program. This authority includes regulating commercial low-level waste (LLW) disposal sites, uranium mill tailings sites, and disposal of uranium mill tailings. Some states also have regulatory authority delegated to them by EPA, such as for discharges from some industrial or mining practices. These are referred to as EPA Authorized States. See Section E.2.4.1.

The general regulations for the three Federal agencies responsible for radioactive waste regulation are contained in Title 10 (for NRC and DOE) and Title 40 (for EPA) of the U.S. *Code of Federal Regulations* (CFR). U.S. Government regulations are developed through an open process, including the opportunity for public comment. New regulations are published in the *Federal Register*, in proposed or final forms. Links to specific regulations and other information for each agency are provided in Table E-1.

DOE Orders are internal directives that function similar to regulations for DOE and DOE contractor activities. Compliance with such orders is mandatory for DOE and is enforced through contract provisions for DOE contractors.

The separation between EPA's standard-setting function and NRC's implementing function for environmental standards reflects an over 40-year-old Congressional policy of centralizing environmental standard setting into a single agency. When EPA was established, it was given environmental authorities scattered among several older agencies, including NRC's and DOE's predecessor, the Atomic Energy Commission (AEC).

[82] See https://energy.gov/em/downloads/fourth-national-report-joint-convention-safety-spent-fuel-management-and-safety.

Table E-1 Spent Fuel, Radioactive Waste, and Disused Sealed Sources Management Regulations, Guidance and Communications
U.S. Nuclear Regulatory Commission
High-Level Waste Disposal Regulations, Guidance, and Communications
https://www.nrc.gov/waste/hlw-disposal/how-we-regulate.html
Low-Level Waste Disposal Regulations, Guidance, and Communications
https://www.nrc.gov/waste/llw-disposal/regs.html
Uranium Recovery Regulations, Guidance and Communications
https://www.nrc.gov/materials/uranium-recovery/regs-guides-comm.html
Decommissioning Regulations, Guidance and Communications
https://www.nrc.gov/waste/decommissioning/reg-guides-comm.html
Spent Fuel Storage Regulations, Guidance and Communications
https://www.nrc.gov/waste/spent-fuel-storage/regs-guides-comm.html
Source Materials Facilities Regulations, Guidance and Communications
https://www.nrc.gov/materials/srcmaterial.html
Medical, Industrial, Academic Uses of Nuclear Materials Regulations, Guidance and Communications
https://www.nrc.gov/materials/miau/regs-guides-comm.html (includes sealed sources and orphan sources)
Export-Import of Radioactive Materials
https://www.nrc.gov/about-nrc/ip/export-import.html
Emergency Preparedness and Response
https://www.nrc.gov/about-nrc/emerg-preparedness.html (reactors) https://pbadupws.nrc.gov/docs/ML1322/ML13227A120.pdf (independent spent fuel storage installations) https://pbadupws.nrc.gov/docs/ML1316/ML13165A140.pdf (fuel facilities)
Special Nuclear Material
https://www.nrc.gov/materials/sp-nucmaterials.html
Packaging and Transportation of Radioactive Material
https://www.nrc.gov/reading-rm/doc-collections/cfr/part071/

U.S. Department of Energy
10 CFR Part 765, *Reimbursement of Costs for Remedial Action at Active Uranium and Thorium Processing Sites*
10 CFR Part 766, *Uranium Enrichment Decontamination and Decommissioning Fund; Procedures for Special Assessment of Domestic Utilities*
10 CFR Part 820, *Procedural Rules for DOE Nuclear Facilities*
10 CFR Part 830, *Nuclear Safety Management*
10 CFR Part 835, *Occupational Radiation Protection*
10 CFR Part 960, *General Guidelines for the Recommendation for Sites for Nuclear Waste Repositories*
10 CFR Part 963, *Yucca Mountain Site Suitability Guidelines*
10 CFR Part 1021, *National Environmental Policy Act Implementing Procedures*
The following DOE directives are applicable to safety:[83]
Order 151.1D, *Comprehensive Emergency Management System*
Policy 226.1B, *Department of Energy Oversight Policy*
Order 226.1B, *Implementation of Department of Energy Oversight Policy*
Order 227.1A, *Independent Oversight Program*
Order 231.1B, *Environment, Safety, and Health Reporting*
Order 360.1C, *Federal Employee Training*
Order 414.1D, *Quality Assurance*
Order 420.1C, *Facility Safety*
Guide 421.1-2, Guide 423.1-1; DOE Guide 424.1-1B, *Implementation Guides for 10 CFR 830*
Order 422.1, *Conduct of Operations*
Order 425.1D, *Startup and Restart of Nuclear Facilities*
Order 430.1B, *Real Property Asset Management*
Order 433.1B, *Maintenance Management Program*
Order 435.1, *Radioactive Waste Management*
Order 440.1B, *Worker Protection Program for DOE Federal Employees*
Order 458.1, *Radiation Protection of the Public and the Environment*
Order 426.2, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*
Order 462.1, *Import and Export of Category 1 and 2 Radioactive Sources and Aggregated Quantities.*
U.S. Environmental Protection Agency
40 CFR Part 61, *National Emission Standards for Hazardous Air Pollutants*
https://www.epa.gov/radiation/radiation-regulations-and-laws#tab-2
40 CFR Part 190, *Environmental Radiation Protection Standards for Nuclear Power Operations*
https://www.epa.gov/radiation/environmental-radiation-protection-standards-nuclear-power-operations-40-cfr-part-190

[83] For DOE Directives, refer to https://www.directives.doe.gov/.

40 CFR Part 191, *Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-level and Transuranic Radioactive Wastes*
https://www.epa.gov/radiation/environmental-radiation-protection-standards-management-and-disposal-spent-nuclear-fuel
40 CFR Part 192, *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings*
https://www.epa.gov/radiation/health-and-environmental-protection-standards-uranium-and-thorium-mill-tailings-40-cfr
40 CFR Part 194, *Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's (WIPP) Compliance with the 40 CFR Part 191 Disposal Regulations*
https://www.epa.gov/radiation/criteria-certification-and-recertification-waste-isolation-pilot-plants-compliance-40-cfr
40 CFR Part 197, *Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada*
https://www.epa.gov/radiation/40-cfr-part-197-resources
Other Title 40, Code of Federal Regulations relating to radiation protection include:
Part 141, *National Primary Drinking Water Regulations* https://www.epa.gov/ground-water-and-drinking-water/table-regulated-drinking-water-contaminants Part 147, *State Underground Injection Control Programs* Part 148, *Hazardous Waste Injection Restrictions* https://www.epa.gov/uic Part 195, *Radon Proficiency Programs* https://www.epa.gov/radon/ Parts 220 and 133, *Ocean Dumping* https://www.epa.gov/ocean-dumping Part 300, *National Oil and Hazardous Substances Pollution Contingency Plan* Part 302, *Designation, Reportable Quantities, and Notification* https://www.epa.gov/ocean-dumping Part 440, *Ore Mining and Dressing Point Source Category (Uranium, Radium, and Vanadium Ores subcategory)* https://www.epa.gov/eg/ore-mining-and-dressing-effluent-guidelines

E.2.1. Nuclear Regulatory Commission

NRC is an independent regulatory agency created from the former AEC by Congress under the Energy Reorganization Act of 1974 to assure protection of public health and safety and the environment, and to promote the common defense and security in the civilian use of byproduct, source, and special nuclear materials.

NRC regulates:

- Commercial nuclear power, non-power research, test, and training reactors;
- Fuel cycle facilities, and medical, academic, and industrial uses of nuclear materials;
- Storage and disposal of nuclear materials and waste; and
- Certain DOE activities and facilities over which Congress has provided NRC licensing and related regulatory authority.

NRC regulates manufacture, production, transfer or delivery, receiving, acquisition, ownership, possession, and use of commercial radioactive materials, including the regulation of the associated radioactive waste. The key elements of NRC's regulatory program are described in detail at: https://www.nrc.gov; this information is also available in previous U.S. National Reports.

Specifically, NRC regulates management and disposal of LLW, HLW, and spent fuel, decontaminating and decommissioning facilities and sites. NRC is also responsible for establishing the technical bases for regulations and provides information and technical bases for developing acceptance criteria for licensing reviews. Table E-1 lists the links to NRC regulations, guidance, and communications.

Important aspects of NRC's regulatory program are inspection and enforcement. NRC has four regional offices, which inspect licensed facilities in their regions, including nuclear waste facilities.[84] NRC's Office of Nuclear Material Safety and Safeguards communicates with state, local and tribal governments, and oversees the Agreement State Program. NRC Agreement States are discussed in Section E.2.4.2.

E.2.1.1 Uranium Recovery Regulation

Section B.4 introduces the Uranium Mill Tailings Radiation Control Act (UMTRCA). NRC is responsible for planning and implementing regulatory programs under UMTRCA. UMTRCA amended the AEA to require EPA to issue generally applicable standards for controlling uranium mill tailings and other residual radioactive materials. EPA issued standards for both Title I (residual radioactive material) and Title II [AEA Section 11e.(2) byproduct material] sites in 1983. The Title I program established a joint Federal/state funded program for remedial action at abandoned mill tailings sites, with final Federal ownership under NRC license. NRC, under Title l, must evaluate DOE designs and agree DOE actions meet standards set by EPA. NRC and DOE have a Memorandum of Understanding (MOU) to clarify their roles and responsibilities and to minimize or eliminate duplication of effort between the two agencies.[85]

UMTRCA Title ll involves planning and directing activities for active, licensed uranium recovery facilities, including facility licensing and operation, and mill tailings management and decommissioning. Title II deals with sites regulated by NRC or Agreement States. NRC regulations are in 10 CFR Part 40, Appendix A, and are consistent with EPA Title II standards and meet UMTRCA requirements. NRC has authority under Title II to control radiological and non-radiological hazards, and to ensure NRC-licensed and Agreement State-licensed sites

[84] Specific information on NRC regional offices can be accessed at: https://www.nrc.gov/about-nrc/organization.html.
[85] DOE, *Memorandum of Understanding between the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission*, GM04-85AL26037, November 1990.

meet all standards and requirements during operations and before termination of licenses. NRC reviews Title II license applicant's plans for operating, reclaiming, decommissioning, and remediating groundwater. NRC also reviews license applications (LA) and renewals; license conditions changes; and annual surety updates.

NRC also provides technical assistance to Agreement States on uranium recovery issues and implements an active interface program including consultation with Federal agencies, states, tribal governments, and other entities to promote understanding of uranium programs and to resolve concerns in a timely manner.

On January 19, 2017, EPA proposed new groundwater protection standards at facilities that extract uranium using the in-situ recovery (ISR) process and accepted comments through July 18, 2017. EPA is evaluating the comments on the proposed standards and information received and will proceed to follow the official rulemaking process.

E.2.1.2 High-Level Waste and Spent Fuel Regulation

Regulatory responsibility for disposal of HLW and spent fuel is described in the Energy Reorganization Act, the Nuclear Waste Policy Act of 1982 (NWPA), as amended, and Energy Policy Act of 1992 (EPAct92). NRC has licensing and regulatory authority for facilities and activities related to the disposal of spent fuel or HLW.

EPA has issued final standards for HLW disposal at Yucca Mountain (40 CFR Part 197), and NRC has published conforming licensing regulations for HLW disposal at Yucca Mountain (10 CFR Part 63). Final standards for HLW disposal for sites other than Yucca Mountain were issued by EPA as 40 CFR Part 191 and by NRC as 10 CFR Part 60. EPA and NRC finalized these regulations for HLW disposal for sites other than Yucca Mountain. These regulations have remained substantially the same since their development over 20 years ago. As the need arises, NRC will consider revisions to 10 CFR Part 60 to take advantage of regulatory enhancements that have occurred since 10 CFR Part 60 was developed. EPA standards and NRC regulations for HLW and spent fuel are generally consistent with national and international recommendations for radiation protection standards.

E.2.1.3 Low-Level Waste Regulation

Commercial LLW disposal facilities are designed, constructed, and operated under licenses issued by either NRC or an Agreement State,[86, 87] pursuant to Section 274 of the AEA, based on NRC health and safety regulations governing waste disposal quantities, forms, and activity levels (10 CFR Part 61). This regulation establishes the procedures, criteria, and terms and conditions for the issuance of licenses for land disposal of LLW. Four performance objectives, including protection of an inadvertent intruder who intrudes into the waste disposal site, define the overall level of safety to be demonstrated by the licensee.[88] Specifically, 10 CFR 61.55 addresses the classes of LLW. These classes are described in Table B-1 of this report. The

[86] Under the provisions of the AEA, NRC can discontinue portions of its regulatory authority and allow individual states (Agreement States) to assume this authority, including regulation of LLW sites in those states.
[87] The process by which a state becomes an Agreement State regulating LLW is described in https://www.nrc.gov/about-nrc/state-tribal/become-agreement.html.
[88] The other performance objectives are protection of the general population from releases of radioactivity; protection of individuals during the operation of the facility (as opposed to after the facility is closed) and stability of the disposal site.

Low-Level Radioactive Waste Policy Act of 1980 (as amended in 1985) gives the states the responsibility for the disposal of LLW generated within their borders (except for certain waste generated by the Federal Government). The Act authorized the states to enter into compacts that would allow them to dispose of waste at a common disposal facility. See Section H.1.1 for additional information on commercially licensed LLW disposal facilities and disposal compacts.

E.2.1.4 Decommissioning Regulation

Decommissioning involves safely removing a facility from service and reducing residual radioactivity to a level permitting the property to be released for unrestricted or restricted use. This action is taken by a licensee before NRC terminates its license.

Section 50.82 of 10 CFR provides the processes and procedures for nuclear power plants (NPPs) decommissioning and license termination. Depending on the type of site, decommissioning requirements are included in 10 CFR Part 30, 40, 70 and 72. 10 CFR Part 20, Subpart E provides the radiological criteria applicable to all facilities except uranium recovery sites, which must meet the requirements of 10 CFR Part 40, Appendix A. However, the diversity and complexity of facilities undergoing decommissioning requires that specific regulations are in place to address the unique features associated with the different types of sites and activities involved in the decommissioning.[89] A unique consideration for decommissioning in the U.S. is a timeliness provision; i.e., specific time periods for decommissioning unused portions of operating nuclear materials facilities in accordance with 10 CFR 30.36, 40.42, 50.82, 70.38 and 72.54. Under 10 CFR 50.82, power reactor licensees are required to complete decommissioning within 60 years.

NRC has developed a number of guidance documents to guide the decommissioning process and help licensees prepare decommissioning documents. The primary decommissioning guidance is documented in the NUREG-1757, *Consolidated Decommissioning Guidance*[90] and NUREG-1700, Rev. 1*, Standard Review Plan for Evaluating Nuclear Power Reactor License Termination Plans*. These documents describe: (1) acceptable methods for implementing NRC's regulations; (2) techniques and criteria used by NRC in evaluating decommissioning actions; and (3) guidance to licensees responsible for decommissioning NRC-licensed sites.[91] The Consolidated Decommissioning Guidance documents are periodically revised and re-issued as a result of lessons learned, changes in regulations, and ongoing continuous improvement activity. For additional information on these activities, please refer to past issues of the U.S. National Report and the *Status of the Decommissioning Program 2016 Annual Report*.[92] To strengthen future decommissioning at existing operating facilities, 10 CFR 20.1501 requires surveys to identify contamination that would require remediation for license termination. Guidance implementing the rule was provided in Regulatory Guide 4.22, *Decommissioning Planning during Operations*, December 2012.

[89] See https://www.nrc.gov/waste/decommissioning/reg-guides-comm/regulations.html.
[90] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1757.
[91] These are accessible from https://www.nrc.gov/waste/decommissioning/reg-guides-comm/guidance.html.
[92] See https://www.nrc.gov/waste/decommissioning.html.

Additional information on NRC's decommissioning approach is provided in Section F.6.1. There are many opportunities for public involvement and information throughout the decommissioning process.[93, 94]

The decommissioning process for non-power reactor facilities can be initiated by any number of conditions.[95] These include expiration of the license or cessation of operations in all or part of the site for 24 months. Pursuant to 10 CFR 50.82, the non-power reactor facilities are required to submit a decommissioning plan (DP). The DP must include the following:

- The choice of the alternative for decommissioning with a description of the planned decommissioning activities;
- A description of the controls and limits on procedures and equipment to protect occupational and public health and safety;
- A description of the planned final radiation survey;
- An updated estimate of the expected costs for the alternative chosen, including a comparison with the estimated present funds set aside for decommissioning and a plan for assuring the availability of adequate funds for completion of decommissioning; and
- A description of technical specifications, quality assurance provisions and physical security plan provisions in place during decommissioning.

NRC inspects the licensee's decommissioning operations to ensure compliance with the DP. These inspections are normally included in the process and confirmatory radiological surveys.[96] In the final steps of decommissioning of material sites, licensees are required to perform a number of actions including certification of the disposition of all licensed material and performance of a radiation survey of the premises.[97]

E.2.1.5 Nuclear Regulatory Commission's Integrated Materials Performance Evaluation Program

NRC, in coordination with the Agreement States, developed and piloted a review process in 1994 for Agreement State and NRC regional materials programs called the Integrated Materials Performance Evaluation Program (IMPEP). Common performance indicators were established to obtain comparable information on the performance of each program. NRC began full implementation of IMPEP in 1996 to ensure that public health and safety are adequately protected from potential hazards of using radioactive materials and to ensure that Agreement

[93] See https://www.nrc.gov/waste/decommissioning/public-involve.html.
[94] Additional information on the decommissioning process for reactors is available at: https://www.nrc.gov/waste/decommissioning/process.html.
[95] Major steps in the complex materials site decommissioning process are described at: https://www.nrc.gov/waste/decommissioning/process.html.
[96] See NRC's decommissioning oversight activities at https://www.nrc.gov/waste/decommissioning/oversight.html.
[97] Specific details for unrestricted versus restricted release, schedules for notification and completion of decommissioning milestones, as well as alternatives in the compliance with regulatory requirements for decommissioning are discussed in greater detail at https://www.nrc.gov/waste/decommissioning.html.

State programs are compatible with NRC's program.[98]

IMPEP utilizes a team of NRC and Agreement State staff to assess the performance of both Agreement State and NRC Radioactive Material Programs. All reviews use the following common performance indicators in the assessment:

- Technical Staffing and Training;
- Status of Materials Inspection Program;
- Technical Quality of Inspections;
- Technical Quality of Licensing Actions; and
- Technical Quality of Incident and Allegation Activities.

Additional areas are identified as non-common performance indicators (Compatibility Requirements, Sealed Source and Device Evaluation Program, Low-Level Radioactive Waste Disposal Program, and Uranium Recovery Program) and may also be addressed in the assessment. NRC regional programs are reviewed similarly to the Agreement States but are not reviewed for compatibility.

The final determination of adequacy of each NRC regional program and both adequacy and compatibility of each Agreement State program is made by a Management Review Board (MRB) composed of NRC managers and an Agreement State program manager who serves as the Agreement State liaison to the MRB. IMPEP review reports recognize good practices and lessons learned, which are made available to all regulatory programs.[99] Lessons learned reflect input and feedback from Agreement State officials and NRC regional staff.

E.2.2. Environmental Protection Agency

EPA has several radioactive waste regulatory functions that are described in more detail below. EPA is composed of a headquarters organization and 10 regional offices. Each EPA regional office is responsible for executing EPA's programs with states in its region. EPA also has 17 laboratories located across the nation.

E.2.2.1 Waste Isolation Pilot Plant Oversight

The Waste Isolation Pilot Plant (WIPP) Land Withdrawal Act (LWA), as amended, requires EPA to issue final regulations for disposal of spent fuel, HLW, and transuranic (TRU) waste. The WIPP LWA also gives EPA authority to develop criteria implementing final WIPP radioactive waste disposal standards. The WIPP LWA specifies that EPA must also determine every five years whether the WIPP facility is in compliance with final disposal regulations. The WIPP LWA also requires EPA to determine whether WIPP complies with other Federal environmental and public health and safety regulations, such as the Clean Air Act (CAA) and the Solid Waste Disposal Act.

[98] The IMPEP program was selected in 2004 as among the top 50 programs for the "Innovations in American Government Awards," sponsored by the Ash Institute for Democratic Governance and Innovation at Harvard University's John F. Kennedy School of Government and administered in partnership with the Council for Excellence in Government.

[99] See https://scp.nrc.gov/impeptools.html.

EPA issued final amendments to its radioactive waste disposal standards for spent fuel, HLW, and TRU waste on December 20, 1993, which were initially promulgated in 1985 (40 CFR Part 191). The final individual protection standards require disposal systems to limit the amount of radiation that an individual can be exposed for 10000 years. The final groundwater protection standards require disposal systems to be designed so that for 10000 years after waste disposal, contamination in off-site underground sources of drinking water will not exceed the maximum contaminant level for radionuclides established by EPA under the Safe Drinking Water Act (SDWA). Containment requirements of Subpart C limit releases of radionuclides to specified levels for 10000 years after the facility accepts its final waste for disposal, while assurance requirements involve additional measures intended to provide confidence in the long-term containment of radioactive waste. EPA issued final compliance criteria on February 9, 1996 (40 CFR Part 194), for certification and recertification of WIPP compliance with the final radioactive waste disposal standards in 40 CFR Part 191.

DOE submitted a Compliance Certification Application to EPA on October 29, 1996, to demonstrate WIPP complies with the criteria at 40 CFR Part 194. EPA then conducted a very open certification review process, involving multiple opportunities for written public comments and public hearings. EPA issued a Final Rulemaking Notice on the certification decision on May 18, 1998. WIPP received its first TRU waste shipment on March 26, 1999.

DOE is required to apply to EPA for re-certification every 5 years. DOE submitted the third Compliance Recertification Application in March 2014. EPA's decision to recertify WIPP's compliance was issued on July 19, 2017 (82 FR 33106).

The Office of Radiation and Indoor Air coordinates most EPA actions under the WIPP LWA. Other EPA offices also play important roles concerning WIPP. EPA’s Region VI office, based in Dallas, Texas, is responsible for collecting and reviewing information related to WIPP compliance with all applicable environmental laws and regulations other than the radioactive waste disposal standards, and provides a recommendation to the EPA administrator. The Region VI office also coordinates with EPA’s Office of Resource Conservation and Recovery on hazardous waste issues. Some TRU waste intended for disposal at the WIPP also contains hazardous waste components, subjecting it to the regulations developed under the Resource Conservation and Recovery Act of 1976, as amended (RCRA).

EPA conducts inspections of both waste generators and WIPP operations. Separate inspections may be conducted for waste characterization activities, quality assurance, or WIPP site activities (procedural or technical).

The State of New Mexico is authorized by EPA to carry out the base RCRA and mixed waste programs in lieu of equivalent Federal programs. The New Mexico Environment Department reviews permit applications for treatment, storage, and disposal facilities for hazardous waste, under Subtitle C of RCRA. WIPP’s Hazardous Waste Facility Permit (HWFP) is renewed every 10 years. The updated HWFP was approved on November 30, 2010, and the permit’s effective date was December 30, 2010.

E.2.2.2 Environmental Protection Agency High-Level Waste and Spent Fuel Disposal Standards

In addition to EPA's generally applicable standards in 40 CFR Part 191, the EPAct92 required EPA to develop radiation protection standards specifically for the Yucca Mountain site to protect the public and the environment from exposure to radioactive wastes disposed in the repository (40 CFR Part 197). These standards were issued in 2001. As a result of a legal challenge to the regulatory compliance period, EPA amended the standard to extend the compliance period and incorporate other supporting provisions. The amended standards were issued in 2008. Further legal challenge to the amended standards is stayed pending resolution of NRC's license review.

E.2.2.3 Mixed Waste Regulation

A dual regulatory framework exists for mixed waste. EPA or authorized states regulate the hazardous waste component and NRC, NRC Agreement States, or DOE regulate the radioactive waste component. NRC and DOE regulate mixed waste radioactive waste components using AEA authority. EPA regulates mixed waste hazardous waste components under its RCRA authority. NRC is authorized by the AEA to issue licenses to commercial users of radioactive materials. RCRA gives EPA authority to control hazardous waste from "cradle-to-grave." Waste handlers must comply with both AEA and RCRA statutes and regulations once a waste is found to be a mixed waste. The requirements of RCRA and AEA are generally consistent and compatible. The provisions in Section 1006(a) of RCRA allow the AEA to take precedence if provisions of requirements of the two acts are inconsistent.

Land Disposal Restriction regulations, under the 1984 Amendments to RCRA, prohibit disposal of most mixed waste until it meets specific treatment standards for hazardous waste, which may be based on a concentration for hazardous constituents or a specific treatment technology. Most commercial mixed waste (generated and stored) can be treated to meet Land Disposal Restriction regulations with commercially available treatment technology. No treatment or disposal capacity is available for a small percentage of commercial mixed waste. Commercial mixed waste volumes are very small (approximately two percent) compared to the total volume of mixed waste being generated or stored by DOE.

DOE has developed Site Treatment Plans to handle its mixed wastes under the Federal Facilities Compliance Act, signed into law on October 6, 1992. These plans are being implemented by orders issued by EPA or the state regulatory authority.

EPA issued regulations in 2001 allowing certain mixed waste to be exempted from RCRA hazardous waste requirements, as long as it meets NRC or Agreement State requirements. These regulations 40 CFR Part 266, Subpart N, apply to:

- Storage at the generator site or another site operating under the same license;
- Treatment in a tank or container at the generator site or another site operating under the same license;
- Transportation to a licensed treatment facility or LLW disposal facility; and
- Disposal at a licensed LLW disposal facility, as long as the waste meets RCRA treatment standards.

E.2.2.4 Uranium Mining and Milling Standards

UMTRCA, which amended the AEA, directed EPA to establish standards for active and inactive uranium and thorium mill sites (see Section D.2.2.3). The standards for active sites were issued in 1983 as 40 CFR Part 192 (and amended in 1995), and establish limits on radon emanations from tailings, as well as contamination limits for buildings, soil, and groundwater. NRC incorporated these standards into its regulations in 10 CFR Part 40, Appendix A. A key aspect of UMTRCA is that it required EPA's standards to address non-radiological contaminants in a manner consistent with EPA's requirements for managing hazardous waste. The inactive site standards, 40 CFR Part 192, Subparts A, B and C are implemented by DOE at inactive sites.

The AEA does not identify uranium-mining overburden as radioactive material to be controlled, and NRC and DOE do not regulate the disposition of conventional mining wastes as part of the nuclear fuel cycle. Once uranium-mining product is beneficiated or is brought into the milling circuit, including production from ISR operations, then NRC and its Agreement States regulate its possession, use, transport, etc. On January 19, 2017, EPA proposed new groundwater protection standards at facilities that extract uranium using the ISR process and accepted comments through July 18, 2017.

EPA has also established National Emission Standards for Hazardous Air Pollutants (NESHAPs) under the CAA for airborne radionuclide emissions from a variety of industrial sources (40 CFR Part 61). Subparts B, T, and W of the CAA apply to underground uranium mines, inactive uranium mill tailings piles, and active uranium mill tailings piles, respectively. EPA issued final revisions to the Subpart W standards on January 17, 2017.[100] The final rule specifies management practices to be used to control radon emanation from conventional tailings impoundments, non-conventional impoundments (e.g., evaporation ponds), and heap leach facilities. See Section E.2.2.4 of the U.S. Third National Report for more information on these regulations.

E.2.2.5 Other Environmental Protection Agency Radiation-Related Authorities

EPA has regulatory responsibilities for the following:

- Developing general radiation protection guidance to be used by the Federal Government. Section F contains additional information about radiation protection;
- Limiting airborne emissions of radionuclides. Subpart H of EPA's NESHAPs standards limits the airborne emissions of radionuclides (other than radon) from DOE sites managing defense-related spent fuel and radioactive waste. A limit of 0.1 milisievert per year (mSv/a) effective dose equivalent is applied to any member of the public in the vicinity of such sites. Emission monitoring is specified, and DOE sites are required to submit an annual compliance report to EPA. Subpart I applied similar requirements to NRC-licensed facilities but was rescinded when NRC established comparable requirements—Subpart I now applies only to Federal facilities other than DOE that are not licensed by NRC;
- Setting drinking water regulations, under the SDWA, as amended, including standards for radionuclides in community water systems;
- Controlling water pollution by regulating point sources that discharge pollutants into surface

[100] See *Revisions to National Emission Standards for Radon Emissions From Operating Mill Tailings*, 82 FR 5142 (January 17, 2017).

waters. Point sources are discrete conveyances such as pipes or man-made ditches. The Clean Water Act authorizes the National Pollutant Discharge Elimination System (NPDES) permit program. These permits apply to such activities as dewatering mines to allow resource recovery of minerals. In most cases, the NPDES permit program is administered by EPA authorized states;

- Remediating radiologically contaminated sites listed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL). See Section D.3.4. The NPL includes sites licensed by NRC or Agreement States, as well as some DOE sites. EPA and NRC entered into a MOU in October 2002 to avoid future confusion about the potential for dual regulation at decommissioned sites. This MOU defines conditions where the two agencies would consult on the decommissioning of NRC-licensed facilities;[101]
- Coordinating with state radiation protection agencies to protect the environment, workers, and the public from naturally occurring radioactive materials exposed or concentrated by mining or processing; and
- Coordinating with DOE, NRC and states on orphaned sources, recycled materials, and controlling imports and exports to prevent radioactively contaminated scrap from entering the U.S.[102] See Sections I and J for additional information.

E.2.3. Department of Energy

DOE is responsible for regulating its spent fuel and radioactive waste management activities pursuant to the AEA (see Table E-1 in the U.S. Fourth National Report), except where Congress has specifically given NRC licensing and related regulatory authority over DOE activities or facilities. Radiation and environmental protection are ensured by a rigorous framework of Federal regulations, DOE Directives (e.g., DOE Orders), and external recommendations by the Defense Nuclear Facilities Safety Board (DNFSB). The major applicable Federal regulations include 10 CFR Part 820, *Procedural Rules for DOE Nuclear Activities*,[103] 10 CFR Part 830, *Nuclear Safety Management*,[104] and 10 CFR Part 835, *Occupational Radiation Protection*.[105] (See Section F.4.3.)

DOE also regulates facility operations and radiation protection through standards and requirements established in DOE Orders. The major applicable Orders include DOE O 458.1, *Radiation Protection of the Public and the Environment*[106] (see Section F.4.3) and DOE O 435.1, *Radioactive Waste Management*.[107] Table E-1 provides a list of spent fuel and radioactive waste management Federal regulations, and DOE Orders.

---

[101] See Office of Solid Waste and Emergency Response Directives 9295.8-06 and 9295.8-06a at https://www.epa.gov/superfund/radiation-superfund-sites#tab-6.

[102] Coast Guard and Department of Homeland Security Customs and Border Protection have the lead in detecting and taking steps to prevent the illegal entry of such materials. They have the authority to take enforcement actions and, depending on the circumstances, may seize or have a shipment returned to the point of origination.

[103] See https://www.gpo.gov/fdsys/granule/CFR-2011-title10-vol4/CFR-2011-title10-vol4-part820.

[104] See https://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title10/10cfr830_main_02.tpl.

[105] See https://www.gpo.gov/fdsys/granule/CFR-2011-title10-vol4/CFR-2011-title10-vol4-part835.

[106] See https://www.directives.doe.gov/directives-documents/400-series/0458.1-BOrder.

[107] See https://www.directives.doe.gov/certification-memos/doe-o435.1-1chg1-and-m435.1-1chg1-certification.

The following sections describe regulation and oversight of DOE's spent fuel and radioactive waste management activities.

E.2.3.1 Department of Energy Regulatory Requirements and Independent Oversight

The Office of Environment, Health, Safety and Security (AU)[108] provides corporate leadership and strategic approaches for protecting DOE's workers, the public, the environment and national security assets. This mission is accomplished through developing corporate policies, standards, and implementation guidance; sharing operating experience, lessons learned, and best practices; and providing technical assistance and support services to DOE programs to identify and resolve environment, safety, health, safeguards, and security issues.

AU develops, manages, and directs programs and policies to protect health and safety of workers and the safety of facility and systems operations. It serves as the primary DOE liaison with Department of Labor Occupational Safety and Health Administration and NRC on health and safety regulation reviews and pending regulatory reform.

The Office of Enterprise Assessment[109] provides an independent regulatory oversight function within DOE, reporting to the Office of the Secretary of Energy. The office serves as a check and balance to ensure that meets DOE meets its responsibilities as a self-regulating entity, and to protect health and safety, and is responsible for:

- Performing assessments in the areas of nuclear and industrial safety, cyber and physical security, and other functions;
- Implementing an investigative capability to conduct Congressionally-mandated enforcement functions in the areas of worker safety and health, nuclear safety, and security;
- Implementing the Enforcement Program to promote overall improvement in DOE's nuclear safety, worker safety and health, and security programs;
- Managing the Independent Oversight Program, providing an independent evaluation of the adequacy of DOE's policy and the effectiveness of line management performance in safeguards and security, cyber security, emergency management, environment, safety, and health;
- Conducting independent reviews of DOE sites, facilities, organizations, and operations in the areas of safety and emergency management; and
- Conducting special reviews of safety and emergency management topics at the request of line management, or as directed by senior DOE management.

DOE regulations in 10 CFR Parts 820, 830, and 835 make DOE nuclear safety requirements subject to enforcement, including the imposition of civil and criminal penalties. Additional functions are: maintaining the internal self-regulatory program; investigating potential violations; and, where warranted, initiating enforcement actions including imposing civil penalties. Those actions are performed according to processes and procedures in 10 CFR Part 820.

[108] See https://energy.gov/ehss/environment-health-safety-security.
[109] See https://www.energy.gov/ea/office-enterprise-assessments.

Oversight activities are further described in DOE O 227.1A, Independent Oversight Program[110] and DOE O 226.1B, *Implementation of Department of Energy Oversight Policy*.[111]

The Low-Level Waste Disposal Facility Federal Review Group (LFRG)[112] was established to fulfill oversight responsibilities for LLW onsite disposal facilities, as well as tank closure. DOE headquarters and site personnel roles and requirements are described in DOE O 435.1. LFRG serves as the regulatory oversight body for compliance reviews of performance assessments, composite analyses, and other documents necessary for design and operation. In addition, annual reviews are submitted to LFRG for review to ensure that all requirements continue to be met.

DOE's Office of the General Counsel (and the National Nuclear Security Administration Office of the General Counsel, as appropriate) provides legal advice regarding compliance with applicable Federal statutes and regulations. It assists in preparing environmental impact statements for major DOE proposed actions.

E.2.3.2 Defense Nuclear Facilities Safety Board

The DNFSB is an independent Federal agency established by Congress in 1988. DNFSB's mandate under the AEA is to make nuclear safety recommendations concerning DOE defense nuclear facilities. DNFSB reviews and evaluates the content and implementation of DOE health and safety standards for design, construction, operation, and decommissioning of defense nuclear facilities. DNFSB is authorized to recommend to the Secretary of Energy any specific measures, such as changes in content and implementation of those standards, DNFSB believes should be adopted to ensure the public health and safety are adequately protected. DNFSB also reviews the design of new defense nuclear facilities before construction begins, as well as modifications to older facilities, and is authorized to recommend changes to protect public health and safety.

E.2.3.3 Other Federal Regulators

Certain DOE facilities and operations are subject to regulation and independent oversight by other agencies as described in Section E.2 above. Both NRC and EPA have oversight over certain DOE facilities. For example, under the Ronald W. Reagan Defense Authorization Act for Fiscal Year 2005, NRC has a consultation and monitoring role over waste from reprocessing determined not to be HLW at DOE sites in Idaho and South Carolina (see Section B.3.4). Under Section 3116, DOE consults with NRC prior to the Secretary of Energy's final determination that waste can be treated as LLW; and after the Secretary's determination, NRC and the state monitor DOE disposal actions to determine compliance with the performance objectives in 10 CFR Part 61. Another example is that EPA certifies the WIPP (see Section D.2.2.1) through its WIPP LWA authority (Section E.2.2.1). Lists of spent fuel and radioactive waste management facilities and their licensing authority are in Annexes D-1A-D-1D and Annexes D-2A and D-2B.

[110] See https://www.directives.doe.gov/directives-documents/0227.1-BOrder.
[111] See https://www.directives.doe.gov/directives-documents/0226.1-BOrder-b.
[112] See https://energy.gov/em/low-level-waste-disposal-facility-federal-review-group-lfrg.

E.2.3.4 State Authorities

EPA authorized states play a significant role in regulation and independent oversight of DOE facilities (see Section E.2.4.1). Most of DOE's cleanup is performed under CERCLA through Federal Facility Agreements (FFAs), and under RCRA through various consent and compliance orders. These enforceable regulatory agreements and orders with Federal and state agencies establish the scope of work to be performed at a given site and the dates that specific cleanup milestones must be achieved. Failure to comply with these agreements and orders is subject to fines and penalties. Table E-2 describes the types of regulatory agreements.[113]

DOE has successfully developed a close working relationship with tribal governments, state regulators, and local citizens. DOE's Office of Environmental Management has the largest Federal Advisory Committee Act chartered citizen advisory board in the Federal Government with boards at eight cleanup sites. DOE also supports working groups with the National Governors' Association, the National Conference of State Legislators, the Energy Communities Alliance (which represents local communities at cleanup sites), the State and Tribal Government Working Group, the National Association of Attorneys General, Nuclear Energy Tribal Working Group, and the Environmental Council of the States.

E.2.3.5 Nuclear Waste Technical Review Board

The Nuclear Waste Technical Review Board (NWTRB) was created by Congressional legislation in the 1987 amendments to the NWPA. It advises both Congress and the Secretary of Energy on technical issues related to DOE's implementation of the NWPA. The NWTRB evaluates the technical validity of all activities undertaken by the Secretary of Energy related to DOE's obligation to manage and develop an approach to dispose of spent fuel and HLW. The NWTRB is a unique Federal agency and is completely independent, non-partisan and non-political. Its 11 members are appointed by the President from a list of nominees submitted by the National Academy of Sciences that makes its nominations based solely on the expertise of the individual in relevant scientific and engineering disciplines. The independent technical peer review offered by the NWTRB contributes to the acceptance of different approaches to managing nuclear waste by the public and scientific communities. The NWTRB is an organization that performs an independent and integrated technical evaluation of DOE's implementation of the NWPA.

E.2.4. State Regulatory Authorities

Provisions of law allow NRC and EPA to delegate or relinquish certain regulatory responsibilities to the states having radioactive materials or nuclear facilities. More complex facilities such as NPPs are regulated by Federal authorities. Regional arrangements allow closer coordination with licensees who often do not reside close to the regulator's headquarters location. These arrangements are not necessarily mandatory; where the state can demonstrate adequate competencies, the appropriate Federal agency may be able to transfer regulatory authority.

[113] The status of cleanup projects can be found at https://energy.gov/em/cleanup-sites.

Table E-2 Regulatory and Agreement Order Descriptions	
Agreement/Order	**Description**
Federal Facility Agreement (FFA)	A legal agreement among DOE, EPA, and sometimes the state. It sets forth schedules and processes for site cleanup under CERCLA, including enforcement provisions for non-compliance. FFAs that include the state as a party often incorporates RCRA compliance requirements, as well as state hazardous waste law requirements that flow from RCRA.
Consent Order Or Consent Agreement Or Settlement Agreement	A legal agreement between DOE and EPA or the state, documenting the settlement of a cleanup issue outside of court. Consent orders, consent agreements, and settlement agreements are legally binding, so compliance disputes may ultimately be taken to court. Most consent orders, consent agreements, and settlement agreements address RCRA issues or state hazardous waste issues that flow from RCRA, although they can also address CERCLA issues. A few also incorporate Toxic Substances Control Act requirements.
Consent Decree	A court-issued enforceable order, generally reflecting an agreement between DOE and EPA or the state. Consent decrees can cover CERCLA or RCRA, as well as state hazardous waste laws.
Site Treatment Plan and Compliance Order	A legal agreement and plan developed under the Federal Facility Compliance Act and RCRA for DOE facilities that generate or store mixed wastes, setting schedules to treat all the facilities' mixed waste.

E.2.4.1 Environmental Protection Agency Authorized States

EPA delegates authorities to states in two areas of radioactive waste management. NESHAPs regulations are based on the requirements of the CAA law, and the authority for delegating to states is described by law. A state must have emission limits at least as stringent as EPA's national standards. Most states have not pursued delegation of NESHAPs regulation. EPA's process for delegating RCRA hazardous waste requirements to states is similar (but would apply to the hazardous waste portion of mixed waste). The state must have a program at least as stringent as EPA's, and the application for authorization must address specific areas of compatibility. The statutory basis for specific rules, however, may differ. Some "base" requirements must be adopted by states, while states may choose not to adopt other rules. The rule issued by EPA in 2001, and described in Section E.2.2.3, allowing mixed radioactive and hazardous waste generators to remain exempt from the hazardous waste requirements, for example, is not immediately effective in authorized states because it provides for a less stringent method of managing these wastes.

E.2.4.2 Nuclear Regulatory Commission Agreement States

The AEA provides a statutory basis for NRC to discontinue portions of its authority to license and regulate byproduct material, source material, and certain quantities of special nuclear material (i.e., quantities of special nuclear material not sufficient to form a critical mass) and allow individual states to assume this authority. NRC retains regulatory authority over NPPs, conversion and enrichment facilities, and the export from or import into the U.S. of byproduct, source, or special nuclear material. NRC also retains the authority to approve the final disposition of a uranium recovery site prior to its transfer to DOE, after closure activities are completed. As of April 2017, 37 of the 50 states have entered into agreements with NRC. These states are called Agreement States.

To become an Agreement State, a state must establish a radiation protection program that is at least as protective as NRC's, is adequate to protect public health and safety, and is compatible with NRC regulations and requirements. The state will adopt compatible legislation and regulations in accordance with their legal system. The state will also develop a program that includes procedures, fee recovery, and enforcement, and maintains sufficient staff for radiation protection programs for agreement materials (byproduct, source, and certain quantities of special nuclear material). Once NRC is satisfied that the state has a program in place to allow a seamless regulatory transition from NRC to the state, NRC will approve the agreement. An Agreement State has similar authority as NRC for the regulation of agreement materials and facilities within the state, while NRC retains overall program review authority.

NRC periodically reviews the performance of each Agreement State to ensure that public health and safety are adequately protected from potential hazards associated with the use of radioactive materials and that Agreement State programs are compatible with NRC's program. See Section E.2.1.5 on NRC's IMPEP.

Agreement States issue radioactive material licenses, promulgate regulations, and enforce those regulations under the authority of each individual state's laws. The Agreement States conduct their licensing and enforcement actions under general direction of the Governor of each state in a manner compatible with the licensing and enforcement programs of NRC.

NRC assistance to states entering into agreements includes review of requests from states to become Agreement States or amendments to existing agreements, meetings with states to discuss and resolve NRC review comments, and recommendations for NRC approval of proposed agreements. NRC also conducts training courses and workshops; evaluates technical licensing and inspection issues from Agreement States; evaluates state rule changes; participates in activities conducted by the Organization of Agreement States[114] and the Conference of Radiation Control Program Directors, Inc.;[115] and provides early and substantive involvement of the Agreement States in NRC rulemaking and other regulatory efforts. NRC also coordinates with Agreement States on event reporting and information, reciprocity arrangements (e.g., to allow an Agreement State licensee to conduct activities in areas under NRC jurisdiction) and responses to allegations reported to NRC involving Agreement States.

[114] See http://www.agreementstates.org.
[115] See http://www.crcpd.org.

F. OTHER GENERAL SAFETY PROVISIONS

Section F addresses other general safety provisions in Articles 21-26 of the Joint Convention including:

- License holder responsibilities;
- Human and financial resources;
- Quality assurance (QA);
- Operational radiation protection;
- Emergency preparedness; and
- Decommissioning.

This section also addresses Articles 4-9 and Articles 11-16. The following provisions are common for both spent fuel and radioactive waste management:

- General safety requirements;
- Existing facilities;
- Siting proposed facilities;
- Facility design and construction;
- Facility safety assessment; and
- Facility operation.

Sections G and H of the United States of America (U.S.) National Report, address these same areas plus Articles 10 and 17 of the Joint Convention for Disposal of Spent Fuel Spent Fuel and Institutional Measures after Closure. These sections also provide additional information specific to management of spent fuel or radioactive waste.

Section E presents the various regulations and directives, many of which are referenced in the following sections governing safety requirements in the U.S., including those for spent fuel management. Most of these regulations are available electronically on the internet. See Table A-2.

This report focuses on important issues and provisions mentioned above. See additional background and specific information in the U.S. Fifth National Report, Section F.[116]

F.1. License Holder Responsibilities (Article 21)

The Joint Convention specifies each Contracting Party must ensure the prime responsibility for safety of spent fuel and radioactive waste management rests with the licensee, and each licensee takes the appropriate steps to meet its responsibility; the government has the responsibility only if there is no licensee. Nuclear Regulatory Commission (NRC) and Agreement State regulations ensure licensees are responsible for safe radioactive waste and

[116] See https://energy.gov/sites/prod/files/2014/10/f18/5th_US__National%20Report_9-18-14.pdf.

spent fuel management. NRC holds the entity specified in the license or certificate as the responsible party for enforcement purposes. Licensees of commercial disposal facilities eventually transfer title and control of these facilities to Federal or state government agencies for long-term stewardship[117] through two regulatory frameworks, one for low level waste (LLW) disposal [Title 10 of the *Code of Federal Regulations* (10 CFR) Part 61] and the other for uranium mill tailings disposal (10 CFR Part 40).

F.2. Human and Financial Resources (Article 22)

Both NRC-regulated and Department of Energy (DOE) facilities have requirements to ensure human and financial resources are sustained for spent fuel and radioactive waste management activities. Table F-1 provides information from NRC on human resources in terms of full-time equivalent (FTE) staff dedicated to regulation in various programmatic areas. It should be noted that these numbers reflect the resources requested in NRC's Fiscal Year (FY) 2018 Congressional Budget Justification.[118]

Table F-1 Distribution of the Nuclear Regulatory Commission's Full-Time Equivalent as Submitted within the Fiscal Year 2018 Congressional Budget Justification

Budgeted Program	FTE Requested
Nuclear Reactor Safety	1978
Nuclear Materials and Waste Safety	627
Corporate Support	616
Inspector General	63
Total	**3284**

Table F-2 provides a breakdown for the human resources in terms of FTEs needed to support the Nuclear Materials and Waste Safety program including radioactive waste, spent fuel and oversight (which includes enforcement). Oversight is a subset of the Regulatory Program. The programmatic categories of nuclear materials and waste safety consist of 627 FTEs. Approximately 93 FTEs or 15 percent of these FTEs are allocated to oversight and enforcement activities.

Table F-2 Nuclear Regulatory Commission Staffing for Materials and Waste Management

Regulatory Program[119]	FTEs Requested for FY 2018
Fuel Facilities	114
Nuclear Materials Users	223
High Level Waste Repository	71

[117] On January 19, 2001, the Utah Radiation Control Board granted Energy*Solutions* Utah an exemption to the state and Federal land ownership rule.
[118] The document is available at NRC's Agencywide Documents Access and Management System (ADAMS), under ML17137A246.
[119] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1100/v32/.

Table F-2 Nuclear Regulatory Commission Staffing for Materials and Waste Management	
Regulatory Program[119]	**FTEs Requested for FY 2018**
Spent Fuel Storage and Transportation	103
Decommissioning and LLW	116
Materials and Waste Safety Total	**627**
Oversight (includes Enforcement)	**FTEs Requested for FY 2018**
Spent Fuel Storage and Transportation	13
Decommissioning and LLW	27
Nuclear Materials Users	53
Oversight Total	**93**

NRC has a report, NUREG-1542, *Performance and Accountability Report - Fiscal Year 2016*, Vol. 22,[120] which summarizes the performance of its mission to protect people and the environment through the regulation of nuclear power and use of nuclear material. It provides key financial and performance information for the U.S. Congress and the public to assess how well it has carried out its mission. This report also documents the finding of an independent auditor on NRC's condensed financial statements. This summary is part of a larger effort to implement openness and transparency in NRC's program performance and financial management information.[121]

NRC's Project Aim

Project Aim is an NRC initiative to improve agency efficiency, effectiveness, and agility. The initiative was driven largely by the need to align NRC's regulatory work environment, structure, and processes with numerous changes that have occurred over the past several years. In response to the September 11, 2001, terrorist attacks, NRC grew significantly to enhance security and incident response. Additionally, NRC added staff to prepare for projected growth in the use of nuclear power in the U.S. The forecasted growth did not occur because of market conditions in the nuclear industry and other factors that resulted in fewer planned new nuclear facilities and the early closure of existing plants. Among these other factors, the accident at Fukushima-Daiichi further eroded interest in moving forward aggressively with construction of new nuclear facilities in the U.S.

Several recommendations related to Project Aim were proposed and are documented in SECY-15-0015, *Project Aim 2020 Report and Recommendations*, dated January 31, 2015.[122] Among these recommendations were the following activities to help NRC function more efficiently:

- Right-sizing NRC while retaining appropriate skill sets needed to accomplish its mission;
- Streamlining NRC processes;
- Improving timeliness in regulatory decision making and responding quickly to changing

[120] The document is available at NRC's ADAMS, under ML16320A585.
[121] Additional detailed information on NRC's approach to open government is accessible at: https://www.nrc.gov/public-involve/open.html.
[122] The document is available at NRC's ADAMS, under ML15012A594.

conditions; and

- Promoting unity of purpose with clearer agency wide priorities.

The Project Aim activities included a "re-baselining" effort to identify work that can be shed or eliminated, deferred, or done with fewer resources. This task, which involved a broad review of NRC's workload, resulted in recommended efficiencies as documented in SECY-16-0009, *Recommendations Resulting from the Integrated Prioritization and Re-Baselining of Agency Activities*, dated January 31, 2016.123 Implementation plans have been developed to achieve these approved efficiencies in an open, collaborative, and transparent manner.

Education, Recruitment, Training and Development, and Knowledge Management

Education and Training Initiative. The U.S. is committed to investing in the next generation of science and technology savvy leaders who will advance university-led innovation, promote a workforce capable of designing, constructing, safely operating, and regulating facilities related to spent fuel and radioactive waste management. The U.S. has numerous opportunities for education and training pertaining to various scientific and engineering fields that support the safe handling, management and disposition of spent fuel and radioactive waste. Education and training needs are met by several means, including college and university undergraduate and graduate programs in nuclear science, environmental sciences and engineering related disciplines; collaboration between academia and industry where major U.S. technology companies and utilities support university research; and engaging in international outreach and encouraging international students to apply to U.S. engineering programs as a means of further improving their home countries' radioactive material/waste, nuclear engineering and nuclear power programs.

In addition, the U.S. supports nuclear research and development activities; human capital development activities such as faculty development grants, curriculum development grants, graduate fellowships, and undergraduate scholarships; and infrastructure and equipment upgrades for university-based research reactors and laboratories. These initiatives to increase nuclear resources, capabilities, and workforce have broad implications for managing spent fuel and radioactive waste. NRC has programs for educating and recruiting competent staff and employees, resulting in recruitment of recent graduates with strong academic records in appropriate disciplines. Additionally, over 40 utility/community college partnerships are set up to educate and train a large cohort of technicians who would be qualified to enter the nuclear industry workforce. This program, called the "Nuclear Uniform Curriculum" is organized by the Nuclear Energy Institute and is coordinated with the Institute of Nuclear Power Operators training requirements.

The Fulbright Scholarship Program is the flagship international educational exchange program sponsored by the U.S. Government and is designed to increase mutual understanding between the people of the U.S. and the people of other countries. The Fulbright Program has provided participants—chosen for their academic merit and leadership potential—with the opportunity to study, teach and conduct research, exchange ideas and contribute to finding solutions to shared international concerns. The Fulbright Program is sponsored by the Department of State's Bureau of Educational and Cultural Affairs and Public Affairs Officers in U.S. Embassies. The Fulbright Program offers a broad array of opportunities for studies including science, technology, and engineering awards and scholarships. These include opportunities for U.S.

[123] The document is available at NRC's ADAMS, under ML16028A208.

scientists and engineers to study abroad and international students to study in the U.S. Historically, the Fulbright Program has not focused on spent fuel and radioactive waste management; a new emphasis is being placed on opportunities that include managing spent fuel and radioactive waste.

Human Resources. Federal agencies within the U.S. have developed comprehensive human resources systems within Government-wide laws and regulations, as well as any unique agency statutes to prepare for meeting mission requirements and individual strategic goals and objectives. The Federal Government regularly solicits feedback in an effort to gain independent and diverse perspectives on ways to improve its work environment and often explores various channels that seek to provide meaningful insights about employees and their work experience. One such mechanism is workforce surveys. The Office of Personnel Management's (OPM's) Federal Employee Viewpoint Survey is mandated by OPM regulations and is conducted annually to measure employee perceptions of the work environment. These surveys provide unique, but also overlapping, insights on the workplace that together build a comprehensive picture of employees' experiences with their job, supervisors, and work units.

Workforce Planning. Workforce planning is a major component of strategic human capital management. It is defined as the systematic process for identifying and addressing the gaps between the workforce of today and the human capital needs of tomorrow. Workforce planning is also an essential tool for aligning human resource requirements through prioritization and shaping of mission related workforce requirements and associated budgetary considerations so organizations can effectively and efficiently meet their strategic objectives. The workforce planning process is a continuous, cyclical process that must begin well before the budget implementation cycle. For example in 2016, NRC created a Strategic Workforce Plan to use as a roadmap to manage its workforce. NRC's plan created a panel made up of senior managers from across NRC to develop methods to facilitate movement of employees within NRC in response to occupational and other hiring needs. NRC instituted a standardized and automated system to identify office staffing needs and to facilitate workforce planning decisions. On January 19, 2017, NRC established a multi-office working group to enhance NRC's existing Strategic Workforce Planning process and better integrate NRC's workload projection, skills identification, human capital management, individual and organizational development, and workforce management. The working group provided recommendations to accomplish these enhancements based on a review of best practices used by the private and public sector.

Recruitment and Hiring. The Federal Government is focused on hiring strong applicants prepared to successfully perform critical skill sets, while still emphasizing Government-wide programs such as hiring of the disabled, employment of veterans, and enhancing diversity. A number of internal and external factors drive changes at Federal agencies. For instance, at NRC forces affecting hiring include flat or decreasing budgets and a lower than projected number of new reactors.

Effective recruitment in high-performing organizations occurs when management is committed to the process and human capital efforts are tied to the agency's mission and program goals. The agency's recruiting and workforce planning efforts must be based on the understanding of the talent challenges, hiring needs, required skills and competencies and a comprehensive, well integrated strategic human capital plan. Hiring priorities and overall recruitment strategies must be carefully analyzed, outlined, well developed, and approved in the workforce planning process.

To meet current and future critical skill needs, the Federal Government targets recent graduates

with strong academic performance in a variety of science and engineering fields (e.g., NRC's Nuclear Safety Professional Development Program). In addition, the Federal Government maintains recruitment activities at targeted universities, professional society conferences and career fairs, as well as placing advertisements in trade journals and web sites to attract professionals in specialized technical disciplines.

The Federal Government makes prudent, targeted use of recruitment, relocation, and retention incentives and pension offset waivers (rehiring annuitants without reduction of salary or pension) to hire and retain employees in mission critical positions. Such incentives are particularly useful for unusual occupations or highly specialized disciplines with few candidates. The Federal Government continues to strengthen student hiring in critical specialties through programs such as the Pathways Program, which provides for cooperative education programs and for targeted appointment of recent graduates leading to permanent career status. The Energy Policy Act of 2005 enables NRC to enter into agreements with colleges and universities to offer university scholarship and fellowship grants, and to offer payment of transportation and lodging expenses for student employees. DOE and Environmental Protection Agency (EPA) use similar arrangements for offering the Oak Ridge Institute for Science and Education (ORISE) Internships, Scholarships and Fellowships. The ORISE and Oak Ridge Associated Universities administer internships and research project training opportunities funded by DOE and EPA offices, as well as other government and commercial sector organizations. These opportunities are available year-round to science and engineering undergraduates, graduate students, recent graduates and post-doctoral researchers.

DOE's Florida International University (FIU) Science and Technology Workforce Development Program is an innovative grant program designed to increase the number of engineers specifically trained and mentored to enter DOE workforce in technical areas of need. This program helps address DOE's future workforce needs by partnering with academic, government and DOE contractor organizations to mentor future scientists and engineers in the research, development, and deployment of new technologies addressing DOE's environmental cleanup challenges. Students selected as DOE Fellows perform research at FIU and at a DOE site. Upon graduation and completion of this fellowship, the students are encouraged to pursue a career at DOE/Office of Environmental Management (EM) (via the Pathways Program) and/or with DOE National Laboratories and DOE contractors across the DOE complex.

Under the Integrated University Program, NRC provides funds to four-year institutions for faculty development, scholarships and fellowships, as well as, scholarships to trade schools and community colleges. These grants are intended to develop scientists and engineers with competencies related to nuclear engineering, radiation protection, and related fields. Students who receive Integrated University Program scholarships and fellowships enter into a service obligation that may be satisfied by employment with NRC, other Federal agencies, state agencies, DOE laboratories, academia, or elsewhere in the nuclear-related industry.

Retaining Staff. The Federal Government relies on the agencies to use many aspects of the human capital management system to retain staff. By providing comprehensive training and development opportunities, staff increase knowledge and experience that may lead to improved performance, career growth, awards and recognition, and constructive feedback through performance management. The standard range of benefits including health, wellness, and work-life programs combined with the possibility of financial incentives when warranted, help

retain Federal staff. Work-life programs include flexible and alternative work schedules, as well as telework, which allow staff to work remotely while maintaining the same standard of job performance.

Training and Development. The Federal Government continues to implement blended learning strategies in its training programs. Blended learning is defined as using a combination of educational techniques to optimize knowledge transfer and delivery using both formal and informal approaches. Examples of various educational techniques typically used include classroom instruction, videos, web sites, virtual classrooms, discussion boards, modeling and simulation, webinars, communities of practice, and hands-on-application of knowledge and practice of skills with the support and guidance of a mentor. Blended learning allows the learners to gain or improve knowledge at any time and incorporate skills while practicing them on the job. This directly decreases the time for employees to complete their jobs competently while reducing the costs associated with attending the training (e.g., travel expenses for training attendance is avoided) and reducing time away from the workplace; thus, improving staff productivity.

The Federal Government strives to maintain a learning culture where knowledge is shared throughout its organizations. Such a culture sustains a learning environment that provides continuing improvement in performance through knowledge management, performance feedback, training, coaching, and mentoring. For example, NRC uses a robust on-boarding program for new hires, then relies on an expanded comprehensive qualification program for current staff in specific technically-oriented positions, while providing timely and effective leadership development programs.

Leadership and Knowledge Management. To address growing concerns about the potential loss of a significant portion of the Federal Government staff and their institutional knowledge, it is increasingly incumbent upon agencies to institute practices and programs to encourage effective succession planning and knowledge management.

The Federal Government leadership development programs consist of competency-based training, assessment, and development programs for Federal employees. Knowledge management remains a top priority to ensure Federal agencies capture and preserve knowledge to assist with employee development and performance. Many agencies use knowledge management tools such as creating communities of practice to enable employees who perform the same job function to share relevant knowledge and critical skills, capture operating experience, and discuss new information. The communities of practice often collaborate to consider safety and security issues, review knowledge gained from inspection, research, and other activities related to regulatory guidance. The method has helped document relevant critical knowledge from employees departing the agencies and from former employees where possible.

F.2.1. Personnel Qualifications for Nuclear Regulatory Commission Licensees

NRC regulations require licensees to have qualified personnel. The requirements provide for an organizational structure of the licensee, both offsite and onsite, including lines of authority and assignments of responsibilities, whether in the form of administrative directives, contract provisions, or otherwise.

NRC establishes qualifications for licensees' employees responsible for operational safety and radiological health, including the radiation safety officer and health physics personnel.

Technical qualifications include training and experience so the licensee's staff is competent to engage in the licensed activities. The licensee must additionally conduct a personnel training program and, within a plan, maintain an adequate complement of trained personnel to carry out licensed activities in a safe manner. See additional information in the U.S. Fourth National Report.

F.2.2. Department of Energy Qualification Requirements

DOE places requirements on contractors for training, proficiency testing, certification, and qualification of operating and supervisory personnel. Training requirements for nuclear safety management are in 10 CFR Part 830 and radiation worker protection in 10 CFR Part 835.

DOE directives further impose additional personnel training and qualification requirements for its activities. Developing and maintaining a technically competent workforce to accomplish its missions in a safe and efficient manner is accomplished through the Federal Technical Capability Program.[124] See additional information in the U.S. Fourth National Report.

F.2.3. Financial Surety

F.2.3.1 Commercial Low-Level Waste Management Facilities

NRC regulations require that financial information provided by commercial LLW management facilities must be sufficient to demonstrate that the financial qualifications of the applicant are adequate to carry out the activities for which the license is sought and other financial obligations (e.g., institutional controls under 10 CFR 61.63). Each applicant must show it either possesses the necessary funds or has reasonable assurance of obtaining them to cover the estimated costs of conducting all licensed activities over the planned operating life of the project, including costs of construction and disposal.

Waste processors are subject to 10 CFR 20.1403 (or equivalent regulations in Agreement States). These regulations require sufficient financial assurance to enable an independent third party, including a governmental custodian, to implement responsibilities for control and maintenance of the site where the license is terminated with restrictions on future use. The financial assurance mechanism and amount are scrutinized by NRC before the license is terminated. No post-closure activities or institutional controls are needed for sites released free of future restrictions.

The financial assurance requirements for operating a commercial LLW disposal facility are contained in NRC regulations at 10 CFR Part 61, Subpart E. These include providing financial assurance for licensed operations, closure, and institutional control. A state has the responsibility to review and accept financial sureties in Agreement States in accordance with its regulations equivalent to 10 CFR Part 61.

An applicant to operate a LLW disposal facility must provide assurance that sufficient funds are available to carry out disposal site closure and stabilization (by an independent contractor, if necessary) including: (1) decontamination or dismantlement of structures; and (2) closure and stabilization of the disposal site so the need for active maintenance by the ultimate site owner is

[124] See https://energy.gov/ehss/worker-health-safety-policy-guidance-reports/federal-technical-capability-program-ftcp.

virtually eliminated and only minor custodial care, surveillance, and monitoring are required. The licensee's surety mechanism is reviewed annually by NRC (or Agreement State) to ensure sufficient funds are available for completion of the closure plan.

Specific requirements for funding the closure and stabilization of an LLW facility are set out in 10 CFR 61.62 and requirements concerning financial assurance for the institutional control of the facility are in 10 CFR 61.63.

Section 61.61 of 10 CFR requires that an applicant for a license to operate a commercial LLW disposal facility demonstrate it possesses the necessary funds or has reasonable assurance of obtaining the necessary funds to cover the estimated costs of conducting all licensed activities over the planned operating life of the project, including the costs of construction and disposal.

Section 61.62 of 10 CFR requires an applicant demonstrate assurance that sufficient funds will be available to carry out disposal site closure and stabilization. These assurances are based on NRC-approved cost estimates reflecting the Commission-approved plan for disposal site closure and stabilization. The applicant's cost estimates must take into account the total capital costs that would be incurred assuming an independent contractor will be hired to perform the closure and stabilization work.

NRC regulations require that applicants provide a detailed breakdown of costs explaining the assumptions used in formulating the cost estimates. The need for ongoing active maintenance should be eliminated to the extent practicable and only minor custodial care, surveillance, and monitoring being required. Additionally, 10 CFR 61.62 details the surety arrangement requirements for disposal site closure and stabilization. The applicant should identify the sources of funds necessary to pay the cost of decommissioning and closing the proposed facility. The closure and stabilization program must be approved by NRC.

NRC reviews the amount of the surety mechanism annually to ensure sufficient funds are available for completion of the closure plan by an independent contractor. The surety amount is required to change based on inflation, increases in the amount of disturbed land, changes in engineering plans and other conditions affecting the costs of site closure and stabilization. Liability under the surety must remain in effect until the closure and stabilization program are completed and approved by NRC and the license is transferred to the long-term site owner. 10 CFR 61.62(e) and (f) require the terms of a surety be open-ended and renewable, unless another arrangement would provide equivalent assurance. In the event a licensee will not or cannot obtain an acceptable replacement surety, notice must be provided to NRC and collection on the surety shall be automatic prior to expiration. Types of financial surety arrangements acceptable to NRC are described in 10 CFR 61.62(g).

Section 61.63 of 10 CFR requires that prior to issuance of a license, an applicant must establish a binding agreement, such as a lease, with the disposal site owner that ensures sufficient funds will be available to cover the cost of monitoring and maintenance during the institutional control period. The binding agreement must be provided to NRC for review and approval as part of the licensing procedure. The binding agreement will be reviewed periodically by NRC to ensure changes in inflation, technology and disposal facility operations are reflected in the arrangement. Any subsequent changes to the agreement between the applicant/licensee and the disposal site owner must be submitted to NRC for approval.

Currently, all licensed commercial LLW disposal sites are in Agreement States. An Agreement State establishes financial surety requirements that are compatible with NRC's requirements for

an LLW disposal facility found at 10 CFR 61.62 and 61.63. The surety ensures that sufficient funds are available for the site operator to conduct all required site closure and stabilization activities and for the site owner to establish and maintain legally durable institutional controls after site termination. An Agreement State must review and approve financial surety arrangements to ensure they meet their regulations.

F.2.3.2 Spent Fuel and High-Level Waste Management Facilities

The Nuclear Waste Policy Act of 1982, as amended, requires utilities having a contract with DOE for the disposal of spent fuel or high-level waste (HLW) to pay fees into the Nuclear Waste Fund (NWF) sufficient to cover the costs associated with disposal activities for spent fuel and HLW. This Act established the fee at $0.001 per kilowatt-hour of electricity generated from nuclear power and required that it be evaluated annually. The statutory fee remained unchanged until 2014 when, to comply with a November 2013 court ruling, the fee was adjusted to zero and the payment of fees by utilities was suspended. The balance of funds in the NWF continues to earn interest.

Financial assurance for the storage of spent fuel is required under provisions at 10 CFR 72.22 and 72.30 for specifically-licensed independent spent fuel storage installations (ISFSIs) to ensure funds are available to store spent fuel in ISFSIs and for future decommissioning activities. ISFSI general licenses are covered by the financial assurance requirements in 10 CFR Part 50 for a reactor licensee. Specific licensees develop ISFSI decommissioning cost estimates and provide them to NRC for review. NRC regulations at 10 CFR 72.30 require that a specific licensee update estimates of the costs to decommission its facility and certify financial assurance for decommissioning has been provided in the amount of the cost estimate every third year during operations. NRC reviews the updated cost estimates. Financial mechanisms used include surety/insurance or other guarantee methods, government statement of intent, or contractual obligations on the part of the firm's customers.

F.2.3.3 Uranium Recovery Waste Management Facilities

NRC regulations require that financial surety arrangements must be established by each mill operator prior to the start of operations to ensure sufficient funds will be available to carry out the decontamination and decommissioning (D&D) of the mill and site and for the reclamation of any tailings or waste disposal areas in the event the licensee is unable to do so. This process is similar for both conventional mills and in-situ recovery (ISR) operations; the main difference is that ISRs have no tailings piles.

The amount of funds to be guaranteed by such surety arrangements must account for costs of an independent contractor performing the work and must be based on NRC-approved cost estimates that address:

- D&D of buildings and the site;
- Reclamation of tailings and/or waste areas in accordance with Appendix A to 10 CFR Part 40; and
- Long-term site surveillance and control (if applicable).

Financial surety arrangements generally acceptable to NRC are surety bonds, trust funds, and letters of credit and combinations thereof, or other arrangements approved by NRC. The surety must also cover payment of the charge for long-term surveillance and control at heap leach and

conventional mill sites (typically long-term surveillance is not required at ISR facilities). A minimum charge of $250,000 (indexed to 1978 U.S. dollars) to cover the costs of long-term surveillance is paid by each mill operator to the General Treasury of the U.S. or to an appropriate state agency prior to the termination of a uranium or thorium mill license.

A variance in funding requirements for the long-term care charge may be specified by NRC, based on the results of a site-specific evaluation, if site surveillance or control requirements at a particular site are determined to be more extensive than annual site inspections.[125] Eventual ownership of the uranium mill disposal site will be transferred to either DOE or an appropriate state agency in perpetuity. The funding should be adequate to cover all costs incurred by the long-term custodian during the long-term care period. The long-term care period is the time that the disposal site will need maintenance to ensure public health and safety and the environment are not threatened. Radium, the principal radionuclide in uranium disposal sites remains a threat for hundreds of thousands of years. For this reason, uranium recovery disposal sites are maintained in perpetuity.

The surety for these 10 CFR Part 40 sites is reviewed and must be approved annually by NRC to ensure that any changes in the surety due to inflation, changes in engineering plans, activities performed, and any other conditions affecting costs are properly accounted in for in the surety amount. This process yields a surety at least sufficient at all times to cover the costs of decommissioning and reclamation of the areas expected to be disturbed before the next license renewal.

F.2.3.4 Complex Material Sites Decommissioning

Several of the existing NRC-regulated decommissioning sites are complex and difficult to decommission for a variety of financial, technical, or programmatic reasons. Certain sites can be thought of as NRC "legacy" sites, those sites where past financial or operational events have created the problems needing a cleanup solution, and ultimately complete decommissioning and license termination. NRC evaluated the lessons from these existing legacy sites and issued a final rule on decommissioning planning to change its current financial assurance[126] and licensee operational requirements to minimize or prevent future legacy sites.[127] The cost to decommission these facilities ranges broadly, from a few thousand dollars up to the hundred-million-dollar range.

See Section E.2.1.4 for more information regarding decommissioning planning. A detailed description of the decommissioning process for all materials sites is available at NRC's web site.[128]

NRC regulations at 10 CFR 20.1406, *Minimization of Contamination*, specifically require that new applications describe how design and operations will minimize contamination and facilitate eventual decommissioning. As mentioned above, NRC published a final rule on decommissioning planning. One aspect of the rule focuses on ensuring that licensees have

[125] Inspections are conducted by the government agency responsible for long-term care of the disposal site to confirm its integrity and to determine the need, if any, for maintenance and/or monitoring (e.g., if fencing is necessary).
[126] More specific information on financial assurance for decommissioning, such as the need for licensees to provide a decommissioning funding plan, is provided at https://www.nrc.gov/waste/decommissioning/finan-assur.html.
[127] Lessons learned from NRC's experiences in decommissioning can be accessed at: https://www.nrc.gov/waste/decommissioning/lessons-learned.html.
[128] See https://www.nrc.gov/waste/decommissioning/process.html.

adequate financial assurance to complete decommissioning, while the other ensures that licensees have an adequate groundwater monitoring program in place and will implement measures to minimize groundwater contamination. The rule has been in effect for approximately 3 years. Waste minimization is more fully discussed in Section F.7.2.

Additional details on financial assurance in decommissioning material sites can be found in 10 CFR 30.35, 40.36, 70.25, and 10 CFR Part 40, Appendix A, II. *Financial Criteria,* that contain financial assurance and recordkeeping requirements for decommissioning, and in NUREG-1757, Vol. 3, Rev. 1, *Consolidated Decommissioning Guidance, Financial Assurance, Recordkeeping, and Timeliness*.[129]

F.2.3.5 Commercial Power Reactor Decommissioning

The regulations pertaining specifically to decommissioning funds for commercial power reactors are contained in 10 CFR 50.75, *Reporting and Recordkeeping for Decommissioning Planning* and 10 CFR 50.82, *Termination of License*. The regulations establish requirements that licensees must meet in order to provide reasonable assurance that funds will be available for the decommissioning process. A power reactor licensee operating under a 10 CFR Part 50 or 10 CFR Part 52 license may use a prepaid segregated fund, external sinking fund, surety, insurance or guarantee, a statement of intent, contractual obligation, or a combination of these methods, which are described in 10 CFR 50.75(e)(1)(i-v). A power reactor licensee may propose other methods of assurance, but must show the method is equivalent to the methods listed in NRC's regulations to obtain NRC approval. Almost all U.S. power reactor licensees use external sinking funds to hold their decommissioning funds.

When a power reactor licensee is a government entity, it may provide assurance by using a statement of intent to obtain funds for decommissioning from its governing legislative body. When a power reactor licensee is a utility, it relies on public utility districts, municipalities, rural electric cooperatives, or state and Federal agency entities to both establish their own assumed real rates of return on their trust fund investments, and recover, through its ratemaking authority, the cost of service allocable to decommissioning. Because a public utility trust fund relies on funds collected through electric rates set by a ratemaking body and charged to customers, it may take credit for future authorized collections.

Licensees that are not public utilities, often referred to as merchant plant licensees, do not have prices guaranteed by a public utility commission. Therefore, these entities may not rely on funds collected through electric rates set by a ratemaking body, and thus may not take credit for future authorized collections. However, they are authorized to take credit for future earnings, at an assumed real rate of return of no greater than two percent, on the balance of the trust fund.

Section 50.75 of 10 CFR requires that, during operations, licensees report their decommissioning fund status biennially. After that period, licensees provide to NRC site-specific cost estimates. Specifically, at or about 5 years prior to the projected end of operations, licensees are required to submit site-specific preliminary decommissioning cost estimates, which include up-to-date assessments of the major factors that could affect the cost to decommission. And, prior to or within 2 years following permanent cessation of operations, licensees are required to submit a Post-Shutdown Decommissioning Activities Report (PSDAR) to NRC, and a copy to affected state(s). The PSDAR must contain a description of the planned

[129] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1757/v3/index.html.

decommissioning activities along with a schedule for their accomplishment, a discussion that provides the reasons for concluding that the environmental impacts associated with site-specific decommissioning activities will be bounded by appropriate previously issued environmental impact statements (EISs), and a site-specific decommissioning cost estimate, including the projected cost of managing irradiated fuel.

F.3. Quality Assurance (Article 23)

QA requirements apply to licensees, licensed subcontractors, applicants for and holders of certificates of compliances for spent fuel storage casks, DOE contractors and subcontractors, and to suppliers. QA programs are applied to the design, purchase, fabrication, handling, shipping, storing, cleaning, assembly, inspection, testing, operation, maintenance, repair and modification of structures, systems and components important to safety. The following subsections provide a summary of QA requirements prescribed by NRC and DOE for spent fuel and waste management activities. NRC regulations cover all commercial licensees and some DOE facilities; DOE activities that are not subject to regulation by NRC are covered by DOE regulations, Orders and contract requirements. While the QA requirements of both agencies are distinct and separate, they share the objective of adequate protection of workers, the public, and the environment.

F.3.1. Nuclear Regulatory Commission Quality Assurance

NRC generally inspects the facilities and activities of licensees and certificate holders. An applicant needs to demonstrate specific technical information that demonstrates NRC's performance objectives and the applicable technical requirements for a LLW disposal operation will be met. The information includes a description of the QA program that is "tailored to LLW disposal, developed and applied by the applicant for the determination of natural disposal site characteristics, and for QA during the design, construction, operation, and closure of the land disposal facility and the receipt, handling, and emplacement of waste."[130]

Guidance to applicants on how to meet the QA regulatory requirements in 10 CFR Part 61 is also provided in NUREG-1293, Rev. 1, *Quality Assurance Guidance for a Low-Level Radioactive Waste Disposal Facility*, April 1991.[131] The criteria in NUREG-1293 are similar to the criteria in 10 CFR Part 50, Appendix B, *Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants*.

The QA program for storage of spent fuel, HLW, and reactor related greater-than-Class C (GTCC) LLW is described in 10 CFR Part 72, Subpart G. An additional useful document is NUREG/CR-6314, *Quality Assurance Inspections for Shipping and Storage Containers.*[132] The QA requirements for packaging and transportation of licensed radioactive material are provided in 10 CFR Part 71, Subpart H. NRC Regulatory Guide (RG) 7.10, *Establishing Quality Assurance Programs for Packaging Used in Transport of Radioactive Material,* provides an acceptable approach for complying with the QA requirements for packaging for transport of radioactive material in 10 CFR Part 71.[133]

QA is generally addressed as part of the license requirements for uranium recovery operations.

[130] See 10 CFR 61.12(j).
[131] The document is available at NRC's ADAMS, under ML11242A180.
[132] The document is available at NRC's ADAMS, under ML012600315.
[133] The document is available at NRC's ADAMS, under ML14064A505.

Areas where QA is particularly important include: disposal cell performance; monitoring, injection, and recovery well construction; and final cover system construction. Typically, technical specifications are developed to provide requirements for materials and construction techniques. A QA testing program for the operational phases, including supervision by a qualified engineer or scientist, is established to ensure the specifications are met. In some cases, onsite pilot projects on a smaller scale can provide a demonstration that reclamation and restoration strategies are achievable.

QA plays a significant role in decommissioning of nuclear facilities. Decommissioning plans (DP) include a QA program to determine if the licensee has adequate controls in place to support the decommissioning. The QA program should address document control, control of measuring and test equipment, corrective action, QA records, audits, environmental monitoring, instrumentation and surveillances. Requirements are specified in 10 CFR 72, Subpart G, and 10 CFR 50.82(b) and guidance is available from NUREG-1757, *Consolidated Decommissioning Guidance: Decommissioning Process for Materials Licensees*.

F.3.2. Department of Energy Quality Assurance

Most DOE activities are subject to QA requirements found in DOE Orders and guidance. DOE QA requirements are specified at 10 CFR 830.120. DOE programs must implement the QA criteria specified in DOE O 414.1D to achieve adequate protection of the workers, the public, and the environment, taking into account the work to be performed and its hazards. They must develop their QA programs by applying 10 QA criteria using a graded approach. The 10 QA criteria fall within three areas: management, performance, and assessment. The management criteria are QA program, personnel training and qualification, quality improvement, and documents and records. The performance criteria are work processes, design, procurement and inspection, and acceptance testing. The assessment criteria are management assessment and independent assessment. DOE performs internal audits and assesses whether its contractors have satisfactorily implemented DOE's QA program.

F.4. Operational Radiation Protection (Article 24)

The following sections describe radiation protection responsibilities at EPA, NRC, and DOE. The U.S. Government also has access to leading experts in radiation protection through institutions such as the National Academy of Sciences (NAS)/National Research Council, the Nuclear Waste Technical Review Board[134] (see Section E.2.3.5) and the National Council on Radiation Protection and Measurements (NCRP). The NAS is a nonprofit institution providing science, technology and health policy advice under a Congressional charter. The NAS established a Board on Radioactive Waste Management (now part of the new Nuclear and Radiation Studies Board) focusing on waste management and disposal.

F.4.1. Environmental Protection Agency

EPA is responsible for issuing guidance to Federal agencies on radiation protection matters. EPA provides emergency response training and analytical support to state, local, and tribal governments and works closely with other national and international radiation protection organizations to further scientific understanding of radiation risks.

[134] See www.nwtrb.gov.

Primary radiation protection regulations for spent fuel management include 40 CFR Part 190, Environmental Radiation Protection Standards for Nuclear Power Operations, and 40 CFR Part 191, Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-level and Transuranic Radioactive Wastes.

Another radiation protection regulation related to 40 CFR Part 191, pertaining to transuranic (TRU) waste (not spent fuel) management at DOE's Waste Isolation Pilot Plants (WIPP) geologic repository, is found in 40 CFR Part 194, *Criteria for the Certification and Re-certification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations*. See Section E.2.2.1 for additional information.

EPA's statutory role includes developing guidance for use by Federal agencies responsible for protecting the public from the harmful effects of radiation. EPA's Federal guidance is often applied by state agencies and the commercial sector to ensure consistency of practice. Guidance documents produced by EPA are available on the internet.[135] Specific dose limits are provided in Table F-3.[136]

F.4.2. Nuclear Regulatory Commission General Radiological Protection Limits

The provisions for general safety for workers and protection of the public during the operational phase of commercial radioactive waste management facilities are addressed in NRC regulations contained in 10 CFR Part 20, *Standards for Protection Against Radiation*. 10 CFR Part 20 includes agency requirements for:

- Dose limits for radiation workers and members of the public;
- Monitoring and labeling radioactive materials;
- Posting radiation areas; and
- Reporting the theft or loss of radioactive material.

The provisions in 10 CFR Part 20 also include:

- Penalties for not complying with NRC regulations; and
- Tables of individual radionuclide exposure limits.

NRC regulates commercial nuclear power generation, as well as medical, academic, and industrial uses of radioactive material.[137] NRC promulgates safety regulations expressed in annual total effective dose equivalent (TEDEs),[138] as well as air and liquid effluent release concentrations. See Table F-3 for occupational and public health protection standards.

[135] For information on EPA Radiation Protection Program, see https://www.epa.gov/radiation/programs.html.
[136] For key radiation protection guidance documents, see https://www.epa.gov/radiation/federal/index.html.
[137] Under the provisions of the AEA, NRC can discontinue portions of its regulatory authority and allow individual states (Agreement States) to assume this authority. Refer to Section E.2.4.2 for more specific information.
[138] Dose is defined here as the TEDE, which is defined as the sum of the deep-dose equivalent for external exposures and the committed effective dose equivalent for internal exposures.

F.4.2.1 Occupational Dose Limits

Operations are conducted so the occupational dose to individual adults complies with the appropriate annual limit (see Table F-3). Annual occupational dose limits are established at 10 CFR 20.1201 for adults and 10 CFR 20.1207 for minors. There are other specific conditions, such as for planned special exposures and specific organ limits, as well as considerations for a soluble uranium chemical toxicity intake limit of 10 mg in a week [10 CFR 20.1201 (e)]. For more specific limits, refer to 10 CFR Part 20, Subpart B.

NRC maintains the Radiation Exposure Information and Reporting System (REIRS) for radiation workers, which provides the latest available information on radiation exposure to the workforce at certain NRC-licensed facilities. It also contains information concerning the recording and reporting requirements of NRC licensees. This information and other details on occupational exposure are available on the internet and updated annually.[139] An example of this information is provided in Figure F-1 that provides historical TEDEs for ISFSIs.[140] In accordance with 10 CFR 72.106, the limit is 0.05 Sv/year.

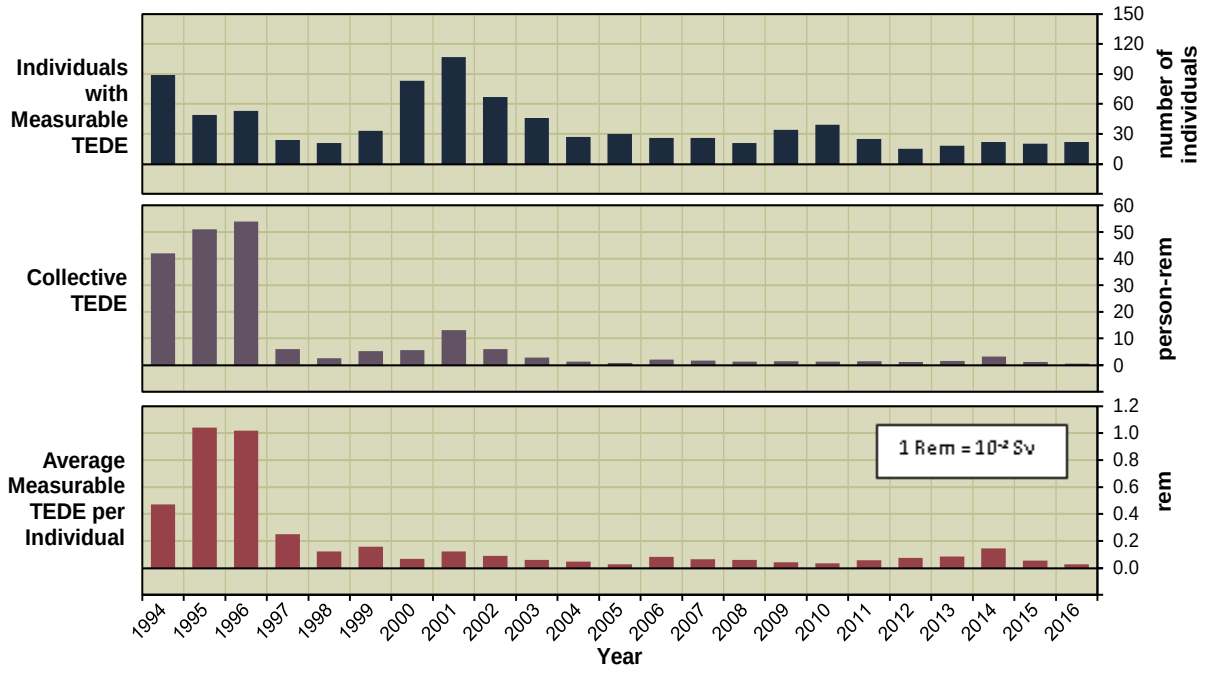

Figure F-1 Average Annual Values at Independent Spent Fuel Storage Facilities,1994-2016

[139] NRC's REIRS for Radiation Workers are accessible at http://www.reirs.com.
[140] This document is published as NUREG-0713, *Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities* 2015, Vol. 37, NRC, April 2017, available at: https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0713/.

F.4.2.2 Public Dose Limits

Public individual dose limits are provided in Table F-3. These dose limits are exclusive of the contributions from background radiation, any medical administration to individuals and other contributions not attributable to other regulated operations. Exposure limits for specific situations are provided in 10 CFR Part 20.

F.4.2.3 Radiological Criteria for License Termination (Decommissioning)

For protection of the public, dose-based requirements for licensees seeking license termination are found in 10 CFR Part 20, Subpart E (see Table F-3). These regulations establish two final states for licensee termination: unrestricted use (10 CFR 20.1402) and restricted use (10 CFR 20.1403 and 10 CFR 20.1404). In addition to the specific limits for each state, NRC requires licensees to maintain doses as low as reasonably achievable (ALARA). This means the licensee must make every reasonable effort to reduce the doses as far below the specified limits as is practical, taking into account the state of technology and economics. See 10 CFR 20.1003.

F.4.2.4 Low-Level Waste Disposal Sites

Under 10 CFR 61.41, doses to members of the public due to releases from a LLW disposal site may not exceed 0.25 mSv to the whole body, 0.75 mSv to the thyroid, or 0.25 mSv to any other organ. In addition, reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment ALARA. See Table F-3 for specific applications of dose.

F.4.2.5 Uranium Mill Tailings Disposal Sites

Reclaimed uranium mills are required to meet a radon release constraint in 10 CFR Part 40, Appendix A in addition to the annual public and occupational dose limits described in previous sections. See Table F-3 for public dose limits. The 0.699 $Bq/m^2/s$ radon release from uranium mill tailings was based on the cost-effectiveness of control for a thick earthen cover design, taking into consideration individual and population doses. There are also groundwater concentration limits for radionuclides and certain hazardous constituents, as found in 10 CFR Part 40, Appendix A, Criterion 5C, as well as a design control requirement.

F.4.3. Department of Energy Radiation Protection Regulations

DOE requires radiation protection for workers and the public in its regulations and directives. 10 CFR Part 835 governs radiation protection of workers at DOE facilities and activities not licensed by NRC. DOE regulations in 10 CFR Part 835 are similar to NRC regulations in 10 CFR Part 20, but there are some differences resulting from the types of radiological activities regulated by DOE and NRC, respectively.

DOE implements applicable radiation protection standards considering and adopting, as appropriate, recommendations of authoritative organizations such as the NCRP and the International Commission on Radiological Protection (ICRP). It is also DOE policy to adopt and implement standards generally consistent with those of NRC.

DOE occupational radiation protection requirements emphasize contamination control and internal dose monitoring because DOE operates facilities involved in weapons production. 10 CFR Part 835 specifies warning signs specifically for contamination areas, contains a table

of surface contamination values, and requires the use of bioassay data instead of air sampling data for internal dose estimation in most cases. DOE-STD-1196-2011, *Derived Concentration Technical Standards*,[141] is a DOE Standard that supports implementing DOE O 458.1. The Standard provides both Derived Concentration Standards and dose coefficients developed using the latest state of knowledge and practice in radiation protection (i.e., ICRP 60, 68, 72, 89, 103, 107).

There is no time limit on the applicability of DOE's radiation protection criteria. DOE considers whether risks may eventually be low enough so continued protection would not be needed. The radioactive material on or in some property may decay to levels where continued protection is no longer needed and the property can be considered for clearance. DOE, or successor agencies, may be required in some cases to maintain control because of the nature of the hazard and statutory requirements. Compliance with these regulations is generally determined by inspectors using survey equipment to measure radionuclide airborne or liquid concentrations within and at control boundaries.

Safety assessment computer models [e.g., RESidual RADiation (RESRAD)][142] are used to forecast exposures, prior to operating a nuclear facility, including spent fuel storage and radioactive waste disposal on a predictive basis. The concentrations and doses predicted by modeling a range of potential scenarios are then compared to dose and concentration limits in the applicable Federal regulations and DOE Orders and Manuals.

F.4.3.1 Collective Dose to the Public

DOE estimates radiation doses to the public around its many sites through extensive continuous radiological monitoring and surveillance programs as part of its commitment to communities where its facilities are located. The offsite individual doses remain well below DOE and EPA's National Emission Standards for Hazardous Air Pollutants (NESHAPs) compliance limits. Figure F-2 shows the historical trend. To put the estimated DOE-wide annual collective dose in perspective, background radiation dose to the population in a large metropolitan area would be more than 20000 person-Sv annually, from natural and man-made sources.

F.4.3.2 Dose to Department of Energy Workers

DOE keeps radiation exposures to workers ALARA within the constraints imposed by work, equipment, and technical conditions. Only 13 percent (10023 out of 75540) of DOE workers monitored for radiation dose received a measurable dose between 2011 and 2015. In 2015, the average annual TED,[143] to a worker with measurable dose was 0.74 mSv, and the collective dose was 7.447 person-Sv. Within the 5-year period from 2011 to 2015, no individual exceeded the 20 mSv administrative limit.

To place DOE worker dose in perspective, the average American receives approximately 6.2 mSv/a from natural and manmade sources.[144] The majority of DOE workers with a measurable dose between 2008 and 2012, received less than 1 mSv TED equivalent. Thousands of people

[141] See https://energy.gov/sites/prod/files/2013/06/f1/DOE-STD-1196-2011.pdf.
[142] See http://web.ead.anl.gov/resrad/home2/.
[143] Total Effective Dose, *E* (TED): DOE uses the term TED that is equivalent to NRC's TEDE. Total Effective Dose, *E* or TED replaced the term from TEDE to TED within ICRP 60 and ICRP 103.
[144] National Council on Radiation Protection and Measurements*, Ionizing Radiation Exposure of the Population of the U.S*, Report No. 160, 2009.

work in radiation areas every day without receiving significant radiation exposure, which may be attributable to the effectiveness of ALARA controls.

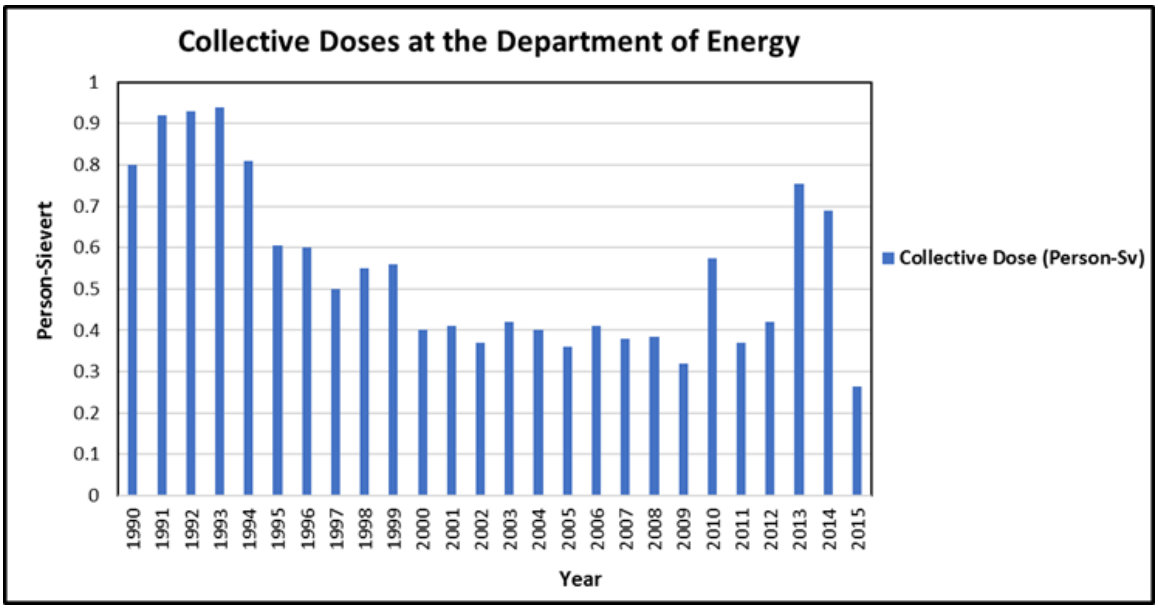

Figure F-2 Estimated Off-Site Radiation Dose to the Public around DOE Sites

F.4.4. Other Radiation Protection Regulations

EPA has the primary role in setting U.S. radiation protection standards that are implemented by NRC, DOE, and other Federal agencies, although other agencies may also regulate certain aspects of radiation protection standards:

- The Occupational Health & Safety Administration of the Department of Labor (DOL) has regulations dealing with worker protection from ionizing radiation found in 29 CFR; and
- The Mine Safety and Health Administration of the DOL has safety and health regulations related to underground mining in 30 CFR Part 57, Subparts 4037 to 5047.

Limits for air and water discharges from spent fuel/radioactive waste facilities are established through rulemaking by the responsible agency. EPA has issued rules for spent fuel, HLW, TRU waste, commercial nuclear fuel cycle, and uranium/thorium mill tailings facilities. See EPA's responsibilities detailed throughout Section E.

Table F-3 Major Radiation Protection Standards

Summary Table Regulation	Agency	U.S. Standard Limit	SI Equivalent
General Public (10 CFR 20.1301 & DOE O 458.1)	DOE & NRC	TEDE:[145] 100 mrem/year	TEDE: 1 mSv/a Ambient Air 1 mSv/a[146]
Uranium mill tailings (40 CFR Parts 61 and 192 & 10 CFR Part 40 App. A)	DOE, EPA, & NRC	$^{226/228}$Ra: 5 pCi/g (surface) 15 pCi/g (subsurface) ^{222}Rn: 20 pCi/m^2-sec. NRC standard includes benchmark dose for other radionuclides. Public dose per 40 CFR Part 190.	$^{226/228}$Ra: 0.19 Bq/g (surface) 0.56 Bq/g (subsurface) ^{222}Rn: 0.74 Bqi/m^2-sec NRC standard includes benchmark dose for other radionuclides.
Residual radioactive material UMTRCA Title I Facilities (40 CFR Part 192)	DOE & EPA	$^{226/228}$Ra: 5 pCi/g (surface) 15 pCi/g (subsurface) ^{222}Rn: 20 pCi/m2-sec. Alternatively, a limit of 0.5 pCi/l in air at the boundary of the facility. Gamma emissions in buildings not to exceed 20 micro roentgen/hr above background.	$^{226/228}$Ra: 0.19 Bq/g (surface) 0.56 Bq/g (subsurface) ^{222}Rn: 0.74 Bqi/m2-sec. Alternatively, a limit of 0.0185 Bq/l in air at the boundary of the facility. Gamma emissions in buildings not to exceed 5.16 mC/kg-hr above background.
HLW operations (10 CFR Part 60)	DOE & NRC	100 mrem/year	1 mSv/a

[145] Dose is defined here as the TEDE, which is defined as the sum of the deep-dose equivalent for external exposures and the committed effective dose equivalent for internal exposures. DOE uses the term Total Effective Dose (TED), which is equivalent to TEDE in other Federal agencies.
[146] Limit is exclusive of radiation from background, medical administrations, and contributions from non-licensed sources.

Table F-3 Major Radiation Protection Standards

Summary Table Regulation	Agency	U.S. Standard Limit	SI Equivalent
Commercial LLW disposal (10 CFR Part 61)	NRC	Annual dose equivalent to public 25 mrem to the whole body 75 mrem to the thyroid, and 25 mrem to any other organ	Annual dose equivalent to public 0.25 mSv to the whole body 0.75 mSv to the thyroid, and 0.25 mSv to any other organ
DOE LLW disposal (DOE O 435.1)	DOE	TEDE to public: 25 mrem/year from all exposure pathways, excluding the dose from radon and its progeny in air. TEDE to public via the air pathway does not exceed 10 mrem/year, excluding the dose from radon and its progeny. Release of radon is less than an average flux 20 pCi/mP^{2}P/s at the surface of the disposal facility; alternatively, a limit of 0.5 pCi/l in air at the boundary of the facility.	TEDE to public: 0.25 mSv/a from all exposure pathways, excluding the dose from radon and its progeny in air. TEDE to public via the air pathway does not exceed 0.10 mSv/a, excluding the dose from radon and its progeny. Release of radon is less than an average flux of 0.74 Bq/m^2/s at the surface; alternatively, a limit of 0.0185 Bq/l in air at the boundary of the facility.
Effluent emissions (10 CFR Part 20) Appendix B, Table 2	NRC	Radionuclide specific activities ≤ 50 mrem/year (100 mrem/year for radionuclides limited by submersion dose).	Radionuclide specific activities ≤ 0.5 mSv/a (1 mSv/a for radionuclides limited by submersion dose).

Table F-3 Major Radiation Protection Standards

Summary Table Regulation	Agency	U.S. Standard Limit	SI Equivalent
Drinking water (40 CFR Part 141)	DOE, EPA, & NRC	Maximum contaminant levels, Radium: 5 pCi/L Gross Alpha 15 pCi/L (excludes Rn & U) Beta/photon: 4 mrem/year Uranium: 30 µg/L	Maximum contaminant levels, Radium: 0.19 Bq/L Gross Alpha 0.56 Bq/L (excludes Rn & U) Beta/photon: 0.04 mSv/a Uranium: 30 µg/L
Uranium fuel cycle (40 CFR Part 190)	DOE, EPA, & NRC	Annual dose equivalent to public 25 mrem to the whole body 75 mrem to the thyroid, and 25 mrem to any other organ	Annual dose equivalent to public 0.25 mSv to the whole body 0.75 mSv to the thyroid, and 0.25 mSv to any other organ
Air emissions (NESHAPs) (40 CFR Part 61, H) and Radiation Protection Programs (10 CFR 20.1101)	DOE, EPA, & NRC	10 mrem/year to nearest off-site receptor	0.1 mSv/a to nearest off-site receptor
Superfund [Comprehensive Environmental Response Compensation, and Liability Act (CERCLA)] cleanup (40 Part CFR 300)	DOE, EPA, & NRC	Protective of human health & environment (lifetime risk), Complies with Applicable or Relevant and Appropriate Requirements	Not Applicable

Table F-3 Major Radiation Protection Standards

Summary Table Regulation	Agency	U.S. Standard Limit	SI Equivalent
Decommissioning (10 CFR Part 20, Subpart E)	NRC	Unrestricted Use: 25 mrem/yr TEDE plus ALARA Restricted Use: If institutional controls fail, not to exceed 100 mrem/yr or 500 mrem/yr (the 500 mrem/year dose limit is dependent on specific criteria in 10 CFR Part 20.1403, e.g., clean-up is not technically feasible at 100 mrem/yr). Alternate criteria: Same criteria as restricted use but TEDE may be greater than 25 mrem/yr but less than 100 mrem/yr with institutional controls in place, under specific circumstances.	Unrestricted Use: 0.25 mSv/a TEDE plus ALARA Restricted Use: If institutional controls fail, not to exceed 1 mSv/a or 5 mSv/a (the 5mSv/a dose limit is dependent on specific criteria in 10 CFR Part 20.1403, e.g., clean-up is not technically feasible at 1mSv/a). Alternate criteria: Same criteria as restricted use but TEDE may be greater than 0.25 mSv/yr but less than 1 mSv/yr with institutional controls in place, under specific circumstances.
Occupational standards (DOE 10 CFR Part 835 OSHA[147] 29 CFR 1910.1096 NRC 10 CFR Part 20.1201)	DOE, OSHA, & NRC	5 rem/year & TEDE (TED)[148] 15 rem/year eye (lens) dose equivalent[149] 50 rem/year Deep Dose + any other organ (other than lens of the eye)	50 mSv/a TEDE (TED) 150 mSv/a eye (lens) dose equivalent 500 mSv/a Deep Dose + any organ (other than lens of the eye)

[147] OSHA = Occupational Safety and Health Administration.
[148] TED means Total Effective Dose – used by DOE.)
[149] NRC does not specify a dose to the lens of the eye or skin for members of the public because significant localized exposure limits cannot be exceeded without exceeding the TEDE to individual members of the public of 1 mSv [See 10 CFR 20.1301(a)(1)].

Table F-3 Major Radiation Protection Standards

Summary Table Regulation	Agency	U.S. Standard Limit	SI Equivalent
Spent Fuel, HLW, TRU management and disposal (40 CFR Part 191)	DOE, EPA, & NRC	Annual Dose to Any Member of the Public from Management and Storage: NRC-licensed sites 25 mrem whole body 75 mrem thyroid 25 mrem other organ DOE disposal sites (non-NRC licensed) 25 mrem whole body 75 mrem thyroid Disposal Standards Applicable for 10,000 Years After Disposal: 15 mrem/year committed effective dose to any member of the public; Radionuclide-specific release limits to the accessible environment; Groundwater concentrations not to exceed drinking water limits.	Annual Dose to Any Member of the Public from Management and Storage: NRC-licensed sites 0.25 mSv whole body 0.75 mSv thyroid 0.25 mSv other organ DOE disposal sites (non-NRC licensed) 0.25 mSv whole body 0.75 mSv thyroid Disposal Standards Applicable for 10,000 Years After Disposal: 0.15 mSv/a committed effective dose to any member of the public; Radionuclide-specific release limits to the accessible environment; Groundwater concentrations not to exceed drinking water limits.

Table F-3 Major Radiation Protection Standards

Summary Table Regulation	Agency	U.S. Standard Limit	SI Equivalent
Spent Fuel and HLW at Yucca Mountain (40 CFR Part 197 & 10 CFR Part 63)	DOE, EPA, & NRC	15 mrem/year to any member of the public from management and storage; 15 mrem/year to the Reasonably Maximally Exposed Individual (RMEI) for 10000 years after disposal for undisturbed performance and from human intrusion; 100 mrem/year to the RMEI between 10000 years and the period of geologic stability after disposal for undisturbed performance and from human intrusion; Ground-water concentrations not to exceed drinking water limits for 10000 years after disposal.	0.15 mSv/a to any member of the public from management and storage; 0.15 mSv/a to the Reasonably Maximally Exposed Individual (RMEI) for 10000 years after disposal for undisturbed performance and from human intrusion; 1 mSv/a to the RMEI between 10000 years and the period of geologic stability after disposal for undisturbed performance and from human intrusion; Ground-water concentrations not to exceed drinking water limits for 10000 years after disposal.
Independent Spent Fuel Storage Installations (ISFSIs) (10 CFR Part 72)	NRC	Annual dose equivalent to a real individual member of the public 25 mrem to the whole body 75 mrem to the thyroid, and 25 mrem to any other critical organ	Annual dose equivalent to a real individual member of the public 0.25 mSv to the whole body 0.75 mSv to the thyroid, and 0.25 mSv to any other critical organ

Note: U.S. Standards for off-site transportation are excluded from the scope of the Joint Convention, and therefore not listed.

NRC has established regulations for commercially generated LLW facilities. NRC collects data from all nuclear power plant (NPP) licensees and licensees' reports are submitted annually in accordance with the reporting frequency required in 10 CFR 50.36a. Commercial NPP licensees produce annual radioactive and environmental reports of their discharges and these are summarized on NRC's web site.[150] Similarly, fuel cycle facility licensees are required to submit semi-annual reports on the reporting schedule required by 10 CFR 70.59.

Information on radiological discharges from DOE facilities engaged in waste management, environmental cleanup and spent fuel activities are available through DOE Annual Site Environmental Reports (ASERs).[151]

DOE regulates air and water discharges from its radioactive waste facilities through its internal orders (DOE O 458.1), while airborne emissions from DOE facilities are regulated by EPA's NESHAPS.[152]

Many states have comprehensive radiation control programs. These programs, for example, may regulate the use of diagnostic and therapeutic x-ray equipment and certain radioactive materials or conduct environmental monitoring.

F.5. Emergency Preparedness (Article 25)

The following subsections describe the extensive emergency preparedness and emergency management programs in place at NRC-licensed and DOE facilities.

The National Response Framework[153] (NRF) is a guide to how the U.S. responds to all types of disasters and emergencies. It is built on scalable, flexible, and adaptable concepts to align key roles and responsibilities across the U.S. This framework describes specific authorities and best practices for managing incidents that range from the serious but purely local to large-scale terrorist attacks or catastrophic natural disasters. The NRF describes the principles, roles and responsibilities, and coordinating structures for delivering the core capabilities required to respond to an incident and further describes how response efforts integrate with those of the other mission areas. It is always in effect, and elements can be implemented at any time. Selective implementation of NRF structures and procedures, such as in response to an incident at a spent fuel or radioactive waste facility, allows for a scaled response, delivery of the specific resources and capabilities, and a level of coordination appropriate to each incident. The response mission area includes 15 core capabilities: planning, public information and warning, operational coordination, critical transportation, environmental response/health and safety, fatality management services, infrastructure systems, mass care services, mass search and rescue operations, on-scene security and protection, operational communications, public and private services and resources, public health and medical services, situational assessment, and fire management and suppression. The priorities of response are to save lives, protect property

[150] Information on operating reactor experience, including releases to the environment, is located at https://www.nrc.gov/reactors/operating/ops-experience.html. In addition, 10 CFR 72.44(d)(3) requires the annual submittal of a summary of effluents from the independent spent fuel storage facility.
[151] ASERs are available at: https://www.energy.gov/ehss/policy-guidance-reports/environment-policy-guidance-reports/annual-site-environmental-reports.
[152] See https://www.epa.gov/compliance/national-emission-standards-hazardous-air-pollutants-compliance-monitoring.
[153] See https://www.fema.gov/national-response-framework.

and the environment, stabilize the incident and provide for basic human needs. The roles of all Federal agencies in the coordinated emergency response to a nuclear accident, are described in the Nuclear/Radiological Incident Annex (NRIA) of the NRF.[154]

As part of the NRF, the Federal Radiological Monitoring and Assessment Center (FRMAC) is a Federal asset available on request by Department of Homeland Security (DHS) and state and local agencies to respond to a nuclear or radiological incident. The FRMAC is an interagency organization with representation from DOE/ National Nuclear Security Administration (NNSA), EPA, NRC, Department of Defense, Department of Health and Human Services, Federal Bureau of Investigations, and other Federal agencies. DOE/NNSA has the responsibility to maintain the operational readiness and to deploy FRMAC upon request. The mission of FRMAC is to coordinate and manage all Federal radiological environmental monitoring and assessment activities during any of the three response phases; immediate, intermediate and delayed (recovery, cleanup) phases of any nuclear, radiological incident or accident, within the U.S. in support of state, local, tribal governments, DHS, and any other Federal coordinating agency. For the management of an event, related to the immediate and intermediate phase of FRMACs response, DOE/NNSA has the lead. The lead will then transition over to EPA for the cleanup and recovery phases of an incident/accident.

In addition, the following subsections describe the extensive emergency preparedness and emergency management programs in place at NRC-licensed and DOE facilities.

F.5.1. Nuclear Regulatory Commission Emergency Preparedness

The principal guidance for preparing and evaluating radiological emergency plans for licensee, state, and local government emergency planners is NUREG-0654/FEMA-REP-1,[155] a joint NRC and Federal Emergency Management Agency (FEMA) document. Although this guidance was developed for operating NPPs, it is still useful for spent fuel storage facilities as they tend to be sited on or near operating or decommissioned NPPs. NUREG-0654/FEMA-REP-1 gives evaluation criteria for an acceptable way to meet the emergency planning standards in NRC and FEMA regulations [10 CFR 50.47(b) and 44 CFR Part 350, respectively]. These criteria provide a basis for licensees, states, tribal, and local governments to develop acceptable emergency plans.

NRC regulations require that comprehensive emergency plans be prepared and periodically exercised to ensure actions are taken, among other things, to notify and protect citizens in the vicinity of a spent fuel storage facility during an emergency. For spent fuel management at an NPP or other significant nuclear fuel cycle facility, the emergency preparedness program may be modified by application for exemption or license amendment upon the facility's entry into the decommissioning phase. The provisions for emergency preparedness and response are usually modified commensurate with the hazard of the materials remaining onsite.

Although the severity and extent of hazards associated with spent fuel storage facilities, disused source storage, or radioactive waste management facilities are different than those associated with a NPP, many of the elements for emergency response are still applicable. See the U.S. Fifth National Report for a full discussion of the emergency response infrastructure,

[154] See https://www.fema.gov/media-library/assets/documents/25554.
[155] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0654/.

requirements, and activities of NRC. It should be noted that NRC has evaluated the applicability of lessons learned from the Fukushima event to spent fuel storage and waste disposal facilities. NRC's staff evaluation can be found in SECY-15-0081 on the lessons learned from Fukushima for facilities other than power reactors.[156] For spent fuel storage and waste disposal facilities, NRC staff has determined that further assessments are not needed based on Fukushima lessons learned and that the existing regulatory requirements and processes ensure adequate protection of public health and safety.

F.5.2. Department of Energy Emergency Preparedness and Management

DOE has implemented an emergency management system for all its sites and facilities. DOE O 151.1D, *Comprehensive Emergency Management System*,[157] describes DOE's emergency management system, by establishing policy; assigning roles and responsibilities; and providing the framework for development, coordination, control, and direction. This order establishes requirements for emergency planning, preparedness, response, recovery, and readiness assurance activities and describes the approach (including a graded approach) for effectively integrating these activities under a comprehensive, all-emergency concept.

Additional emergency management details are found in DOE Guide 151.1-1A, *Emergency Management Fundamentals and the Operational Emergency Base Program*.[158] This Guide provides information about the emergency management fundamentals embedded in the requirements of DOE O 151.1D, as well as acceptable methods of meeting the requirements for the Operational Emergency Base Program, ensuring all DOE facilities have effective capabilities for all-emergency preparedness and response. See additional information on DOE's Emergency Management Activities and its independent oversight in the U.S. Third National Report, Section F.5.2.[159]

F.5.3. Environmental Protection Agency Emergency Preparedness and Response

EPA's primary responsibilities in a radiological emergency are to perform environmental monitoring and cleanup activities (designated as Emergency Support Function 10 in NRF).[160] EPA's specific role will vary depending on the nature of the incident. Per the NRIA of the NRF, EPA is the coordinating agency for the Federal environmental response to incidents where the radioactive material involved is not licensed, owned, or operated by a Federal agency or an NRC Agreement State. This includes incidents involving foreign, unknown, or unlicensed radiological sources that have actual, potential, or perceived radiological consequences in the U.S. or its territories (most recently, EPA provided domestic environmental monitoring for the Fukushima accident). Through its RadNet monitoring system (see Section H.5), Radiological Emergency Response Team, laboratory capabilities, and other assets, EPA works with other Federal agencies, state and local governments and first responders, and international organizations to monitor, contain, and cleanup any radiological materials released to the environment. As an example, EPA's monitoring capabilities have been deployed to support

[156] The document is available at NRC's ADAMS, under ML15050A066.
[157] See https://www.directives.doe.gov/directives-documents/100-series/0151.1-BOrder-c.
[158] See https://www.directives.doe.gov/directives-documents/0151.1-EGuide-1a.
[159] See https://energy.gov/em/downloads/third-national-report-joint-convention-safety-spent-fuel-management-and-safety.
[160] See https://www.epa.gov/radiation/radiological-emergency-response.

responses to wildfires threatening DOE installations in New Mexico and Washington. At times, EPA's extensive assets for responding to chemical emergencies will also be involved.

EPA is also responsible for supporting state and local authorities in planning for radiological emergencies. A key aspect of this planning is the development of protective action guides (PAGs) to help emergency managers and public officials make decisions about evacuation or other actions to protect the public.[161] EPA proposed revisions to the 1992 PAG Manual in 2013, incorporating for the first-time planning guidance for cleanup and waste disposal after a radiological emergency. Final revisions to the PAG Manual were issued in December 2016, and additional guidance on protective actions for drinking water were issued in January 2017.[162]

EPA also conducts training[163] for first responders and participates in a wide variety of exercises.

F.6. Decommissioning Practices (Article 26)

Both NRC and DOE have active decommissioning programs as discussed in Section D.3. Their approaches are discussed in the following subsections.

F.6.1. Nuclear Regulatory Commission Decommissioning Approach

NRC regulates nuclear facility decommissioning with the ultimate goal of license termination. NRC regulations assign responsibility for decommissioning licensed and unlicensed[164] facilities to the licensee or other responsible parties. NRC regulates radiological decommissioning but not site restoration activities. For non-power reactors and other non-reactor sites, NRC evaluates the authorized party's proposed DP, including the licensee's justification for using a particular remediation methodology, to determine if it is appropriate. For power reactors, the process is different and is described in Section F.6.1.1. The decommissioning process consists of a series of integrated activities ending with license termination and site release. Decommissioning may be relatively simple and straightforward, or complex. Specific details on decommissioning activities at NRC authorized facilities are detailed in annual reports on the status of the decommissioning program.[165] Information is provided on specific provisions such as timing, the review process, financial assurance, public participation and other programmatic considerations.[166]

NRC does not identify a reference scenario for a critical radiological accident during decommissioning. Licensees are required to analyze their particular facility and determine the appropriate health and safety measures necessary to maintain worker and public doses within

[161] See https://www.epa.gov/radiation/protective-action-guides-pags.
[162] See *Final Revision to the PAG Manual Protective Action Guides and Planning Guidance for Radiological Incidents,* 81 FR 88679 (December 8, 2016) and *Revision to the PAG Manual: Protective Action Guide (PAG) for Drinking Water After a Radiological Incident,* 82 FR 6498 (January 19, 2017), respectively. Additional information and the full combined PAG Manual are available at https://www.epa.gov/radiation/protective-action-guides-pags.
[163] See https://www.epa.gov/radiation/radiation-protection-document-library.
[164] Some facilities are not licensed, but NRC and the Agreement States have regulatory authority to deal with safety-related issues for non-operational sites. Some of the complex sites discussed in Section D.3.3 of this report do not have active licenses, because they are either legacy sites or sites whose license was previously terminated, but are deemed no longer in compliance with safety standards. See https://www.nrc.gov/info-finder/decommissioning/complex/.
[165] Sites Undergoing Decommissioning (by location or name) is available at https://www.nrc.gov/info-finder/decommissioning/.
[166] *Status of Decommissioning Program 2016 Annual Report* is available at: https://www.nrc.gov/waste/decommissioning.html.

NRC limits. The health and safety plan is provided to NRC as part of the DP or License Termination Plan (LTP). NRC reviews the plan as part of its review and approval of the DP or LTP.

This comprehensive decommissioning program uses a dose-based approach for regulating decommissioning activities, and includes routine decommissioning sites, formerly licensed sites, non-routine and complex sites, fuel cycle sites, and test, research and power reactors. NRC provides oversight of decommissioning sites through its four regional offices. Remediation of these sites is now managed more effectively as part of this larger program.

F.6.1.1 Nuclear Reactor Facilities

In accordance with 10 CFR Part 50.82(a), after a nuclear power reactor licensee decides to permanently cease operations (see Figure F-3, Step 1), the licensee must submit written certification to NRC within 30 days of a decision (Step 2). Once the licensee removes the fuel permanently from the reactor vessel, the licensee is required to submit written certification to NRC, stating the date the fuel was permanently removed from the reactor vessel and stating the disposition of the fuel (Step 3). Licensees must also submit a PSDAR (Step 4) prior to or within 2 years after shutdown. The PSDAR is a report outlining the licensee's plan and schedule for decommissioning, an updated site-specific decommissioning cost estimate and an affirmation that the decommissioning can be completed within the existing EIS for the site. RG 1.185 provides guidance on the PSDAR content requirements. NRC will make the PSDAR available for public comment and will also schedule a public meeting in the vicinity of the licensee's facility within 90 days of NRC's receipt of the licensee's PSDAR submittal (Step 5) to discuss and obtain comments on the PSDAR. Normally, NRC will hold the meeting at least 30 days before the 90-day period ends.

Once the licensee certifies that the facility has permanently ceased operation and the fuel has been permanently removed from the reactor vessel, and the 90-day period has passed, decontamination and dismantlement under the 10 CFR 50.82 may commence (Step 6).

Reactor licensees may choose immediate dismantlement (DECON) or monitored deferred status (SAFSTOR) options. The choice of decommissioning method (SAFSTOR vs. DECON) is left entirely to the licensee. Licensees are not restricted to solely a SAFSTOR or DECON approach and can combine the SAFSTOR and DECON options. Current regulations require decommissioning be completed within 60 years. Spent fuel can remain stored in the spent fuel pool or in dry cask storage facilities until a disposal option becomes available.

Licensees must submit an LTP for NRC approval as a supplement to the final safety analysis report (FSAR) or as an equivalent document (Step 7). NUREG-1700, Rev. 1, *Standard Review Plan for Evaluating Nuclear Power Reactor License Termination Plans*, describes the information to be submitted in the LTP.[167] NRC will approve the plan, by license amendment. By regulation [10 CFR 50.82(a)(9)(i)], the licensee must submit an LTP at least 2 years before the planned license termination date. NRC must issue a notice of receipt of the LTP, make the

LTP available for public comment, and publish an opportunity for a hearing. NRC will hold a public meeting near the facility to discuss and obtain comments from the public on the LTP.

[167] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1700/.

While NRC is not required to provide responses to public feedback received on the PSDAR or LTP, NRC endeavors in the public meetings to answer the questions asked in the public meetings. In its PSDAR acknowledgment letter, NRC summarizes comments received on the PSDAR and responds to comments that are within the scope of the decommissioning process. Because an LTP is approved by license amendment, NRC typically responds to public comments on the LTP in NRC's safety evaluation of the LTP and addresses comments received at the LTP public meeting in the meeting summary issued after the public meeting, to the extent that the comments were not addressed at the public meeting.

NRC shall terminate the license if it determines that the remaining dismantlement has been performed in accordance with the approved LTP, and the final radiation survey and associated documentation, including an assessment of dose contributions associated with parts released for use before approval of the LTP, demonstrate that the facility and site have met the criteria for decommissioning in 10 CFR Part 20, Subpart E (Step 8).

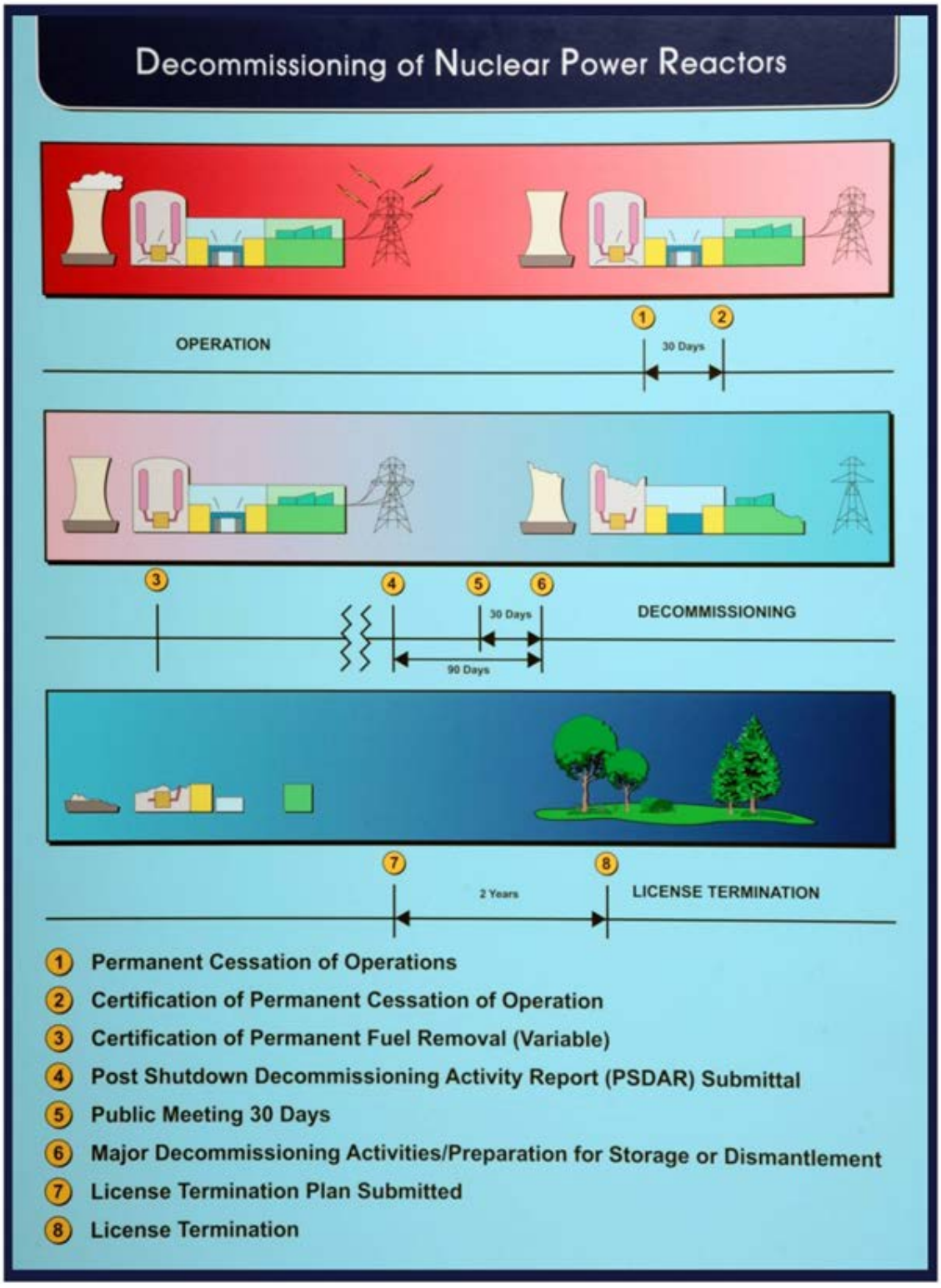

Figure F-3 Decommissioning Process for Nuclear Power Reactors in 10 CFR 50.82(a)

F.6.1.2 Materials Facilities and Activities

Material facilities decommissioning activities include reviewing and approving DPs before decommissioning begins and maintaining regulatory oversight of complex decommissioning sites during decommissioning by conducting inspections, interacting with the affected public, undertaking financial assurance reviews, reviewing and approving significant changes to the DP, and coordinating with other partner Federal agencies.

The initiating conditions for decommissioning a materials facility, as well as the major steps and timing for decommissioning, are documented in annual reports on the status of the decommissioning program.[168] There are occasions in which the licensee requests restricted release of the site. In those cases, where the authorized party proposes restricted release of the site, NRC first evaluates the compliance with the financial assurance and institutional control provisions of the DP, before considering the remainder of the DP.

NRC's staff review is guided by NUREG-1757, *Consolidated Decommissioning Guidance*,[169] where NRC has consolidated its decommissioning guidance for materials sites into a more risk-informed and performance-based document.

NRC inspects the facility during decommissioning operations to ensure compliance with the DP and NRC's regulations. NRC has developed a comprehensive suite of inspection and evaluation procedures and criteria to implement NRC's inspection programs. Licensees may, in some situations, make minor changes to the DP, if the process for making the minor changes has been included in the DP and has been reviewed and approved by NRC. These inspections will normally include in-process and confirmatory radiological surveys. LLW from decommissioning is disposed at a licensed LLW disposal facility after components and materials are dismantled and decontaminated. Other waste with sufficiently low concentrations of radionuclides, e.g., building rubble, can be disposed by alternate methods. See Section H.3.2.

F.6.1.3 Decommissioning License Termination Criteria

NRC's dose limit for a decommissioned facility is detailed in 10 CFR Part 20 [Subpart E for unrestricted use (10 CFR 20.1402) and restricted use (10 CFR 20.1403 and 10 CFR 20.1404)]. Table F-3 provides the dose limit for decommissioning. License termination with restrictions on post-license termination uses of the site (restricted release) is permissible when achieving the unrestricted levels would result in net public or environmental harm or the residual radioactivity associated with restricted release is ALARA. Restricted release requires relying on institutional controls (see 10 CFR 20.1403 for specific provisions). However, during the period of performance of the institutional controls, the decommissioned facility would be required to comply with the unrestricted release dose limit.

F.6.2. Department of Energy Decommissioning Approach

DOE's management approach for disposing excess facilities is described in DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*,[170] with the technical

[168] *Status of Decommissioning Program 2016 Annual Report* is available at: https://www.nrc.gov/waste/decommissioning.html.
[169] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1757/.
[170] See https://www.directives.doe.gov/directives-documents/0413.3-BOrder-b.

approaches described in DOE O 430.1C, *Real Property Asset Management*.[171] Further guidance is provided in DOE Guide 430.1-4, *Decommissioning Implementation Guide*.[172] Additional Orders and Guides for decommissioning and cleanup related activities are found in DOE's Directives system.[173]

Most decommissioning projects are conducted under a variety of regulatory processes—most commonly CERCLA—and site-specific cleanup agreements, which are legally binding and specify the process, end states, decision points, and required approvals. Regulatory requirements and independent oversight for these projects, as well as for spent fuel and radioactive waste management activities are described in Section E.2.3. See additional information on DOE Decommissioning Projects in the U.S. Third National Report.[174]

F.7. General Safety Requirements (Articles 4 and 11)

General safety requirements addressed in the subsections below were called out specifically in the Joint Convention report preparation guidance.[175]

F.7.1. Criticality Control and Residual Heat Removal

F.7.1.1 Criticality Control

The American Nuclear Society Standards Subcommittee 8 (ANS-8), Operations with Fissionable Materials Outside Reactors, developed national standards for the prevention and mitigation of criticality accidents during handling, processing, storing, and transporting special nuclear materials at fuels and materials facilities. These national standards have been approved by the American Nuclear Society Committee N16 on Nuclear Criticality Safety and by the American National Standards Institute (ANSI). ANSI/ANS-8 nuclear criticality safety standards provide guidance and criteria on good practices for nuclear criticality safety generally acceptable to NRC for the prevention and mitigation of nuclear criticality accidents. NRC has incorporated recommendations from these sources into guidance at RG 3.71, *Nuclear Criticality Safety Standards for Fuels and Material Facilities*.[176]

NRC has published Interim Staff Guidance[177] on the safety of spent fuel management, including criticality and sub criticality safety. Specifically:

- SFST-ISG-8, Rev. 3, *Burnup Credit in the Criticality Safety Analyses of PWR Spent Fuel in Transport and Storage Casks*; and
- SFST-ISG-19, *Moderator Exclusion under Hypothetical Accident Conditions and Demonstrating Subcriticality of Spent Fuel under the Requirements of 10 CFR 71.55(e)*.

[171] See https://www.directives.doe.gov/directives-documents/0430.1-BOrder-bc2.
[172] See https://www.directives.doe.gov/directives-documents/400-series/0430.1-EGuide-4.
[173] See https://www.directives.doe.gov/.
[174] See https://energy.gov/em/downloads/third-national-report-joint-convention-safety-spent-fuel-management-and-safety.
[175] International Atomic Energy Agency, *Guidelines Regarding the Form and Structure of National Reports: Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management* (INFCIRC/604/Rev. 1), Vienna, Austria, July 2006.
[176] See https://www.nrc.gov/reading-rm/doc-collections/reg-guides/fuels-materials/rg/.
[177] See https://www.nrc.gov/reading-rm/doc-collections/isg/spent-fuel.html.

Criteria for criticality safety for the independent storage of spent fuel, HLW, and GTCC LLW are defined in NRC regulations in 10 CFR Part 72, *Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-level Radioactive Waste, and Reactor-related Greater Than Class C Waste, Subpart F, General Design Criteria*. Section 72.124 establishes criteria for nuclear criticality safety, including design for criticality safety, methods of criticality control, and criticality monitoring.

F.7.1.2 Residual Heat Removal

Dry storage cask systems (for both HLW and spent fuel) are required to have reliable passive heat removal capability. NRC regulations and DOE Orders require the decay heat removal for storage facilities be capable of reliable operation so the temperatures of materials used for systems, structures, and components important to safety, e.g., fuel assembly cladding material, and solidified HLW packages, remain within the allowable limits under normal, off-normal, and accident conditions. Additionally, wet and dry fuel assembly transfer systems must also have adequate decay heat removal under normal, off normal, and accident conditions. Technical specifications for heat removal capability for a storage system are proposed by the applicant or may result from the review and evaluation of submittals relating to those areas.

F.7.2. Waste Minimization

Waste minimization programs in the U.S. are mandated by law; regulations; and, for some Federal agencies, a Presidential Executive Order.[178] The Pollution Prevention Act of 1990[179] focused industry, government, and public attention on reducing the amount of pollution through cost-effective changes in production, operation, and raw materials use.

EPA's Waste Minimization Program seeks to reduce or eliminate waste in manufacturing by promoting the concept of sustainability.[180] EPA works with industry, government agencies, and communities to voluntarily find ways to help them reduce the amount of waste they generate, particularly if the wastes contain one or more waste minimization priority chemicals.

Federal agencies, such as DOE, are subject to Executive Orders mandating waste minimization and pollution prevention programs, particularly Executive Order 12780, *Federal Agency Recycling and the Council on Federal Recycling and Procurement Policy*, and Executive Order 12856, *Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements*. DOE has programs designed to reduce environmental releases and the amount of waste eventually requiring treatment, storage, and disposal at DOE sites. Such reduction activities include site-wide coordination, planning, reporting, employee awareness, assessments, incentives, cost-savings initiatives, recycling, and affirmative procurement programs. In 10 CFR 20.1406, NRC requires applicants for licenses to "minimize, to the extent practicable, the generation of radioactive waste." These regulations combined with the cost and availability of disposal of radioactive waste in the U.S. provides strong incentives to waste generators to practice waste minimization.

[178] Greening the Government through Leadership in Environmental Management Executive Order 13148 is available at https://energy.gov/nepa/downloads/executive-order-13148-greening-government-through-leadership-environmental-management.
[179] 42 U.S.C. 13101 and 13102.
[180] See https://www.epa.gov/hw.

NRC issued a Policy Statement to emphasize the desirability of reducing waste volume to conserve disposal capacity and reduce the overall disposal costs.[181] However, the Policy Statement does not provide a quantitative value for reduction. The rising unit cost of disposal in the U.S. has had the effect of reducing overall volume. Unit disposal costs for several classes of LLW vary from site to site, with costs based on complex formulae that account for package weight, volume, overall radioactivity, waste classification, and surface contamination, difficulty in handling, as well as various state and local surcharges.

NRC licensees, as a practical matter, take steps to reduce the volume of radioactive waste due to the cost of disposal at licensed commercial burial sites. Licensees use process control to help reduce the amount of waste generated. Common means of volume reduction are compaction and incineration. NRC requirements for treatment or disposal by incineration are provided in 10 CFR 20.2004. This regulation provides specific requirements for onsite incineration of waste oils that have been radioactively contaminated in the course of operating or maintaining a commercial nuclear power reactor. Licensees may seek Commission approval for treatment or disposal of other licensed materials by incineration pursuant to 10 CFR 20.2002. This provision in NRC's regulations allows for other disposal methods, different from those already defined in the regulations, provided that doses are maintained ALARA and within the regulatory dose limits in 10 CFR Part 20. See Section H.3.1 for additional information regarding 10 CFR 20.2002 provisions.

Additional information on minimization of waste throughout all stages of the nuclear fuel cycle, including disposal, can be found in RG 4.21, *Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning*, June 2008.[182] This guidance provides examples of measures, which can be combined to support a contaminant management philosophy. This philosophy includes prevention of unintended release, early detection of potential releases, and aggressive cleanup when releases happen.

F.7.3. Interdependencies within Spent Fuel and Waste Management

Successful management of spent fuel and radioactive waste requires careful integration among power or research reactors, waste generators, storage facilities, treatment facilities, disposal sites and their transportation interfaces (Articles 4(iii) and 11(iii)). Integration is achieved through interface management, such as specified waste acceptance criteria, so generators and operators of disposal facilities have a common understanding of the waste characteristics, packaging requirements, transportation specifications, etc. Acceptance requirements constrain the management of interfaces between the various steps in spent fuel and waste management. The U.S. recognizes the importance of this integration and manages the interfaces between various steps, e.g., storage, transportation, and disposal.

The U.S. Government uses a system composed of inspections, enforcement, QA, testing and record keeping, thereby ensuring interdependencies among these steps remain relatively seamless. Manifests are prepared for shipments of radioactive waste and spent fuel. Portal monitors and other monitors located at specific check points are used to confirm the characteristics of radioactive materials as they are transferred within a site, as well as in shipments between facilities. Disposal facility operators use the monitoring results to review and verify the validity of assumptions made and to update the assessments as specified in

[181] The document is available at NRC's ADAMS, under ML15023A098.
[182] The document is available at NRC's ADAMS, under ML080500187.

Article 15 for the period after closure. The U.S. has regulations governing cradle-to-grave management of radioactive waste, and waste managers are responsible for the safety of their inventories under the terms of their licenses or safety bases.

F.7.4. National Laws/Regulations and International Criteria and Standards

The U.S. has an extensive and comprehensive set of laws and regulations for radiation protection, meeting the intent of Article 4 and Article 11 of the Joint Convention. EPA (see Section E) is responsible for developing national environmental standards and guidance for Federal and state agencies containing recommendations for their use in developing radiation protection requirements. The U.S. Government works with international organizations, such as the International Atomic Energy Agency (IAEA) and the ICRP, to ensure U.S. standards are in general harmony with recommendations from these organizations. NRC, DOE, and EPA are involved in the process of revising and drafting IAEA Safety Standards relating to nuclear, radiation, waste, and transport safety. Because transportation is excluded from the definitions of radioactive waste and spent fuel management [see Article 2, items (i) and (n)], the activities supporting the revision of Safety Standard TS-R-1 are not discussed in this report. However, the U.S. Government has a very active role in the Radiation Safety Standards Committee, the Waste Safety Standards Committee, the Nuclear Safety Standards Committee, and the Commission on Safety Standards. These committees meet biannually to review and approve safety standards for publication by the IAEA. The U.S. also supports IAEA efforts to encourage nations to follow the guidance in the Code of Conduct on the Safety and Security of Radioactive Sources.

The U.S. believes these standards and the Code of Conduct are a valuable source of guidance that a country can use to establish or enhance its national programs. These standards and guidance, however, do not prescribe the only approach to establishing strong national programs and are not binding on any country, except to the extent an individual country, acting in accordance with its national framework, incorporates all or parts of them into its national law or regulations.

Where appropriate, the U.S. Government also references the IAEA safety standards in regulations and regulatory guidance. The manner in which safety standards are used to inform and guide regulations and regulatory guidance varies among the technical programs. For example, the IAEA's safety standards are used as reference documents to inform the development of requirements and guidance in radiation protection and waste management programs. Many of the differences in how the safety standards are applied to regulations stem from the fact that NRC regulatory guidance predates most IAEA safety standards. Furthermore, some requirements were written with a greater level of detail than the IAEA's safety standards.

In addition, NRC agreed with recommendations from the 2010 Integrated Regulatory Review Service (IRRS) mission to further harmonize the requirements and guidance in NRC's programs with IAEA safety standards. See Section K.3 on 2010 and 2014 IRRS Missions. NRC has revised its policy guidance and now directs staff to consider IAEA standards as a point of reference when drafting or revising RGs, and to consider direct endorsement of the IAEA standards where appropriate.

Several agencies now use or allow the use of the updated dose coefficients found in ICRP

Publications 60, 68 and 72.[183] New recommendations have been issued by the ICRP and most U.S. agencies are studying those changes before considering any revisions to current public and worker dose limits. Any change from effective dose equivalent to effective dose as the basis for human dosimetry has not yet occurred on a broad scale, although new regulations may incorporate the newer dose methods.

F.7.5. Biological, Chemical, and Other Hazards

The U.S. has major environmental laws taking into account the potential effects of biological, chemical, and other hazards; facility operators must abide by these laws to protect workers, the public, and the environment. EPA issues and enforces regulations to implement these environmental laws. EPA in turn delegates some regulatory authority to states meeting the minimum Federal requirements.

One law that addresses biological, chemical and other hazards is the Resource Conservation and Recovery Act (RCRA), which grants EPA the authority to control hazardous waste from "cradle-to-grave." This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also sets forth a framework for the management of non-hazardous solid wastes. The 1986 amendments to RCRA enabled EPA to address environmental problems resulting from underground tanks storing petroleum and other hazardous substances. RCRA focuses only on active and future facilities and does not address abandoned or historical sites covered by CERCLA (Superfund).[184] The 1984 Federal Hazardous and Solid Waste Amendments to RCRA required phasing out land disposal of untreated hazardous waste. Other mandates of this law include increased enforcement authority for EPA, more stringent hazardous waste management standards, and a comprehensive underground storage tank program. Impacts from non-radiological hazards are assessed as part of the environmental assessment (EA) process. These assessments are required prior to constructing spent fuel and radioactive waste management facilities.

F.7.6. Avoiding Undue Burden/Impacts on Future Generations

Avoiding undue burdens on future generations is one important goal of U.S. policy to manage, store, and dispose of spent fuel and radioactive waste. Progress made toward timely decommissioning of inactive nuclear facilities and storage and permanent disposal of spent fuel and radioactive waste is a strong component of a strategy to achieve this policy.

F.7.7. Assessing Environmental Impacts (National Environmental Policy Act Process)

The National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4321 et seq.), is the basic National charter for protection of the environment. It establishes policy, sets goals, and provides means for carrying out the policy. NEPA requires Federal agencies to consider the potential environmental effects of their proposed actions and reasonable alternatives in their decision-making process. The Council on Environmental Quality, NRC, DOE, EPA and other Federal agencies have promulgated regulations to implement NEPA requirements. NEPA also requires that Federal agencies inform the public of their environmental impact evaluation and include the public to participate in the NEPA process. See additional information in the U.S.

[183] See http://www.icrp.org/publications.asp.
[184] 42 U.S.C. 9601, et. seq.

Third National Report.

F.7.8. Public and Stakeholder Involvement

The U.S. recognizes the many benefits derived from public participation in its program activities, including spent fuel and radioactive waste management. Public participation in the U.S. regulatory program is open and ongoing, and consists of both formal and informal communication between government officials and stakeholders. Regular communication with the public allows the government to gather the most diverse collection of opinions, perspectives, and values from the broadest spectrum of the public, enabling the government to make better, more informed decisions and providing the public with the opportunity to influence decisions that affect their communities. Information is available to members of the public about different topics, including decommissioning, spent fuel, and radioactive waste.[185]

Congress enacted the WIPP Land Withdrawal Act in October 1992, giving EPA significant new responsibilities for certifying DOE's determination of compliance at WIPP. EPA, in implementing its responsibilities, committed to conducting an open public process including interaction with all interested parties. This increased the public's understanding of EPA's role and responsibilities for the WIPP project, enabled the public to have informed opinions about the project by increasing their knowledge about radiation and its risks, and enhanced the overall decision-making process.[186]

Many DOE sites have Site-Specific Advisory Boards (SSABs) chartered under the Federal Advisory Committee Act to provide consensus advice and recommendations to DOE on environmental cleanup issues at the site including spent fuel and waste management activities.[187] In addition, some nuclear power utilities and state governments have established citizen advisory panels, or community engagement panels, to provide a public avenue for information exchange and comment on activities related to decommissioning of individual nuclear power plants.[188]

In the U.S., state, tribal and local governments have primary responsibility for public safety and emergency response. Radioactive waste management activities occurring within the public domain are most often associated with transport of radioactive materials, including DOE shipping campaigns. DOE has established a stakeholder forum[189] for the purpose of communicating at a national level with state and tribal governments about DOE shipments of radioactive waste and materials. Through this forum, DOE provides information and updates on waste management activities, resources for emergency preparedness training, and opportunities to coordinate on current and future shipments. Working groups have been

[185] See https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/.
[186] Additional information on the WIPP outreach program was provided in the U.S. Second National Report in Annex F-8. https://www.epa.gov/radiation/waste-isolation-pilot-plant-wipp.
[187] Information on SSABs may be found at https://energy.gov/em/services/communication-engagement/em-site-specific-advisory-board-em-ssab.
[188] Information on Southern California Edison's Community Engagement Panel may be found at https://www.songscommunity.com/cep.asp; Information on the state of Vermont's Nuclear Decommissioning Community Advisory Panel may be found at http://publicservice.vermont.gov/electric/ndcap; Information on the state of Massachusetts' Nuclear Decommissioning Citizens Advisory Panel may be found at http://www.mass.gov/eea/waste-mgnt-recycling/nuclear-decommissioning-citizens-advisory-panel/
[189] Information on DOE's National Transportation Stakeholders Forum may be found at https://www.energy.gov/em/services/waste-management/packaging-and-transportation/national-transportation-stakeholders-forum

established within the forum to provide a venue for representatives from state, tribal and Federal Government agencies to collaborate in addressing issues relating to radioactive waste management, including development of public information and communication materials. DOE facilitates participation in these and other joint- Federal, state, and tribal planning groups through funded cooperative agreements with regional state organizations and others that support tribal representatives. These cooperative agreements provide financial support for self-organized regional and tribal committees, to conduct initiatives or studies a committee elects to take on, to obtain relevant training, and to travel to DOE meetings, other technical meetings, or conferences. In addition, individual waste management programs within DOE have established smaller planning groups, comprised of state and tribal representatives, that meet twice or more per year to hear technical presentations from DOE staff, program updates, or hold discussions on issues relating to their respective waste programs.

NRC believes that nuclear regulation should be conducted as openly as possible. Ensuring appropriate openness explicitly recognizes that the public must be informed about, and have a reasonable opportunity to participate in, NRC's regulatory processes. NRC extends opportunities to participate in the agency's regulatory process to a diverse body of stakeholders, including the general public, Congress, other Federal agencies, states, local governmental bodies, Indian tribes, industry, technical societies, the international community, and citizen groups. NRC has developed web sites and has used other electronic social media tools (e.g., Twitter, Facebook, and NRC blog) to disseminate timely, accurate information on issues of interest to the public or events at nuclear facilities. NRC seeks public involvement early in the regulatory process to promptly address any safety or environmental concerns. Any member of the public may petition NRC to develop, change, or rescind a rule under 10 CFR 2.802, *Petition for Rulemaking*. In addition to the formal petition process under 10 CFR 2.206, where members of the public can request that NRC take action such as modifying, suspending, or revoking a license, and the hearing processes integrated into the licensing program, NRC also uses feedback forms at public meetings to obtain public input.

DOE, EPA, and NRC conduct public hearings and public meetings, accept written and electronic comments on proposed actions, participate in stakeholder meetings, and provide and maintain internet sites.[190] The NEPA process also allows for public input during the preparation and review of Federal documents that analyze the potential environmental impact of the government's proposed actions. NRC's internet web site provides a full description of the agency's public information process and meeting calendar.

F.8. Existing Facilities (Articles 5 and 12)

The U.S. conducts safety reviews of both commercial and governmental spent fuel and radioactive waste management facilities under its existing regulations.[191] Additional reviews of existing facilities are not required to comply with the Joint Convention because existing facilities are already subject to periodic safety reviews. The frequency and type of assessments and inspections depend on the type of facility and results of previous safety reviews. For example, for ISFSIs or a Monitored Retrievable Storage Facility, regulations in 10 CFR 72.70 specify licensees shall update periodically the FSAR to ensure the information included in the report

[190] See https://energy.gov/, https://www.epa.gov/radiation and http://www.nrc.gov.
[191] See 10 CFR Part 72; Section 72.70.

contains the latest information developed.[192]

F.9. Siting Proposed Facilities (Articles 6 and 13)

The U.S. has a legal and regulatory framework to site proposed new facilities to ensure safe and secure operation of the facilities and protection of the environment. The process provides for evaluation of all relevant site related factors, safety impacts to workers, the public, the environment, and socio-economic and historic and cultural impacts. See Section E.

Site selection for a new spent fuel or waste management facility follows the NEPA process and siting criteria of the applicable Federal agency. Licensees select a site based on consideration of many factors, including geography, demography, meteorology, hydrology, seismology, and the geology characteristics of the site and the surrounding area. Nearby industrial parks, transportation, sensitive areas, parklands, historical sites, and military facilities are also a consideration in the selection process.

Collaborative involvement is central to the NEPA process, in which information from other stakeholders including states, Indian tribes, local government agencies, and the public are gathered. The NEPA process begins with scoping. The purpose of scoping is to define the parameters of the NEPA analysis and focus the analysis on those aspects of the proposed action that may have a potential significant impact, while eliminating from detailed consideration those issues that are not environmentally significant. Scoping occurs early in the environmental review process.

NRC regulations prescribe site characterization activities and pre-license application reviews by NRC, as well as the application requirements for licensing and construction authorization. From the information supplied in response to the regulations, NRC can determine if the applicant has properly addressed environmental, socioeconomic, and other site considerations, which could be adversely affected by the proposed operation or facility.

F.10. Facility Design and Construction (Articles 7 and 14)

Articles 7 and 14 of the Joint Convention require that spent fuel and radioactive waste management facilities be designed and constructed to limit possible radiological impacts and discharges throughout their life cycle. This is accomplished by performing reviews of the proposed operations against well-established design and construction criteria in the standards, regulations and orders. Subsequent monitoring and inspection during the construction process provides confidence that the facility will operate safely. Examples include DOE O 420.1C, which requires all facilities to be designed for protection from natural phenomena and to facilitate safe decommissioning at end of their operating life. NRC, EPA, and Agreement and Authorized States have similar provisions concerning limiting radiological impacts and discharges at spent fuel and waste management facilities.

F.11. Assessing Facility Safety (Articles 8 and 15)

The Joint Convention requires that a systematic safety assessment and an EA appropriate to the hazards present at the facility be prepared to cover the entire life cycle. Updated and detailed assessments are required before operations commence. Although a safety

[192] See https://www.nrc.gov/reading-rm/doc-collections/cfr/part072/part072-0070.html.

assessment is generally a stand-alone process, it is also addressed as part of the NEPA process (see Section F.7.7). NRC employs a risk-informed and performance-based approach to decision-making where risk insights are considered along with other factors such as engineering judgment, safety limits, redundancy, and diversity. Risk insights are gathered by asking three questions: "What can go wrong?", "How likely is it?", and "What are the consequences?" A risk assessment is a systematic method for addressing these three questions to understand likely outcomes, sensitivities, areas of importance, system interactions, and areas of uncertainty. This is applied agency wide in the decision-making process.

F.12. Facility Operation (Articles 9 and 16)

The U.S. uses results of inspection, monitoring, and testing to verify and review safety assessment assumptions [per Article 16(iii) of the Joint Convention].

F.12.1. Nuclear Regulatory Commission Facility Safety

NRC regulations for issuing site-specific licenses for the operation of ISFSI are in 10 CFR Part 72. These regulations incorporate a graded approach and require the licensee to demonstrate via safety assessment, in an FSAR, that the facility is operated safely. NRC regulations require licensees to update safety assessments whenever significant new information becomes available; indicating there is a possibility of reducing a margin of safety or requiring a change to license conditions. Part 72 also requires the operator of an ISFSI to update its FSAR every 24 months and update its DP to reflect current inventories and conditions of the site and structures at the time of decommissioning.

NRC has regulations (10 CFR Part 61) and internally developed licensing and inspection programs governing the authorization to operate LLW disposal facilities. Part 61 requires the licensee to prepare a performance assessment (PA) of the disposal facility demonstrating that the performance objectives of Part 61 were fulfilled. The PA must be updated whenever significant changes are made to the disposal facility and at the time of closure.

Operational safety data are reported to or identified by NRC in event reports, inspection reports, component failure reports, industry reports, safeguard and security events, reports of defects and noncompliance (10 CFR Part 21), and reports of operational experience at foreign facilities. NRC screens operations safety data for safety significance, trends and generic implications, and the need for further regulatory action. NRC also develops, coordinates, and issues generic communications to alert industry to safety concerns and recommends the need for special inspections or event investigations.[193] Examples were included in previous U.S. National Reports.

F.12.1.1 Inspecting Nuclear Regulatory Commission-Licensed Commercial Facilities and Activities

NRC inspects licensed commercial NPPs, research reactors, fuel cycle facilities, and radioactive materials activities and operations, including their management of radioactive waste and discharge of radioactive effluents. If an inspection identifies that a licensee is not in compliance with regulatory and/or license requirements, NRC informs the licensee of the problems found and provides the licensee an opportunity to address the problems. NRC conducts follow-up

[193] See https://www.nrc.gov/reading-rm/doc-collections/gen-comm/.

inspections to ensure problems are corrected.

NRC's safety oversight program is designed to limit exposures to acceptable limits and maintain them ALARA, protect the environment, and safeguard radioactive material from terrorist threats. The oversight program includes inspections and assessments of licensee and vendor activities with a focus on minimizing risk to public health and safety. NRC issues reports to document inspection findings. These inspection reports may contain enforcement actions and follow-up inspection items. NRC makes inspection reports electronically available for public review in ADAMS by searching for a site name or docket number.

NRC also conducts routine safety inspections of ISFSIs and of vendors and fabricators of dry cask storage systems. The inspectors examine whether licensees and vendors are performing activities in accordance with radiation safety requirements, licensing and certificate of compliance (CoC) requirements, and QA program commitments. Announced or unannounced NRC inspections are conducted during pre-operational testing, and periodically between 1 and 3 years afterward, to determine if the licensee is in full compliance. Licenses and the technical specifications included in CoCs for cask designs contain additional inspection/review requirements. Inspectors follow guidance in NRC's Inspection Manual Chapter 2690, *Inspection Program for Dry Storage of Spent Reactor Fuel at Independent Spent Fuel Storage Installations and for 10 CFR Part 71 Transportation Packagings*.[194]

For an ISFSI that has routine operations with loaded dry-cask disposal systems, an inspection is planned every 2 to 3 years. Inspections may occur more frequently, depending upon prior inspection history, licensee performance, lessons learned, emergent issues or scheduling issues. In addition, cask unloading occurrences should be inspected. After renewal of an ISFSI license or CoC, NRC inspectors will evaluate whether licensees are adequately performing all activities associated with the licensee's aging management program.

NRC conducts approximately 900 inspections of its nuclear material licensees per year. These inspections review areas such as training, radiation protection programs, patient dose records, and security, as well as radioactive waste and/or spent fuel management. Details in the conduct and documentation of an inspection are addressed in operational inspection manual chapters.[195]

[194] The document is available at NRC's ADAMS, under ML120390415.
[195] A full list is presented at https://www.nrc.gov/reading-rm/doc-collections/insp-manual/manual-chapter/.

F.12.1.2 Nuclear Regulatory Commission Enforcement and Civil Penalties

If any person violates NRC regulatory or license requirements, NRC initiates action based on its Enforcement Policy, taking into account results from inspections and investigations, testing or other violation identification mechanisms, including allegations. NRC's Enforcement Policy, including its revisions, is available to NRC licensees and members of the public on NRC's web site.[196]

CALENDAR YEAR 2016 NRC ENFORCEMENT SUMMARY HIGHLIGHTS

NRC issued 89 escalated enforcement actions, including:

- 61 escalated Notices of Violation without civil penalties
- 16 actions involving civil penalties totaling $297,500 (including one civil penalty of $140,000)
- 12 enforcement orders without imposed civil penalties

The Office of Enforcement advises and manages NRC enforcement programs, provides programmatic and implementation direction to regional and headquarters offices conducting or involved in enforcement activities, and ensures regional enforcement programs are adequately carried out. NRC uses three primary enforcement sanctions: Notices of Violations (NOVs), Civil Penalties, and Orders.[197] Details of these sanctions and NRC enforcement process can be found in previous U.S. National Reports and at NRC's Office of Enforcement web site.[198]

NRC authority to issue orders is detailed in Section 161 of the Atomic Energy Act of 1954 as amended (AEA), and extends to any area of licensed activity affecting the public health and safety. NRC authority to issue civil penalties for violations of regulatory or license requirements is detailed in Section 234 of the AEA. NOVs and civil penalties are issued based on the significance of the violations. Orders may be issued for violations, or in the absence of a violation, to address a public health or safety issue. A graphical representation of NRC's graded approach for dispositioning violations is included on NRC's web site.[199] Civil penalties are normally assessed for severe violations, as well as for deliberate violations. Due to amended legislation requiring Federal agencies to adjust their civil penalty amounts for inflation, in 2016 the maximum civil penalty amount NRC is authorized to impose for violations of its regulatory requirements more than doubled. Additional details on severity levels and recent enforcement actions for materials facilities are available at NRC's web site.[200]

In most cases orders, including those resulting from use of Alternative Dispute Resolutions[201] are made available to the public. Significant enforcement actions (including actions to individuals) are included in the Enforcement Document Collection in the Electronic Reading Room of NRC's web site. Enforcement annual reports are also publicly available. [202]

[196] See https://www.nrc.gov/about-nrc/regulatory/enforcement/enforce-pol.html.
[197] The term *Order* within this context is distinguished from a DOE Order.
[198] See https://www.nrc.gov/about-nrc/regulatory/enforcement/program-overview.html.
[199] See https://www.nrc.gov/reading-rm/basic-ref/enf-man/process.pdf.
[200] See https://www.nrc.gov/reading-rm/doc-collections/enforcement/actions/materials/.
[201] See https://www.nrc.gov/about-nrc/regulatory/enforcement/adr.html.
[202] See https://www.nrc.gov/reading-rm/doc-collections/enforcement/annual-rpts/. However, orders containing classified, safeguards, or security-related information must be redacted or kept nonpublic.

F.12.2. Department of Energy Facility Safety

DOE exercises regulatory authority over spent fuel and radioactive waste management operations conducted by DOE or on its behalf pursuant to the AEA, except in cases where Congress has specifically provided NRC authority over DOE facilities or activities (see Section E.2.3). The major applicable Federal regulations include 10 CFR Part 820, *Procedural Rules for DOE Nuclear Activities*,[203] 10 CFR Part 830, *Nuclear Safety Management,*[204] 10 CFR 835, *Occupational Radiation Protection,*[205] and 10 CFR Part 851, *Worker Safety and Health Program*.[206] DOE's nuclear safety regulations are similar to those of NRC's.

In addition to the regulations referenced above, facility operations and radiation protection programs fall under standards and requirements established in DOE Orders and Directives. The major applicable orders include DOE O 420.1C, *Facility Safety*, DOE O 458.1, *Radiation Protection of the Public and the Environment*,[207] and DOE O 435.1, *Radioactive Waste Management.*

Other requirements for implementing 10 CFR Part 830 are found in DOE O 422.1-2A, *Conduct of Operations*.[208] Implementation guidance is found in DOE G 421.1-2, *Implementation Guide for Use in Developing Documented Safety Analyses to Meet Subpart B of 10 CFR 830,*[209] and DOE G 423.1-1B, *Implementation Guide for Use in Developing Technical Safety Requirements.*[210] Table E-1 provides a list of spent fuel and radioactive waste management Federal regulations, as well as DOE Orders and other Directives. Further details are found in previous U.S. National Reports.

Oversight and enforcement responsibilities for DOE facility safety is assigned to the Office of Enterprise Assessment. The office is focused on providing effective and consistent safety-related policy development, technical assistance, education and training. Key safety functions include:

- **Corporate Safety Analysis** providing analysis and certification of DOE-wide performance in protecting the public, the workers, and the environment while performing the missions of DOE. This analysis supports corporate decision-making and synthesizes operational information to support continuous environmental, safety, and health improvement across the DOE complex. Such analysis is a means of communicating experiences to potentially reduce risk, improve efficiency, and enhance the cost-effectiveness of DOE processes and operations.
- **Corporate Safety Programs** including safety program topics such as Accident Investigation, Accident/Incident Reporting System, Analytical Services Program, Behavior-Based Safety/Human Performance, Corrective Action Management Program, Federal Occupational Safety and Health, and Laboratory Accreditation Program.

[203] See https://www.gpo.gov/fdsys/granule/CFR-2011-title10-vol4/CFR-2011-title10-vol4-part820.
[204] See https://www.gpo.gov/fdsys/granule/CFR-2011-title10-vol4/CFR-2011-title10-vol4-part830.
[205] See https://www.gpo.gov/fdsys/granule/CFR-2011-title10-vol4/CFR-2011-title10-vol4-part835.
[206] See https://www.gpo.gov/fdsys/granule/CFR-2011-title10-vol4/CFR-2011-title10-vol4-part851.
[207] See https://www.directives.doe.gov/directives-documents/0458.1-BOrder.
[208] See https://www.directives.doe.gov/directives-documents/0422.1-BOrder.
[209] See https://www.directives.doe.gov/directives-documents/0421.1-EGuide-2.
[210] See https://www.directives.doe.gov/directives-documents/0423.1-EGuide-1a.

Under the Office of Enterprise Assessment,[211] the Office of Enforcement promotes overall improvement in DOE's safety and security programs through management and implementation of DOE enforcement programs for safety and classified information security authorized by the AEA. The office is independent of DOE offices that develop and implement policy and programs. The office conducts enforcement investigations using systematic enforcement practices to evaluate operational events and conditions representing potentially serious violations of DOE's nuclear safety, worker safety and health, and classified information security regulations. These investigations can result in civil penalties against DOE contractors that violate the regulations.

- **Worker Safety and Health Enforcement** implementing 10 CFR Part 851, which is DOE's congressionally mandated requirement for a worker safety and health program that reduces or prevents occupational injuries, illnesses, and accidental losses by providing DOE contractors and their workers with safe and healthful workplaces at DOE sites; and, procedures for investigating whether a violation of a requirement of this regulation has occurred, determining the nature and extent of any such violation, and imposing an appropriate remedy.
- **Nuclear Safety Enforcement** implementing DOE's nuclear safety enforcement program in accordance with 10 CFR Part 820, *Procedural Rules for DOE Nuclear Activities*, as authorized by AEA. 10 CFR Part 820 provides procedures that govern the conduct of DOE personnel in nuclear activities and ensure that all personnel attain compliance with DOE's nuclear safety requirements.

[211] Detailed information about the enforcement mission and functions may be found at https://energy.gov/ea/services/enforcement.

G. SAFETY OF SPENT FUEL MANAGEMENT

This section provides additional information relative to the Articles pertaining solely to spent fuel. This section also addresses Article 10 of the Joint Convention. Section F described aspects common to spent fuel and radioactive waste safety per Articles 4-9 and 11-16 of the Joint Convention, respectively.

G.1. General Safety Requirements (Article 4)

The need for general safety requirements is found in the Atomic Energy Act of 1954, as amended and the Nuclear Waste Policy Act, as amended. The licensing requirements for storage of spent fuel, high-level waste (HLW), and reactor related greater-than-Class C (GTCC) low-level waste (LLW) at an independent spent fuel storage installation (ISFSI) are contained in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 72. Additional applicable regulations include 10 CFR Part 71, *Packaging and Transportation of Radioactive Material*, Part 73, *Physical Protection of Plants and Materials* and Part 75, *Safeguards on Nuclear Material Implementation of US/IAEA Agreement*. Table E-1 lists key Nuclear Regulatory Commission (NRC) regulations.

Although both pool storage and dry storage are safe methods for spent fuel management, there are significant differences in the operation and safety practices of these facilities. Pool storage requires consistent operational vigilance by utilities or other licensees and relies on the satisfactory performance of mechanical systems using pumps, piping and instrumentation, whereas dry cask storage systems rely on passive measures to ensure safety.

NRC authorizes storage of spent fuel at ISFSIs under two licensing options: site-specific and general licenses. To obtain a site-specific license, an applicant submits an application to NRC and NRC performs a technical review of all aspects of the proposed ISFSI. The application must contain general and financial information; the applicant's technical qualifications to be able to safely operate the ISFSI; a safety analysis report; quality assurance (QA) program; an operator training program; physical protection, decommissioning, and emergency plans; an environmental report; and specific license conditions.

Upon approval, NRC issues a specific license for up to a 40-year term. NRC completed a rulemaking in 2011 to extend the license and certificate of compliance (CoC) from 20-year to 40-year terms. The licensee has an option for renewal at the end of the license term.[212]

A general license to store spent fuel at an ISFSI is automatically granted without having to file an application, via 10 CFR 72.210, to any nuclear power plant (NPP) licensee that has a license under 10 CFR Part 50 or 10 CFR Part 52. The general license is valid for 40 years from the loading date of each storage cask, as long as the licensee maintains its 10 CFR Part 50 or 10 CFR Part 52 license and continues to meet the other requirements of the general license.

The prospective general licensee must also review its security program, emergency plan, QA program, training program and radiation protection program, and make any necessary changes to incorporate the ISFSI at its reactor site.

[212] More specific information about the licensing process for both wet and dry storage facilities can be found at https://www.nrc.gov/waste/spent-fuel-storage.html.

NRC has approved 14 dry spent fuel storage designs, which general licensees may consider for use at their site. Each NRC-approved storage cask design has been technically reviewed for its safety aspects and found adequate to meet spent fuel storage requirements in 10 CFR Part 72. The CoC is issued for a term of up to 40 years and can be renewed. The CoC designations and models are listed in NRC regulations (10 CFR 72.214).

NRC approves dry cask storage systems by evaluating each design for resistance to normal and off-normal conditions of use and hypothetical accident conditions such as floods, earthquakes, tornados, and temperature extremes. The maximum allowable heat generation from the fuel assemblies stored in each cask may be different for each design. The temperature of the fuel in the casks continuously decreases over time. There have been no releases of spent fuel storage cask contents or other significant safety problems from the dry cask storage systems in use today.

G.2. Existing Facilities (Article 5)

ISFSIs in the United States of America use different dry storage system designs (some that are licensed for a specific site). The designs encompass dual-purpose canisters, vault storage systems, and metal and concrete storage casks. These storage casks are made by several vendors and have been licensed or certified by NRC. Almost all ISFSIs are owned and operated by 10 CFR Part 50 power reactor license holders. ISFSI facilities are identified in Annex D-1D.

Typical examinations for renewal of a storage license or CoC evaluate aging of components through corrosion, chemical attack, and other mechanisms that may cause a reduction in the efficacy of important storage cask components. Current guidance on renewing site-specific storage licenses or CoCs is contained in NUREG-1927, Rev. 1, *Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel*.[213] NRC decisions on the siting of ISFSIs are made available to the public.

G.3. Siting Proposed Facilities (Article 6)

Siting of ISFSIs at operating NPPs is addressed as part of the overall safety evaluation for the operating facility. For the case of siting ISFSIs at an away-from-reactor facility, 10 CFR Part 72, Subpart E, *Siting Evaluation Factors*, addresses factors such as the radiological criteria, design basis events, geologic considerations, and controlled areas.[214]

G.4. Spent Fuel Management Facility Design and Construction (Article 7)

General design criteria contained in 10 CFR Part 72, Subpart F establish the design, fabrication, construction, testing, maintenance, and performance requirements for structures, systems, and components important to safety, as defined at 10 CFR 72.3. These are minimum requirements for the design criteria and operation for an ISFSI or monitored retrievable storage installation.

Subpart L of 10 CFR Part 72, establishes requirements for spent fuel storage cask design approval and fabrication for use by general licensees. This subpart also contains requirements and conditions for renewal of designs having an NRC CoC; record keeping and reporting

[213] NUREG-1927 is available at https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1927/r1.
[214] For more detailed information on spent fuel storage, refer to https://www.nrc.gov/waste/spent-fuel-storage.html.

requirements; procedures for amending a CoC; and periodic updating of safety analysis reports. QA requirements, which apply to both the facility and certificate holder, are located in 10 CFR Part 72, Subpart G.

NRC reviews safety analysis reports using guidance to the staff in NUREG-1536, *Standard Review Plan for Spent Fuel Dry Storage Systems at a General Licensee Facility – Final Report*, [215] and NUREG-1567, *Standard Review Plan for Spent Fuel Dry Storage Facilities*.[216] These plans ensure the quality and uniformity of NRC reviews.

G.5. Assessing Facility Safety (Article 8)

Technical evaluations of ISFSI safety are performed in six major areas: (1) siting; (2) operating systems; (3) criteria and technical design; (4) radiation safety programs supporting protection of both worker and public health and safety; (5) accidents; and (6) proposed technical specifications. Additional details and specific requirements are contained in NUREG-1567.

Demonstrating compliance with long-term performance requirements, by necessity, will involve the use of complex predictive models supported by data from field and laboratory tests, site-specific monitoring, and natural analog studies supplemented with prevalent expert judgment.

G.6. Facility Operation (Article 9)

NRC's regulations and its licensing and inspection programs address numerous aspects of spent fuel and radioactive waste storage activities, including the storage of spent fuel or reactor related GTCC LLW at an ISFSI; approval of the storage cask design; and the safe operation of the ISFSI. There have been no releases of spent fuel storage cask contents or other significant safety problems from the dry cask storage systems in use today.

Inspections ensure safe operation and continued integrity of the fuel in the storage cask. Other than a review of indirect parameters, there are no periodic inspections required to determine damage to the contents as part of the facility license conditions. It is important to note that studies have been performed on dry storage system canisters and their contents, which show no degradation that would warrant changing the storage systems' licensing bases. The results of these studies are located in NUREG/CR-6831, *Examination of Spent PWR Fuel Rods after 15 Years in Dry Storage*.[217] For more information on Extended Storage Collaboration Program, see Section A.3.1.2.

NRC issued guidance on the standard format and content of technical specifications and recommendations on the most important fuel parameters in NUREG-1745, *Standard Format and Content for Technical Specifications for 10 CFR Part 72 Cask Certificates of Compliance*, and NUREG/CR-6716, *Recommendations on Fuel Parameters for Standard Technical Specifications for Spent Fuel Storage Casks*.[218] The important parameters are those with a large influence on criticality safety and radiation shielding doses. The ultimate determination of

[215] NUREG-1536 can be accessed at https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1536.
[216] NUREG-1567 can be accessed at https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1567.
[217] The document is available at NRC's Agencywide Documents Access and Management System (ADAMS), under ML032731021.
[218] These documents are available at NRC's ADAMS, under ML011940387 and ML010820352, respectively.

parameters is based on those the applicant uses in its modeling to demonstrate safety of the storage cask and facility design.

Requirements for incident reporting are located in 10 CFR 72.74, 72.75, and 72.80. The rules require reporting significant events where NRC may need to act to maintain or improve safety or to respond to public concerns. All events are considered against the International Nuclear Event Scale (INES). A report is generated under INES requirements if the event is classified a Level 2 or above. Section F.12 provides additional information on facility operations. Events are identified as potentially affecting operating experience are reported by licensees quarterly.

G.7. Spent Fuel Disposal (Article 10)

Department of Energy (DOE) has developed and is executing a research and development (R&D) program regarding the long-term management of spent fuel to ensure that any potential concerns are identified and addressed before safety is compromised. DOE is also identifying alternatives and conducting scientific research and technology development to enable long-term storage, transportation, and geologic disposal of spent fuel and radioactive wastes generated by existing and future nuclear fuel cycles. The research focuses on sustainable fuel cycle options and technologies that minimize waste generation, improve safety, and complement institutional measures in limiting proliferation risk. The main objective in this R&D is to develop a suite of options that will enable decision makers to make informed choices about how to safely manage the spent fuel from reactors. This R&D will be performed on functions in storage, transportation, and disposal in a variety of geologic environments, as well as work to better understand the potential degradation mechanisms involved in long-term dry cask storage. See Section A.3.1 for current information on U.S. spent fuel and HLW disposal.

H. SAFETY OF RADIOACTIVE WASTE MANAGEMENT

This section addresses Articles 11-16, which focus exclusively on radioactive waste management. This section also addresses Article 17 of the Joint Convention. This section addresses Nuclear Regulatory Commission's (NRC's) safety requirements for low-level waste (LLW) and uranium recovery programs. See Section B.2.3.2 for additional information on waste types. Section F describes common elements of spent fuel and radioactive waste safety per Articles 4-9 and 11-16 of the Joint Convention, respectively.

Primary legal basis and agency responsibilities for management of radioactive waste are discussed in detail in Section E. NRC regulates commercial radioactive waste including high-level waste (HLW), LLW, and uranium mill tailings. NRC's regulatory framework for disposing and managing commercial spent fuel is described in Sections F and G.

Department of Energy's (DOE's) waste management practices are described in DOE Order (O) 435.1, *Radioactive Waste Management*. This order and its implementing manual require that all DOE radioactive waste be managed to protect worker and public health and safety, and the environment. DOE O 435.1 applies to all DOE radioactive waste classes, including HLW, transuranic (TRU) waste, and LLW. The requirements span the life cycle of waste management facilities from planning through decommissioning and post closure.

H.1. Existing Commercial LLW Management Facilities and Past Practices (Article 12)

H.1.1. Currently-Licensed LLW Facilities

The Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA) replaced the Low-Level Radioactive Waste Policy Act of 1980 and gives states responsibility for providing disposal capacity for LLW generated within their borders (except for certain waste generated by the Federal Government and GTCC LLW). The LLRWPAA authorized states to enter into compacts allowing them to dispose of waste at a common disposal facility and exclude waste from states outside the compact. The LLRWPAA did not have a requirement that compacts be comprised of contiguous states. As a result, there are several compacts made up of non-contiguous states. Most states have entered into compacts. Figure H-1 shows the makeup of U.S. regional compacts for LLW disposal. There are now 10 compacts, comprising 42 states, and 10 unaffiliated states (the District of Columbia and Puerto Rico are considered states by the Atomic Energy Act of 1954 as amended (AEA), and LLRWPAA). Four active LLW disposal sites are associated with compacts. Existing U.S. commercial LLW disposal sites are discussed in Section D.2.2.2. All of these disposal sites are in Agreement States.

The commercial sector's LLW is typically stored on-site by licensees or by third party waste processors, either until it has decayed away (can be disposed of as ordinary waste in for example a municipal solid waste landfill) or until amounts are large enough for shipment to a LLW disposal site. LLW disposal occurs at commercially operated LLW disposal facilities and could be licensed by either NRC pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 61, or Agreement States pursuant to their regulations, which are compatible with 10 CFR Part 61.[219] All currently operating sites are licensed by Agreement States. Facilities must

[219] There are no disposal facilities currently licensed by NRC for disposal of greater-than-Class C (GTCC) LLW. GTCC LLW is stored until a disposal facility is established in accordance with the LLRWPAA.

be designed, constructed, operated, and closed to meet rigorous safety standards. The operator of the facility must also extensively characterize the facility site and analyze how the facility will be protective of public health, safety, and the environment for thousands of years. NRC regulations in 10 CFR 61.12(k) for land disposal of LLW require license applicants submit a description of their radiation safety program for control and monitoring of radioactive effluents to ensure compliance with the radiation dose limits for the general population. Also, as required by 10 CFR 61.53(c), the licensee must maintain a monitoring program during the construction and operation of a LLW disposal facility. The monitoring system must be capable of providing early warning of releases of radionuclides from the disposal site before they leave the site boundary. Similarly, per 10 CFR 61.53(d), the licensee responsible for post-operational surveillance of the disposal site must maintain a monitoring system capable of providing early warning of releases after the site is closed. NRC is currently working to revise certain portions of 10 CFR Part 61. See Section K.1.3, for additional information on the rulemaking.

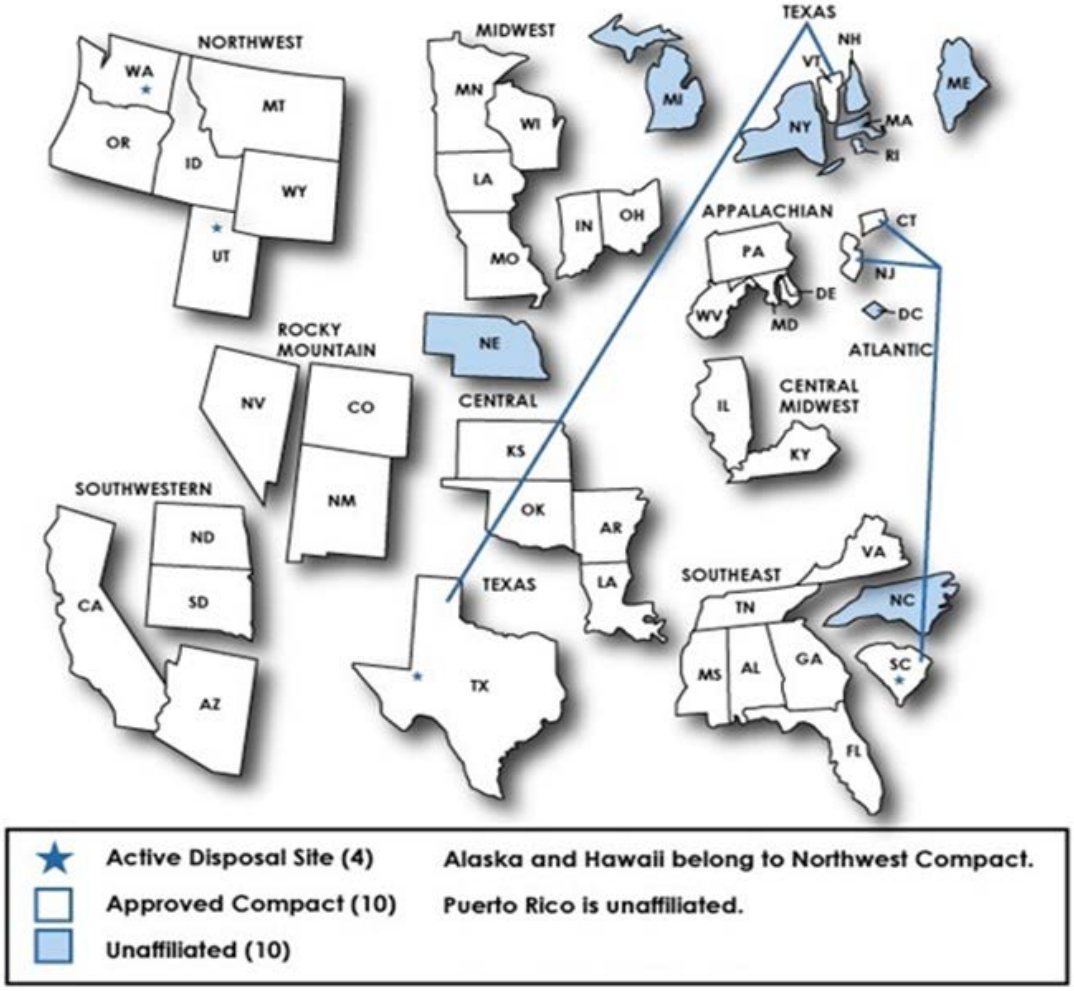

Figure H-1 U.S. Low-Level Waste Compacts[220]

[220] See https://www.nrc.gov/waste/llw-disposal/licensing/compacts.html.

H.1.2. Past Practices and Formerly Licensed Facilities

NRC reviewed sites with terminated licenses to ensure these facilities were properly decontaminated and posed no threat to public health and safety. Sites needing further attention were included as part of ongoing decommissioning programs or transferred to an Agreement State or another Federal agency. Past U.S. National Reports provide detailed information.

H.2. Department of Energy Waste Management Facilities

General safety requirements for DOE facilities were discussed in Section F. The following subsections contain additional information on the safety of radioactive waste management at DOE facilities. DOE manages radioactive waste owned or generated by DOE, including waste from atomic energy defense activities and waste resulting from DOE cleanup activities. Requirements for waste management are provided in DOE O 435.1, *Radioactive Waste Management*.

H.2.1. Past Practices (Article 12)

Some past radioactive waste management practices require additional environmental restoration activities or interventions as new technology and additional characterization information become available. Examples of these past practices include waste disposal techniques, such as soil columns or crib trenches, as well as sites where remaining residual radioactivity does not meet today's standards for unrestricted release. Environmental restoration activities resulting in off-site management and disposal of radioactive waste must meet the applicable requirements of DOE O 435.1. Cleanup decisions are reached through a formal regulatory process under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or Resource Conservation and Recovery Act of 1976 (RCRA) regulations (for mixed waste). See Section E.2.2.3 on mixed waste regulation.

CERCLA, a 1980 law commonly known as Superfund, authorizes Environmental Protection Agency (EPA) to respond to releases, or threatened releases, of hazardous substances that may endanger public health, welfare, or the environment. CERCLA, administered by EPA, provides a Federal "Superfund" to clean up uncontrolled or abandoned hazardous waste sites, as well as accidents, spills, and other emergency releases of pollutants and contaminants into the environment. Through CERCLA, EPA was given authority to identify those parties responsible for releases and ensure their cooperation in the cleanup.

Low levels of residual radioactivity may remain at many DOE sites. If necessary, long-term management (e.g., institutional controls) will be implemented to ensure future use of the land is safe and barriers to prevent access are functioning as intended. Several DOE sites have waste disposal on-site in CERCLA disposal cells requiring long-term stewardship. See Section H.2.5 for DOE's regulations on long-term management of legacy sites.

H.2.2. Siting Proposed Facilities (Article 13)

In addition to the requirements in DOE O 435.1, DOE radioactive waste management facilities, operations, and activities are designed and sited in accordance with DOE O 420.1A, *Facility*

Safety,[221] and DOE O 430.1C, *Real Property Asset Management*.[222] Proposed locations for radioactive waste management facilities are evaluated to identify features to be avoided or that must be considered in facility design and analyses. Criteria for siting a proposed new facility or expansion of an existing facility must consider:

- Environmental and geotechnical suitability;
- Human activity prohibiting site use;
- Suitability for the volume of proposed waste disposal;
- Presence of flood plain, tectonic, or water table fluctuation characteristics; and
- Ability to control radionuclide migration pathways, surface erosion and run-off.

H.2.3. Design and Construction (Article 14)

Design and construction was briefly discussed in Section F.10 of this report. Generally applicable requirements and procedures for nuclear facility design, construction and operation are in 10 CFR Part 830, *Nuclear Safety Management*, DOE O 420.1C, *Facility Safety*, DOE O 414.1D, *Quality Assurance*, DOE Policy (P) 450.4A, *Safety Management System Policy*, [223] and DOE Acquisition Regulation clauses at 48 CFR 970.5223-1, 48 CFR 970.5204-2, and 48 CFR 970.1100-1. DOE Manual (M) 435.1-1, Change 2, *Radioactive Waste Management Manual* requires new or modified waste management facilities subject to contamination with radioactive or other hazardous materials be designed to facilitate decontamination. A proposed decommissioning method must be included in the design.

H.2.4. Assessing Facility Safety (Article 15)

Radioactive waste facilities, operations, and activities must have a radioactive waste management basis consisting of physical and administrative controls to ensure protection of workers, the public, and the environment. Safety is ensured through specific waste management controls (waste acceptance criteria and waste certification programs), and based on regulatory requirements. See Table F-3 for major radiation protection standards.

After September 26, 1988, DOE LLW disposal facilities are required to be sited, designed, operated, maintained, and closed so there is a reasonable expectation that the facilities will comply with the performance objectives for DOE LLW facilities.[224] Site-specific radiological performance assessments (PA) are prepared and maintained for DOE LLW disposal facilities.

In addition to PAs, site-specific radiological composite analyses are prepared and maintained for LLW disposal facilities receiving waste after September 26, 1988. The composite analysis accounts for all sources of radioactive material left at DOE sites potentially interacting with the LLW disposal facility, contributing to the dose projected to a hypothetical member of the public from existing or future disposal facilities. The composite analysis results are used for planning,

[221] See https://www.directives.doe.gov/directives-documents/0420.1-BOrder-a.
[222] See https://www.directives.doe.gov/directives-documents/0430.1-BOrder-bc2.
[223] See https://www.directives.doe.gov/directives-documents/0450.4-APolicy.
[224] The date of issuance of DOE O 5820.2A, *Radioactive Waste Management*, the first detailed, prescriptive DOE LLW management order. LLW disposed of before (and after) that date is subject to the requirements of DOE Order 458.1, *Radiation Protection of the Public and the Environment*.

radiation protection activities, and future use commitments to minimize the likelihood current LLW disposal activities will result in the need for future corrective or remedial actions. See additional information in the implementation guidance for DOE O 435.1 (DOE Guide 435-1, *Implementation Guide for Use with DOE M 435.1-1*).[225] The PA and composite analysis are maintained to evaluate changes affecting the performance, design, and operating bases for the facility. Additional iterations of the PA and composite analysis are conducted as necessary during the post-closure period.

A disposal authorization is a part of the radioactive waste management basis for a disposal facility and is obtained from DOE management prior to construction of a new LLW disposal facility. The disposal authorization statement is issued based on a review of the facility's PA, composite analysis, preliminary closure plan, and preliminary monitoring plan. It specifies the limits and conditions on construction, design, operations, and closure of the LLW facility based on these reviews. More details on PAs, composite analyses, and compliance demonstration are discussed in the U.S. Fourth National Report.

Disposal Facility Closure Plans are developed for DOE LLW disposal sites. A preliminary closure plan is developed and reviewed with the PA and composite analysis. The closure plan is updated following the disposal authorization statement to incorporate conditions specified in the disposal authorization statement. Closure plans are updated as required during the operational life of the facility. Closure plans also include the total expected inventory of wastes to be disposed of at the facility over the operational life.

H.2.5. Institutional Measures after Closure (Article 17)

Institutional control measures are integrated into land use and stewardship plans and programs, and continue until the facility can be released pursuant to DOE O 458.1, *Radiation Protection of the Public and the Environment*. Most radioactive waste disposal sites will not meet DOE criteria for unrestricted release at any time in the foreseeable future. The location and use of the facility are filed with the local authorities responsible for land use and zoning.

DOE P 454.1, *Use of Institutional Controls,*[226] requires the maintenance of active and passive controls for as long as the hazard exists. The active control period is determined by public risk, and some sites may indeed be released for either controlled or uncontrolled use. DOE anticipates many of its facilities may never be released from active institutional control.

DOE will use active institutional controls for at least 100 years following closure. Active controls, such as fences, roadways, signs, and periodic surveillance, prevent human intrusion during this period. See additional information on institutional controls including those applicable to TRU waste disposal at the Waste Isolation Pilot Plant in the U.S. Fourth National Report.

H.3. Other Waste Management Facilities or Practices (Article 12)

H.3.1. Management Strategies for Low-Activity Waste Sites

Low-activity waste (LAW) does not have a statutory or regulatory definition, but generally means wastes that contain some residual radioactivity, including naturally occurring radionuclides,

[225] See https://www.directives.doe.gov/directives-documents/400-series/0435.1-EGuide-1.
[226] See https://www.directives.doe.gov/directives/0454.1-APolicy/view.

which can be safely disposed of in hazardous or municipal solid waste landfills. LAW is equivalent to very low-level waste in the International Atomic Energy Agency waste classification scheme. In the U.S., LAW is invariably a fraction of the limits for Class A LLW contained in 10 CFR Part 61, and is often below concentrations that are considered safe for unrestricted release under international standards. Although these materials could be disposed of in a LLW disposal facility licensed under 10 CFR Part 61, if a licensee so chooses, disposal at another type of facility, such as a hazardous waste facility, can be authorized under 10 CFR 20.2002. This provision in NRC's regulations allows for other disposal methods, different from those already defined in the regulations, provided that doses are maintained as low as reasonably achievable and within the regulatory dose limits in 10 CFR Part 20. DOE has provisions for case- and site-specific considerations of LLW. If a case- and site-specific prospective dose assessment demonstrates that it would be protective, LLW may be approved for disposal in hazardous or municipal landfills that have a waste acceptance criteria (WAC) permitting such disposal. The disposal of LLW in hazardous or solid waste landfills is permitted, provided that the WAC and regulatory dose limits are met at the receiving disposal facilities. Mill tailings from extraction and concentration from uranium and/or thorium are disposed of under a separate set of regulations.

The U.S. implements or oversees cleanup programs producing substantial amounts of LAW (see additional information in the U.S. Fourth National Report). For example, NRC established the complex sites decommissioning program in the early 1990s and continues to oversee the cleanup of sites contaminated with radioactive materials and licensees who implement the cleanup as discussed in Section D.3.3.

Estimating future needs for storage or disposal capacities for LAW, LLW, or mixed waste is the waste generator's responsibility. Hazardous waste facilities and municipal or industrial solid waste landfills are now used by U.S. generators for some LAW disposal. Both types of facilities are regulated under RCRA, which is implemented by EPA and, in the case of hazardous waste, by states authorized by EPA, and, for non-hazardous solid waste, by states alone. See Section E.2.2.3 on mixed waste regulation.

Licensees in non-Agreement States are required to get NRC approval for alternate disposal of LAW (10 CFR 20.2002). The approval request must identify amounts, concentrations, and specific radionuclides and include a PA demonstrating exposures will be no more than a few tens of microsieverts (μSv). NRC approval exempts such waste from further regulatory control with regard to the waste's radioactive content. Agreement States have regulations similar to 10 CFR 20.2002 covering the disposal of LAW.

DOE, on a case-by-case basis and in coordination with state regulators, has established authorized limits for waste disposal at specific solid waste landfills. The authorized limits are established to ensure no special regulatory requirements beyond those already in place for the landfill are necessary.

H.3.2. Controlling Solid Materials Disposition

In the international context, Controlling Solid Materials Disposition is referred to as clearance. NRC generally addresses the release of solid material on a case-by-case basis using license conditions and existing regulatory guidance described in NUREG-1757. In each case, material may be released from a licensed operation with the understanding and specific acknowledgment that the material may contain very low amounts of radioactivity, but the concentration of radioactive material is so small that its control through licensing is no longer

necessary. Some materials are only contaminated on or near the surface; others are contaminated throughout their volume. The regulatory processes for release of these materials are different.

Land disposal is another option for disposition of low activity radioactive material from licensed facilities (see Section H.3.1). NRC can consider specific licensing actions, as well as generic requests, concerning the disposition of solid materials. NRC regulations do not contain generally applicable standards for the disposition of solid materials with relatively small amounts of radioactivity in, or on, materials and equipment.[227] The offsite disposition of solid materials prior to license termination will continue to be evaluated on a case-by-case basis using existing regulations and guidance.

H.3.2.1 Surface Contaminated Radioactive Material Release

Criteria used by licensees to determine whether the material may be released are approved during the initial licensing or license renewal of a facility, as part of the facility's license conditions or radiation safety program. The licensees' actions must be consistent with the regulatory requirements of 10 CFR Part 20, *Standards for Protection against Radiation* (e.g., 10 CFR 20.1501). The licensee performs a survey of the material prior to its release.

Nuclear reactor licensees historically follow a policy that was established and documented in NRC Office of Inspection and Enforcement Circular 81-07 and Information Notice 85-92.[228] The reactor licensees survey equipment and material before release, to identify the presence of controlled radioactive material above natural background levels. If "presence" of material is detected, then no release may occur. Otherwise, the solid material in question can be released for unrestricted use.

For materials licensees, NRC usually authorizes the release of solid material through specific license conditions. Since the previous U.S. National Report, NRC has rescinded Regulatory Guide (RG) 1.86, *Termination of Operating Licenses for Nuclear Reactors*,[229] which was previously used to provide criteria to evaluate the release of solid materials. RG 1.86 is obsolete because it contains outdated regulatory processes. Criteria used to evaluate solid materials before they are released are contained in Fuel Cycle Policy and Guidance Directive FC 83-23, *Termination of Byproduct, Source, and Special Nuclear Material Licenses*.[230] This document contains a table of surface contamination criteria, similar to the one presented in the withdrawn RG 1.86, which may be applied by licensees for use in demonstrating that solid material with surface contamination can be safely released with no further regulatory control. These surface contamination criteria have been used in many contexts for all types of licensees for many years.

---

[227] American National Standard ANSI/HPS N13.12-2013, *Surface and Volume Radioactivity Standards for Clearance* was updated in May 2013. However, it has not been incorporated into the U.S. regulatory infrastructure.
[228] These documents are available from NRC's web site: Information Notice No. 85-92: *Surveys of Wastes Before Disposal From Nuclear Reactor Facilities* (December 2, 1985) https://www.nrc.gov/reading-rm/doc-collections/gen-comm/info-notices/1985/in85092.html, and IE Circular No. 81-07: *Control of Radioactively Contaminated Material* (May 14, 1981) https://www.nrc.gov/reading-rm/doc-collections/gen-comm/circulars/1981/cr81007.html.
[229] See https://www.federalregister.gov/documents/2016/08/12/2016-19195/termination-of-operating-licenses-for-nuclear-reactors.
[230] The document is available at NRC's Agencywide Documents Access and Management System, under ML030650166.

H.3.2.2 Volumetrically Contaminated Radioactive Material Release

NRC guidance on release levels is summarized in an NRC report (NUREG-1757, Vol. 1, Rev. 2, Section 15.11). Release levels are determined based on two methods, namely through the use of existing NRC guidance or through the development of alternative approaches, which are reviewed by NRC on a case-by-case basis.

NRC's guidance for volumetric contaminated radioactive material release, has not changed since the previous U.S. National Report and is also available from the NRC web site.[231] For materials licensees, controlled releases of volumetrically contaminated concrete may be approved, pursuant to 10 CFR 20.2002, under an annual dose criterion of a few tens of μSv.

Reactor facilities release volumetrically contaminated materials under the provisions of Information Notice No. 88-22, *Disposal of Sludge from Onsite Sewage Treatment Facilities at Nuclear Power Stations*.[232] This provision permits release of materials if no licensed radioactive material above natural background levels is detected, provided the radiation survey used a detection level that is consistent with the lower limit of detection values used to evaluate environmental samples.

Radioactive waste management of materials resulting from decommissioning (decontamination, dismantlement, demolition, etc.) is addressed in NUREG-1757, Rev. 2, Section 17.5.

H.4. Uranium Recovery Facilities

Uranium milling waste is designated as AEA Section 11e.(2), "byproduct material" as described in Section B.2.3.2.

H.4.1. General Safety Requirements (Article 11)

The general radiological waste safety provisions, as well as for siting and closure, for uranium milling activities are addressed in 10 CFR Part 40, with specific criteria described in Appendix A.[233] The criteria in Appendix A cover provisions such as siting and design of tailings impoundments and disposal of tailings or wastes. These provisions also address a number of non-radiological constituents (e.g., ammonia) contained in tailings. See Table F-3 for radiation safety criteria. See additional information in the U.S. Fourth National Report.

H.4.2. Existing Facilities and Past Practices (Article 12)

The existing facilities are designated as Uranium Mill Tailings Radiation Control Act Title I (closed or abandoned by 1978) or Title II (under license in 1978 or later) facilities. Reclamation at Title I facilities is largely complete with the exception of the former Atlas site near Moab, Utah; however, groundwater issues remain unresolved at a few sites. Many Title II conventional mills in the U.S. are being decommissioned and reclamation activities are either completed or near completion. The goal of the reclamation activities is to provide long-term stabilization and closure of the tailings impoundments and the sites. See Section D.2.2.3 for additional

[231] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1757/v1/.
[232] See https://www.nrc.gov/reading-rm/doc-collections/gen-comm/info-notices/1988/in88022.html.
[233] Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily for Their Source Material Content.

information.

NRC or the Agreement State inspects these sites at various intervals depending on the operational (or stand-by) and reclamation status. The inspection frequency can range from multiple times per year at an operating facility to once every 3 years at a facility in standby or reclamation status. Annex D-3 provides status of uranium recovery facilities.

H.4.3. Siting, Design, and Construction (Articles 13 and 14)

Appendix A to 10 CFR Part 40 has 13 criteria for the siting, design, construction, operation, termination and post-closure provisions.[234] Technical Criterion 1 sets broad objectives for siting and design. The intent is to provide permanent isolation of tailings and associated contaminants by minimizing disturbance and dispersion by natural forces, and to do so without ongoing maintenance. Additional criteria specify the period of performance (longevity) and other design considerations such as the presence of a liner system and dewatering method. Construction considerations include the preference for below grade disposal and reliance on a full self-sustaining vegetative cover or rock cover to reduce wind and water erosion.

H.4.4. Safety Assessment (Article 15)

A safety assessment is performed as part of the application review process for a uranium recovery operation. The application must provide detailed information on facilities, procedures, and equipment. Additionally, the applicant must provide an environmental report with sufficient information for NRC to prepare an environmental assessment (EA) under the provisions of the National Environmental Policy Act (see Section F.7.7). If the EA identifies potential significant environmental impacts, NRC will prepare an Environmental Impact Statement.

H.4.5. Institutional Measures after Closure (Article 17)

Uranium recovery licensees are required by license conditions to complete site decontamination, decommissioning, and surface and groundwater remedial actions consistent with decommissioning, reclamation, and groundwater corrective action plans before license termination.[235] Licensees must document the completion of these remedial actions in accordance with NRC requirements. This information includes a report documenting completion of tailings disposal cell construction, as well as radiation surveys and other information required by 10 CFR 40.42. See additional information on other institutional measures such as a Long-Term Surveillance Plan implemented by the custodial agency in the U.S. Fourth National Report.

H.5. Monitoring Releases to the Environment

RadNet, formerly known as the Environmental Radiation Ambient Monitoring System, is EPA's national network of sampling locations distributed across all 50 states and Puerto Rico. The network regularly samples the nation's air, precipitation, and/or drinking water for gross radioactivity levels or for specific radionuclides.[236]

[234] These criteria can be accessed at https://www.nrc.gov/reading-rm/doc-collections/cfr/part040/part040-appa.html.
[235] See https://www.nrc.gov/waste/decommissioning/reg-guides-comm.html.
[236] RadNet data and instructions for viewing reports are available through the RadNet home page at https://www.epa.gov/radnet.

RadNet includes:

- 139 fixed air monitors that can deliver real-time data using various telemetry methods (25 have additional dose rate monitoring);
- 40 portable (or "deployable") real-time air monitors;
- 30 precipitation sampling locations; and
- 64 drinking water sampling locations.

EPA's strategy for siting the fixed air monitors is to place them in locations ensuring national coverage from both a population and geographic standpoint. The monitors are operated mostly by state and local government officials. The RadNet fixed air, precipitation, and drinking water monitoring networks are managed at EPA's radiation laboratory in Montgomery, Alabama. The 40 deployable air monitors are maintained at EPA's facility in Las Vegas, Nevada.

The RadNet system is designed to provide information to help evaluate the degree and extent of contamination caused by a release of radioactive materials to the environment.

RadNet normally operates in a "routine" mode, sampling radiation in all media on a regularly defined schedule. RadNet operates in an "emergency" (or alert) mode when there is a threat or actual release of a significant amount of radioactive material, potentially accelerating the frequency of sampling and generating many more data records for a given period of time compared to the RadNet routine mode. In response to the incident at Fukushima in March 2011, EPA increased precipitation and drinking water sampling and analysis and stationed deployable monitors in several western states, as well as Guam and Saipan. In addition to real-time air monitor measurements, more than 1700 samples were collected in the first month following the incident.

EPA does not sample milk as part of the RadNet system. Following the Fukushima incident, EPA and the Food and Drug Administration (FDA) agreed that milk sampling should instead be a component of the routine sampling done by FDA to ensure the milk supply is safe.[237] EPA last sampled milk in April 2014.

EPA also has developed RadMap, which is an interactive desktop tool to provide government at all levels with information about long-term radiation monitoring stations across the country. RadMap employs a stand-alone geographic information system (GIS) platform to allow users to view information about the network of approximately 2000 Federal, state, local and industrial/commercial monitors. Information provided includes points of contact, available data, data collection parameters and frequency, demographics, and geographic points of interest, as well as links to the monitoring station owner's web site, if available. RadMap is a particularly useful tool for emergency responders and decision-makers to help assess the need for and appropriate location of additional monitoring resources. As a preloaded GIS program, RadMap ensures access to critical information even if computer network capabilities are unavailable.[238]

[237] Information on FDA's Total Diet Study, Toxic Elements in Food and Foodware, and Radionuclides in Food programs may be found at https://www.fda.gov/Food/default.htm.
[238] See https://www.epa.gov/radiation/radmap.

I. TRANSBOUNDARY MOVEMENT

I.1. U.S. Legal and Policy Framework for Transboundary Movement

The Atomic Energy Act of 1954, as amended (AEA), assigns regulatory oversight responsibility to Nuclear Regulatory Commission (NRC) for commercial imports and exports of source, special nuclear and byproduct materials to and from the United States of America (U.S.).[239] NRC regulations governing commercial imports/exports are set forth in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 110. See additional historical information in the U.S. Fourth National Report.

Department of Energy (DOE) has independent authority for imports and certain exports under the AEA. Thus, DOE imports and certain exports are not subject to NRC export/import licensing regulations. For example, NRC's regulatory authority does not apply to DOE import of disused sealed sources.

A specific license is required under 10 CFR Part 110 for imports or exports of radioactive waste as defined in 10 CFR 110.2. Such radioactive waste may also contain or be contaminated with hazardous waste.[240]

Exports of irradiated or spent fuel are addressed in other provisions governing exports of special nuclear material. A specific NRC license for imports of spent fuel is required if the shipment exceeds 100 kilograms. Because DOE has separate statutory authority to import nuclear material and equipment, it is not subject to NRC import licensing.

I.2. Regulatory Requirements for Export or Import of Radioactive Waste

After an applicant has submitted an application to NRC and provided the required information for a license to import or export radioactive waste, NRC then forwards the application to Department of State (DoS) to coordinate reviews by interested U.S. Federal Government agencies for proposed exports and for contacting the involved foreign governments (material origin, intermediate, and/or ultimate consignee) to either provide notice of proposed imports or to obtain assurances/consent for proposed exports.

Once DoS issues an executive branch letter that the appropriate authorities of the country of origin have consented and the proposed export or import appears to be consistent with the guidelines of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, NRC will begin preparations to issue the license. The license to import or export radioactive waste will be issued if NRC makes a final determination that all applicable legal requirements have been satisfied. A brief description of the export and import review process for each is provided below since the reviews involve different considerations.

[239] Although not within the scope of the Joint Convention, NRC is also responsible for imports and exports of nuclear production and utilization facilities and any equipment or components, which are especially designed or prepared for use in such facilities.

[240] Defined in Section 1004(5) of the Solid Waste Disposal Act, 42 U.S.C. 6903(5). EPA regulates imports and exports of hazardous waste.

I.2.1. Exports

To issue a license for an export of radioactive waste, NRC must determine that the appropriate authorities of the country of origin have consented to the proposed export, in addition to receiving recommendations from interested U.S. Federal agencies. Export-licensing criteria are specified at 10 CFR 110.42. For proposed exports of radioactive waste, NRC requests DoS to contact the government of the recipient nation to ask if it will accept such an import from the U.S. and requests confirmation that the designated consignee is authorized to receive the radioactive waste. DoS will ask the government to provide assurances that the material will be maintained in accordance with terms and conditions of the agreement if the material is subject to a peaceful nuclear cooperation agreement between the U.S. and the recipient nation. The U.S. accepts responses and assurances received from the nation of destination as confirmation that it has the administrative and technical capacity and regulatory structure to manage and dispose of the waste. NRC regulations do not require specific assessments and findings about the adequacy of the receiving nation's administrative and technical capacity and regulatory structure. NRC considers circumstances under which it would issue a license authorizing the export of radioactive waste to a nation without a regulated waste disposal program.

Nations importing enriched uranium from the U.S. for use as reactor fuel, whether it is in the form of fresh fuel or spent fuel must obtain U.S. consent prior to retransferring it to a third party and for reprocessing, enrichment, or other alterations in form or content under the terms and conditions of U.S. peaceful nuclear cooperation agreements. Requests for U.S. approvals of such retransfers and alterations are submitted to and processed by DOE/National Nuclear Security Administration, which coordinates U.S. interagency review of the proposed transaction. The U.S. is also consulted about the return of materials resulting from reprocessing if a nation obtains U.S. approval to transfer spent fuel to a third nation for reprocessing.

I.2.2. Imports

For proposed imports of radioactive waste, NRC receives the application and forwards it to DoS. DoS then contacts the government of the exporting nation, and seeks acknowledgement that they are aware of the proposed transaction and solicits any comments they might wish to provide. NRC has exclusive jurisdiction within the U.S. (the states and U.S. territories) to grant or deny specific licenses for non-DOE imports of radioactive waste. As part of the review of an application for a license to import radioactive waste, NRC consults with, as applicable, the Agreement State in which the facility is located and the associated low-level waste compact commission(s) to confirm that an appropriate facility has agreed to accept and is authorized to possess the waste for management or disposal. NRC will not grant an import license for waste intended for disposal unless it is clear the waste will be accepted by a disposal facility, the host state, and the compact commission (where applicable). These are among the factors considered in determining the appropriateness of the facility agreeing to accept the waste for management. U.S. origin sources being returned to a manufacturer, distributor or other entity, which is authorized to receive and possess the sealed source or the device containing the sealed source, may be imported under the general import license. In August 2013, NRC published guidance on the import of non-U.S. origin radioactive sources.[241]

[241] NRC published a Branch Technical Position on the Import of Non-U.S. Origin Radioactive Sources on August 28, 2013 (78 FR 53020). See https://www.gpo.gov/fdsys/pkg/FR-2013-08-28/pdf/2013-20975.pdf.

I.3. Implementation Experience to Date

NRC ensures that exports and non-DOE imports of nuclear materials facilities and equipment under NRC's jurisdiction are licensed in accordance with applicable U.S. statutory and regulatory requirements, as well as U.S. Government commitments to legally binding international treaties and multilateral and bilateral agreements. In addition, NRC and DOE continue to exercise global leadership by implementing and promoting international guidance such as the Code of Conduct on the Safety and Security of Radioactive Sources. Table I-1 provides the total number of licensing actions and Table I-2 provides the number of specific licenses issued for import or export of Category 1 and 2 radioactive materials. Appendix P to 10 CFR Part 110 provides import and export threshold limits for specific radionuclides. This includes discrete sources of Radium-226.

Imports of Category 1 and 2 radioactive material are authorized by an NRC general license, if the material is of U.S. origin and the U.S. recipient is authorized by NRC or Agreement State regulations to receive and possess the sealed source or device containing a sealed source, including disused sealed sources being returned to the U.S. manufacturer or distributor. If the disused sealed sources were supplied by a non-U.S. manufacturer or distributor and are being sent to a U.S. facility solely for disposal, then a specific NRC import license would be required.

Table I-1. Completed Export/Import Nuclear Regulatory Commission Licensing Actions for January 2000–March 2017

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Byproducts	1	0	0	2	6	7	2	3	1	1	7	3	6	5	3	2	1	1	51
Components	13	19	5	7	15	10	11	16	5	9	13	16	14	25	2	16	12	1	209
Moderator Material	4	2	3	3	6	3	1	2	1	2	1	4	16	7	1	6	3	2	67
Reactor & Major Reactor Components	4	5	2	0	1	3	1	4	1	3	0	0	2	1	1	2	1	0	31
Special Nuclear Material	50	86	68	53	56	51	64	52	43	69	41	37	38	29	4	13	11	6	771
Source Material	10	17	2	14	11	4	5	8	12	5	5	8	8	3	1	7	3	1	124
Waste Exports	2	3	1	4	1	5	2	5	3	0	6	4	1	6	0	0	3	1	47
Waste Imports	3	4	0	2	2	3	3	9	2	1	5	4	2	5	0	1	3	1	50
Total	87	136	81	85	98	86	89	99	68	90	78	76	87	81	12	47	37	13	1350

Source: NRC, Office of International Programs.

Table I-2 Appendix P Licenses Issued December 2005–December 2016

Year	Combination License	Export License	Import License	Total
2005	15	0	0	15
2006	49	15	19	83
2007	54	12	7	73
2008	21	12	6	39
2009	26	13	5	44
2010	26	12	5	43
2011	0	14	0	14
2012	0	35	0	35
2013	0	20	0	20
2014	0	11	0	11
2015	0	20	0	20
2016	0	9	0	9
Total	191	173	42	406

Source: NRC, Office of International Programs.

This page intentionally left blank.

J. DISUSED SEALED SOURCES

J.1. General Safety for Sealed Sources (Article 28)

Radiation safety programs for use and storage of byproduct material as a sealed source or device are based on robust containment of radioactive material. Sealed sources and devices are designed to withstand stresses imposed by the environment in which they are possessed and used. Regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) Parts 20 and 30 through 39 provide requirements for both vendors and users of sealed sources and devices. Agreement States issue adequate and compatible regulations for the control of sealed sources and devices within their borders.

Nuclear Regulatory Commission (NRC) regulations at 10 CFR 30.32(g) require that those seeking a license to use byproduct material in the form of a sealed source or in a device that contains the sealed source must either identify, in their application, whether the proposed source or device is already registered or provide the information necessary for NRC to perform a safety evaluation of the sealed source or device. Information on NRC's safety evaluation and registration criteria are contained in 10 CFR 32.210. In addition, the regulations clarify the regulatory responsibility of holders of product registration certificates.

Regulations in 10 CFR Parts 30, 31, and 32 allow for use of equipment that requires registration by a vendor, rather than a specific licensee. Also allowed are sources and devices, which are exempt from both registration and licensing, when certain requirements are met. The individuals who use licensed products are exempt from licensing requirements. The initial manufacturer or distributor must apply for and receive a specific license that allows the distribution of these products to individual users. These types of products include gauges, watches, gun sights containing tritium, and smoke detectors containing americium.

NRC and the Agreement States perform safety evaluations of the ability of sealed sources and devices to contain licensed material for use under the conditions requested. These evaluations are summarized in registrations, which are maintained by NRC in the National Sealed Source and Device Registry. Although full access to the registry is unavailable publicly, the general public can still download reports on current and former vendors and products from the National Registry from NRC's public web site.[242] Information on the regulatory process for evaluating and licensing sealed sources and devices is available to the public through NRC's web site.[243] Agreement States also provide information from their radiation safety evaluations to NRC for the registry. A vendor is required to provide detailed information about its sealed source or device to the regulatory agency with jurisdiction, either NRC or an Agreement State(s). NRC estimates there are approximately two million of these devices and sources in existence.

Licensees possessing, using, packaging, handling, transferring, and disposing licensed material are required to comply with the general occupational and public radiation protection regulations, listed in Table E-1. This includes licensing, financial assurance and record keeping for decommissioning, expiration and termination of licenses, and decommissioning.

[242] See https://www.nrc.gov/materials/miau/sealed-source.html.
[243] See https://www.nrc.gov/materials/miau/sealed-source.html.

J.2. Sealed Sources Security and Accountability

Disposal of commercial sealed sources continues to be a challenge in the U.S. for two main reasons. First, existing commercially available disposal sites in the U.S. limit the radioactive inventory, isotopic content, and geographic origin of waste they will accept. However, even though disposal capacity has increased and NRC updated the guidance for disposal of certain high activity sources[244] [such as high activity cobalt-60 (^{60}Co) and cesium-137 (^{137}Cs)] (see discussion in Section J.3), many commercial actinide sources [such as americium-241] still have no disposal pathway. Second, higher activity sources must be transported in packages that meet both NRC and Department of Transportation regulations. These packages are expensive, and the availability of large volume containers capable of transporting high activity sources is limited. The U.S. is currently exploring financial assurance requirements for the management of sealed sources once they reach the end of their working life (see Section A.3.4.2). DOE/National Nuclear Security Administration (NNSA) has designed two Type B containers; the first container received certification in 2014 and was delivered in March 2017. The safety analysis report for the second design is currently undergoing NRC review.

Licensees possessing disused sealed sources, such as sources that have been determined to be greater-than-Class C (GTCC) low-level waste (LLW) or certain high activity sources, that have no disposition path are responsible for properly storing the sources in accordance with NRC or Agreement State regulatory and/or license requirements until disposal. These sources must be stored at the owners' facilities or at commercial waste facilities in accordance with NRC requirements under 10 CFR Parts 30 through 39 or equivalent Agreement State requirements, as applicable. The regulations require licensees to secure the material to prevent unauthorized removal or access to licensed materials stored in controlled or unrestricted areas. All licensed facilities that use, store, or dispose of radioactive materials are inspected on a regular basis to ensure adequate safety and physical protection. The U.S. has progressed in addressing commercial sealed source management and disposal challenges, while maintaining adequate safety and physical protection of radioactive material during all phases of production, use, storage, and disposal.[245] Disposal access for many commercial Class A, B, and C sealed sources are now available to LLW generators in all 50 states. The U.S. continues to address the challenges of the disposal of the highest activity sealed sources. However, significant commercial sealed source disposal challenges remain, including development of disposal capability for GTCC LLW and certain higher activity B and C sealed sources, e.g., ^{137}Cs and ^{60}Co sources, as well as the high cost of commercial source transportation and disposal.

J.3. Management of Disused Sealed Sources

DOE/NNSA recovers, securely stores, and disposes, as appropriate, commercially licensed sealed sources that pose a threat to national security and/or public health and safety. DOE/NNSA prioritizes recovery of sources registered with the program based on threat reduction criteria developed in coordination with NRC.

[244] See https://www.nrc.gov/waste/llw-disposal/llw-pa/llw-btp.html.
[245] The Energy Policy Act of 2005 established the interagency Task Force on Radiation Source Protection and Security. Additional information is available at: https://www.nrc.gov/security/byproduct/task-force.html.

Working with state partners, DOE/NNSA facilitates the collection and disposal of disused radioactive sealed sources at commercial LLW disposal facilities. In addition, Environmental Protection Agency has the authority and capability to recover orphan sources. Recovered sources are managed in accordance with the objectives of the Joint Convention found in Article 1.

In February 2015, NRC published the revised Concentration Averaging and Encapsulation Branch Technical Position (CA BTP). The CA BTP provides guidance for determining the classification of commercial LLRW, including sealed sources. The CA BTP considers the disposal of additional sealed sources containing radioactive quantities of concern by increasing the generic disposal limit for ^{137}Cs. It also clarifies guidance related to the classification of ^{60}Co sources. The revised CA BTP provides detailed discussion of alternative approaches that could be used for the disposal of Class A, B, and C sealed sources.

A demonstration project evaluating the acceptability of the alternative approaches contained in the CA BTP has begun. The Conference of Radiation Control Program Directors requested a state regulator evaluate the disposal of a device containing high activity sealed sources in a commercial disposal facility. The technical justification for this type of disposal is complete and personnel at the disposal facility have coordinated with the state regulator to ensure the technical sufficiency of the proposal. The disposal was completed in September 2017.

This page intentionally left blank.

K. GENERAL EFFORTS TO IMPROVE SAFETY

This section provides a summary of ongoing United States of America (U.S.) activities (some of which were addressed in Section A.3) and efforts to ensure safe management of spent fuel, radioactive waste, and disused sealed sources. Measures taken to address suggestions and challenges, which were identified in previous review meetings, are discussed below. In addition, this section describes strong features of the current U.S. program, possible areas for improvement, major challenges, and how the U.S. plans to address these challenges. Finally, this section describes U.S. peer review missions, measures taken to make public the related reports, and actions taken to enhance openness and transparency in the implementation of U.S. obligations under this Convention.

K.1. Current Strong Features of the U.S. Program

The U.S. Government has continued to focus on safety within the U.S. nuclear programs and has continued to strengthen its regulatory framework by issuing new regulations and establishing policies related to waste management and spent fuel management. The Fifth Review Meeting highlighted a few positive activities of the U.S. programs:

- Global work on source collection;
- Major investments in supporting a large number of international programs worldwide; and
- International sharing of the lessons that emerged from the Waste Isolation Pilot Plant (WIPP) events.

Some features are continuing strengths that were highlighted in previous Review Meetings. Other features are new and have evolved since the Fifth Review Meeting. Some of these strong features also have associated challenges that are addressed in Section K.2.

K.1.1. Disused Sealed Sources

The U.S. has made significant progress in addressing commercial sealed source management and disposal challenges. Disposal options for many commercial Class A, B, and C sealed sources are now available to low-level waste (LLW) generators in all 50 states. The U.S. has also made progress in addressing ongoing challenges regarding the disposal of the highest activity sealed sources. Additional discussion is provided in Section A.3.4.

K.1.2. International Collaboration

The U.S. continues to maintain a strong and robust international program to support the safe and secure management of spent fuel and radioactive waste. International activities link the U.S. to the world's evolving practices, and provide a forum for exchanging strategies and technologies with other nations. Through international cooperation, countries can coordinate on the development of formal agreements with each other, enabling an exchange of detailed scientific and technical information, or joint sponsorship of activities in areas such as alternatives for geologic disposal environments and long-term storage.

Participation in these types of activities benefits the U.S. through the acquisition and exchange of information, particularly related to complex issues dealing with topics such as performance assessments, database development, and peer review by experts of other participating nations. These international projects serve U.S. goals in advancing scientific understanding, enhancing

environmental protection, and improving global safety and security. In fostering international cooperation on waste management, the continued goal is to lead to an optimized national disposal system and promote the exchange of institutional and technical knowledge throughout the international community. See additional information in the U.S. Fifth National Report.

The examples of organizations and agreements under which the U.S. has continued interactions include: Organization for Economic Cooperation and Development/Nuclear Energy Agency, International Association for Environmentally Safe Disposal of Radioactive Materials, Extended Storage Collaboration Program, International Framework for Nuclear Energy Cooperation (IFNEC),[246] International Atomic Energy Agency (IAEA), multi-lateral initiatives and bilateral agreements and Memoranda of Understanding.

The U.S. participated as a lead role in several international activities related to decommissioning including the IAEA's International Conference on Advancing the Global Implementation of Decommissioning and Environmental Remediation Programs in May 2016. The U.S. also participated in Organization for Economic Cooperation and Development/Nuclear Energy Agency decommissioning activities particularly the "Working Party on Dismantling and Decommissioning" and its task groups. The U.S. has hosted, sponsored, or participated in workshops, discussion panels, and training sessions, as well as in decommissioning workgroups and decommissioning projects and related activities. Further, the U.S. participated in training and development of decommissioning regulatory framework through bilateral and multilateral international counterparts.

For more information on these international collaborative interactions, see the U.S. Fifth National Report.

K.1.3. Nuclear Regulatory Commission Rulemaking Activities

Nuclear Regulatory Commission (NRC) has continued to develop new or updated regulations to further enhance safety. Rulemaking activities of particular note relating to the provisions in the Joint Convention include:

1. 10 CFR Part 61 Rulemaking

NRC is proposing to amend its regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 61 that govern LLW land disposal facilities to require new and revised site-specific technical analyses and to permit the development of site-specific criteria for LLW acceptance based on the results of these analyses. The proposed changes would ensure that future LLW streams that differ significantly from those considered during the development of the original regulations [i.e., depleted uranium (DU) and other unanalyzed waste streams] can be disposed of safely and meet the performance objectives for land disposal of LLW during the compliance period. The proposed changes would also increase the use of site-specific information to ensure that the performance objectives are met. Performance objectives are designed to provide protection of public health and safety.

[246] See the web site for more information on IFNEC, www.ifnec.org.

In addition, NRC has developed a guidance document, NUREG-2175, *Guidance for Conducting Technical Analyses for 10 CFR Part 61,*[247] to facilitate the development of information and analyses that will support licensees or license applicants in addressing the regulatory requirements.

2. Potential Rulemaking on Regulatory Improvements for Power Reactors Transitioning to Decommissioning

As noted in the U.S. Fifth National Report, the 2010 Integrated Regulatory Review Service (IRRS) mission identified this topic as a potential rulemaking opportunity. Since that time, a number of U.S. nuclear power plants (NPPs) announced the transition to a decommissioned status earlier than the end of the expected operational life of the plant. NRC began rulemaking activities on regulatory improvements for reactors transitioning to decommissioning. See Section A.3.7.1 for additional information.

3. GTCC LLW and Transuranic Waste Possible Rulemaking

NRC plans to prepare a regulatory basis for the disposal of greater-than-Class C (GTCC) LLW and transuranic (TRU) waste for a possible rulemaking. During the development of the regulatory basis, NRC will conduct public workshops to receive input from stakeholders and to address TRU waste in 10 CFR Part 61. See Section A.3.8.

K.1.4. Sharing Lessons Learned from the Waste Isolation Pilot Plant Incidents

After nearly three years of recovery and restart efforts following the February 2014 closure, the WIPP conducted its first waste emplacement on January 4, 2017, with official reopening on January 9, 2017. Through the Accident Investigation Board findings and subsequent recovery efforts, many valuable lessons learned emerged. These included important organizational and programmatic changes to ensure the safety and continued viability of WIPP as a national asset.

Safety culture, incentives and oversight. An important emphasis is reinforcing safety culture and accountability at all levels—from the operational level through the highest levels of management. Significant effort has been invested to build awareness of safety issues, clearly prioritize safety as a primary driver and program success indicator (alongside waste emplacement, for example), and recognize and reward safety conscious actions and behavior.

In additional, program oversight has been increased at multiple levels. Institutional structures have been revised to clearly separate oversight functions from responsibility for operations.

Maintenance and ground control. Deferred maintenance on key equipment complicated the recovery and restart of operations. A systematic effort was undertaken to identify maintenance and equipment upgrade needs, and to ensure that schedules and waste emplacement plans account for maintenance activities. Similarly, because of natural salt creep, maintenance (ground control) in the underground portion of the disposal facility became a significant challenge after a nearly 1-year absence of underground operations. As an example, “catch up” roof bolting has been a necessary priority to ensure structural stability and worker safety during preparations for restart and resumption of waste emplacement.

[247] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2175/.

Revised Waste Acceptance Criteria (WAC) for WIPP. Additional oversight and controls have also been put in place for waste documentation, packaging, characterization, and approval for waste disposal.

The WAC specifically incorporates enhancements to ensure potential chemical incompatibilities, like the one that caused the February 2014 radiological incident at WIPP, are adequately assessed. These measures include the following:

- Enhanced Acceptable Knowledge – detailed verification of source documentation for potentially incompatible materials and to ensure adequate information basis;
- Chemical Compatibility Evaluations – identifying the range of possible chemical combinations that could occur in each waste stream using a rigorous, regulator - approved methodology;
- Basis of Knowledge for Oxidizing Chemicals – instructs waste certification programs to identify potential presence of oxidizing chemicals based upon acceptable knowledge and identifies approaches for treating such waste streams as required to address the oxidizing agent; and
- Document database – centralized tracking and approval of changes to site-specific procedures that affect characterization of waste to be disposed at WIPP.

Waste certification activities at generator sites were temporarily suspended until sites demonstrate their ability to comply with the new WAC. The Carlsbad Field Office is performing Generator Site Technical Reviews at each site to ensure waste packaging and treatment activities meet new WIPP WAC requirements.

K.2. Major Challenges, Plans to Address These Challenges, and Possible Areas of Improvement

The following challenges were identified for the U.S. at previous review meetings:

- Management and disposal of spent fuel and high-level waste (HLW) (see Section A.3.1);
- Timely development of GTCC LLW disposal capability (see Section K.2.1);
- Development of Hanford Waste Treatment and Immobilization Plant facility as key element of the strategy for defense HLW management (see Section D.2.1);
- Disposition of spent fuel and radioactive waste arising from medical isotope production (see Section K.2.2);
- Recovery of WIPP facility (see Section K.1.4);
- Disposal of DU (see Section A.3.2.2).

In addition, the Fifth Review Meeting suggestions included:

- Continue efforts to consolidate rulemaking and corresponding guidance in order to facilitate the orderly transition from operation to decommissioning (see Section K.1.3);
- Promote information exchange at the international level about U.S. experience related to decommissioning and decontamination and emergency response (see Section K.1.2);
- Continue efforts in cleanup of major U.S. legacy sites (see Section K.2.3).

See Sections K.2.1 through K.2.3 for information on activities to address some of these challenges and suggestions.

K.2.1. GTCC LLW Disposal

GTCC LLW disposal is an action the Department of Energy (DOE) remains committed to achieving. As required by the Energy Policy Act of 2005, DOE will submit a report to the U.S. Congress and await Congressional action before making a final decision on disposal for GTCC LLW. The Report to Congress is in progress. See Section A.3.8 for additional information.

In addition, NRC is working toward developing a regulatory basis and eventual technical criteria for GTCC LLW disposal at licensed facilities. See Section K.1.3 for additional information.

K.2.2. Disposition of Spent Fuel and Radioactive Waste Arising from Medical Isotope Production

DOE is working to accelerate the establishment of reliable, commercial production of the medical isotope molybdenum-99 (^{99}Mo) in the U.S. without the use of highly-enriched uranium (HEU). DOE established the ^{99}Mo Uranium Lease and Take-Back program in January 2016, in accordance with the American Medical Isotope Production Act of 2012. At the time this report was written, U.S. production of ^{99}Mo has not yet commenced and DOE continues to provide support for these projects. See Section A.3.6 for additional information.

K.2.3. Continue Efforts in Cleanup of Major U.S. Legacy Sites

DOE has been charged with the responsibility of cleaning up 107 sites across the U.S., most of which resulted from defense activities. To date, DOE has made substantial progress in nearly every area of nuclear waste cleanup and completed cleanup at 91 of these sites. Currently, DOE's waste management mission emphasis is on dispositioning radioactive liquid tank waste, HLW, and TRU waste. Over the last several years over one-third of DOE's annual cleanup resources were spent for radioactive liquid tank waste stabilization and disposition. This investment is necessary to reduce technical uncertainties and risks associated with the cleanup work DOE has to accomplish in the next several decades. In other cleanup activities, such as remediation of the contaminant plumes in deep subsurface vadose zones, the decommissioning of DOE nuclear facilities, and the management of spent fuel, there remains technical uncertainties that also must be addressed. Similarly, there are inherent uncertainties and risks associated with DOE's aging nuclear facilities and associated infrastructure. DOE is increasing its investment in innovation and technology to reduce the aggregate cleanup cost, complete cleanup sooner, and, most importantly, perform work and operate facilities more effectively and in a manner that ensures public, worker, and environmental safety.

K.3. Peer Review

The U.S. Government strongly supports the IAEA's suite of peer review services. NRC regularly provides technical experts to participate in IRRS missions around the world, often at a senior leadership level. As discussed in the U.S. Fourth National Report, the U.S. Government

hosted an IRRS Mission in 2010[248] and a follow-up mission in February 2014.[249]

The follow-up mission review team commended NRC for effectively addressing one of two recommendations and 19 of 20 suggestions from the original IRRS mission. One new suggestion was raised concerning transition of operating reactor plants to decommissioning. On April 13, 2016, the U.S. sent a letter to IAEA[250] that served as the final update regarding the 2010 and 2014 IRRS missions. Of the three open items, the one remaining recommendation focuses on operating reactors; however, the two remaining suggestions fall within the scope of this report.

The first suggestion cited: "NRC should consider proper ways aimed at more direct implementation of as low as is reasonably achievable (ALARA) principle in setting up the radiological acceptance criteria for design basis accidents as well as in assessment of acceptability of the results of relevant safety analysis." The Commission directed NRC staff to examine regulations (i.e., 10 CFR Part 20) that contain dose criteria. In July 2014, NRC staff issued for public comment an advance notice of proposed rulemaking that discussed ALARA planning. However, in light of the comments and feedback received on potential changes, NRC staff is no longer contemplating revising the regulations. NRC staff determined that the current NRC regulatory framework continues to provide adequate protection of the health and safety of workers, the public, and the environment.

The second suggestion cited: "NRC should consider developing a consolidated rulemaking and corresponding guidance in order to facilitate the orderly transition from operation to decommissioning and ensure that the current staff knowledge and experience on this subject remain imbedded in the processes and the regulation." Prior to receiving the preliminary report, NRC began to review the existing process for transitioning regulatory responsibilities from the operating to the decommissioning phase of a commercial NPP. On December 30, 2014, the Commission directed NRC staff to: (1) proceed with a rulemaking on reactor decommissioning, (2) set an objective of early 2019 for completion of this rulemaking, and (3) continue processing current and pending applications for decommissioning amendments and exemptions until that regulatory work is complete.[251]

In accordance with the Commission's direction, NRC staff has entered into the regulatory basis development stage for the proposed rulemaking. See Section A.7.1.

K.4. Openness and Transparency for Joint Convention Activities

While ensuring safe management of spent fuel, radioactive waste, and disused sealed sources, the U.S. maintains certain principles in the way it carries out its Joint Convention activities. These principles focus on ensuring safety and security while appropriately balancing the interests of its stakeholders, including the public and licensees. See Section F.3.7.8.

[248] See http://www-ns.iaea.org/downloads/actionplan/IRRS%20Mission%20to%20the%20USA__Oct_2010_1.pdf.
[249] The document is available at NRC's ADAMS, under ML14265A068.
[250] The document is available at NRC's ADAMS, under ML16106A037.
[251] SRM-SECY-14-0118, "Request by Duke Energy Florida, Inc, for Exceptions from Certain Emergency Planning Requirements." The document is available at NRC's ADAMS, under ML14364A111.

The U.S. had made publicly available its National Reports on the DOE web site[252] and the IAEA Joint Convention web site.[253] Past Review Meeting presentations from 2006,[254] 2009,[255] 2012,[256] and 2015[257] are also publicly available. In addition, a redacted version of the questions and comments received from other contracting parties during the Fifth Review Meeting was made publicly available.

[252] See https://energy.gov/em/downloads/fourth-national-report-joint-convention-safety-spent-fuel-management-and-safety.
[253] See http://www-ns.iaea.org/conventions/results-meetings.asp?s=6&l=40.
[254] The document is available at NRC's ADAMS, under ML061320554.
[255] The document is available at NRC's ADAMS, under ML16203A283.
[256] The document is available at NRC's ADAMS, under ML12164A397.
[257] The document is available at NRC's ADAMS, under ML16203A263.

This page intentionally left blank.

ANNEXES[258]

[258] Refer to LIST OF ACRONYMS AND ABBREVIATIONS at the end of the report.

Annex D-1A Spent Fuel Management Facilities[259]: Government Facilities

State	Installation	Facility	Function	Licensee	Regulator	SF[260] Source	Inventory	Units	Estimated Activity (Bq)[261]
Colorado	U.S. Geological Survey (Denver)	Research/Test Reactor	Wet Storage	U.S. Geological Survey	NRC	2	0.04	MTHM	5.35E+14
	Fort St. Vrain	ISFSI	Dry Storage	DOE	NRC	2	14.73	MTHM	1.53E+17
Idaho	Idaho National Lab	Multiple INL facilities	Wet Storage	DOE	DOE	1, 2	2.93	MTHM	1.58E+17
		Multiple INL facilities	Dry Storage	DOE	DOE	1,2	195.74	MTHM	1.70E+18
		ISFSI[262]	Dry Storage	DOE	NRC	2	81.59	MTHM	9.25E+16
Illinois	Argonne National Lab	ANL Spent Fuel Storage	Dry Storage	DOE	DOE	1, 2	0.12	MTHM	3.90E+15
Maryland	National Institute of Standards and Technology (Gaithersburg)	Research/Test Reactor	Wet Storage	National Institute of Standards and Technology	NRC	2	0.02	MTHM	1.14E+16
	Armed Forces Radiobiology Research Institute (Bethesda)	Research/Test Reactor	Wet Storage	Armed Forces Radiobiology Research Institute	NRC	1	0.02	MTHM	3.03E+14

[259] Data Source: DOE National Spent Nuclear Program database (Spent Fuel Database Version 6.2.3, 3/24/2011) except where noted. Navy Spent Fuel is excluded from this report.
[260] SF Sources: 1-Defense applications; 2-Commercial NPPs and Test/Research Reactors.
[261] Source Term estimates calculated for 2017 based on methodology described in report DOE/SNF/REP-078 Rev. 2, *Source Term Estimates for DOE Spent Nuclear Fuels*.
[262] In addition to this facility, NRC licensed a second DOE ISFSI at Idaho, which DOE subsequently decided not to construct.

Annex D-1A Spent Fuel Management Facilities[259]: Government Facilities

State	Installation	Facility	Function	Licensee	Regulator	SF[260] Source	Inventory	Units	Estimated Activity (Bq) [261]
New Mexico	Sandia National Lab (SNL)	Multiple SNL Facilities	Dry Storage	DOE	DOE	1, 2	0.24	MTHM	5.89E+16
Rhode Island	Rhode Island Atomic Energy Commission (Narragansett)	Research/Test Reactor	Wet Storage	Rhode Island Atomic Energy Commission	NRC	2	0.02	MTHM	1.63E+14
South Carolina	Savannah River Site (SRS)	SRS Storage	Wet Storage	DOE	DOE	1, 2	29.42	MTHM	1.78E+18
			Dry Storage	DOE	DOE	2	0.01	MTHM	2.96E+15
Tennessee	Oak Ridge Reservation (ORR)	Multiple ORR Facilities	Wet Storage	DOE	DOE	2	0.47	MTHM	2.86E+17
Washington	Hanford Site	Multiple Hanford Facilities	Dry Storage	DOE	DOE	1, 2	2127.88	MTHM	1.79E+18
			Wet Storage	DOE	DOE	1	1.50	MTHM	9.19E+14

Annex D-1B Spent Fuel Management Facilities: University Research Facilities[263]

State	Installation	Facility	Function	Licensee	Regulator	Inventory	Units	Estimated Activity (Bq) [264]
California	University of California (Irvine)	Research Reactor	Wet Storage	University of California	NRC	21.42	kgU	9.85E+13
	University of California (Davis)[265]	Research Reactor	Wet Storage	University of California	NRC	72.31	kgU	9.92E+14
Florida	University of Florida (Gainesville)	Research Reactor	Wet Storage	University of Florida	NRC	23.81	kgU	1.38E+14
Indiana	Purdue University (West Lafayette)	Research Reactor	Wet Storage	Purdue University	NRC	17.53	kgU	2.12E+14
Kansas	Kansas State University (Manhattan)	Research Reactor	Wet Storage	Kansas State University	NRC	21.08	kgU	5.23E+14
Maryland	University of Maryland (College Park)	Research Reactor	Wet Storage	University of Maryland	NRC	16.35	kgU	4.95E+14
Massachusetts	University of Lowell (Lowell)	Research Reactor	Wet Storage	University of Lowell	NRC	10.13	kgU	1.23E+14
	Massachusetts Institute of Technology (Cambridge)	Research Reactor	Wet Storage	Massachusetts Institute of Technology	NRC	19.85	kgU	5.77E+15
	Worcester Polytechnic Institute (Worcester)	Research Reactor	Wet Storage	Worcester Polytechnic Institute	NRC	22.75	kgU	1.40E+13
Missouri	University of Missouri (Columbia)	Research Reactor	Wet Storage	University of Missouri	NRC	35.44	kgU	3.18E+15

[263] Data Source: DOE National Spent Nuclear Program database (Spent Fuel Database Version 6.2.3, 3/24/2011) except where noted.
[264] Formerly McClellan AFB (Sacramento).
[265] Source Term estimates calculated for 2017 based on methodology described in report DOE/SNF/REP-078 Rev. 2, *Source Term Estimates for DOE Spent Nuclear Fuels*.

Annex D-1B Spent Fuel Management Facilities: University Research Facilities[263]

State	Installation	Facility	Function	Licensee	Regulator	Inventory	Units	Estimated Activity (Bq) [264]
Missouri	University of Missouri (Rolla)	Research Reactor	Wet Storage	University of Missouri	NRC	26.46	kgU	3.29E+15
North Carolina	North Carolina State University (Raleigh)	Research Reactor	Wet Storage	North Carolina State University	NRC	315.40	kgU	6.22E+14
Ohio	Ohio State University (Columbus)	Research Reactor	Wet Storage	Ohio State University	NRC	26.15	kgU	3.16E+14
Oregon	Oregon State University (Corvallis)	Research Reactor	Wet Storage	Oregon State University	NRC	77.06	kgU	8.78E+14
	Reed College (Portland)	Research Reactor	Wet Storage	Reed College	NRC	30.86	kgU	4.34E+14
Pennsylvania	Pennsylvania State University (University Park)	Research Reactor	Wet Storage	Pennsylvania State University	NRC	37.57	kgU	1.38E+15
Texas	Texas A&M University (College Station)	Research Reactor (2)	Wet Storage	Texas A&M University	NRC	70.76	kgU	1.30E+15
	University of Texas (Austin)	Research Reactor	Wet Storage	University of Texas	NRC	35.17	kgU	2.73E+14
Utah	University of Utah (Salt Lake City)	Research Reactor	Wet Storage	University of Utah	NRC	26.82	kgU	1.22E+15
Washington	Washington State University (Pullman)	Research Reactor	Wet Storage	Washington State University	NRC	67.48	kgU	3.06E+15
Wisconsin	University of Wisconsin (Madison)	Research Reactor	Wet Storage	University of Wisconsin	NRC	68.06	kgU	4.34E+14

Annex D-1C Spent Fuel Management Facilities: Other Research and Nuclear Fuel Cycle Facilities[266]								
State	**Installation**	**Facility**	**Function**	**Licensee**	**Regulator**	**Inventory**	**Units**	**Estimated Activity (Bq)[267]**
California	Aerotest Research (San Ramon)	Research/Test Reactor	Wet Storage	Aerotest Research	NRC	17.43	kgU	3.54E+15
	General Electric (Pleasanton)	Research/Test Reactor	Wet Storage	General Electric	NRC	3.86	kgU	5.11E+12
Michigan	Dow Chemical Co. (Midland)	Research/Test Reactor	Wet Storage	Dow Chemical Co.	NRC	14.81	kgU	2.23E+14
Virginia	BWX Technology, Inc.	Fuel Cycle Facility	Dry storage	BWX Technology, Inc.	NRC	43.48	kgU	2.15E+15

[266] Data Source: DOE National Spent Nuclear Program database (Spent Fuel Database Version 6.2.3, 3/24/2011) except where noted.
[267] Source Term estimates calculated for 2017 based on methodology described in report DOE/SNF/REP-078 Rev. 2, *Source Term Estimates for DOE Spent Nuclear Fuels.*

Annex D-1D Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Facilities[268]

State	Site	Facility (Installation)	Spent Fuel Function	Licensee	Regulator	Inventory	Units
Alabama	Browns Ferry	Browns Ferry 1, 2, & 3	Wet Storage	Tennessee Valley Authority	NRC	1475	MTHM
		ISFSI	Dry Storage	Tennessee Valley Authority	NRC	746	MTHM
	Farley	Farley 1 & 2	Wet Storage	Southern Nuclear Operating Co.	NRC	920	MTHM
		ISFSI	Dry Storage	Southern Nuclear Operating Co.	NRC	520	MTHM
Arizona	Palo Verde	Palo Verde 1, 2, & 3	Wet Storage	Arizona Public Service Company	NRC	1041	MTHM
		ISFSI	Dry Storage	Arizona Public Service Company	NRC	1360	MTHM
Arkansas	Arkansas Nuclear	Arkansas Nuclear 1 & 2	Wet Storage	Entergy Nuclear Operations, Inc.	NRC	648	MTHM
		ISFSI	Dry Storage	Entergy Nuclear Operations, Inc.	NRC	846	MTHM
California	Diablo Canyon	Diablo Canyon 1 & 2	Wet Storage	Pacific Gas & Electric Co.	NRC	878	MTHM
		ISFSI	Dry Storage	Pacific Gas & Electric Co.	NRC	510	MTHM
	Humboldt Bay	ISFSI	Dry Storage	Pacific Gas & Electric Co.	NRC	29	MTHM
	Rancho Seco	ISFSI	Dry Storage	Sacramento Municipal Utility District	NRC	228	MTHM
	San Onofre	San Onofre 1, 2, & 3 (shutdown)	Wet Storage	Southern California Edison Co.	NRC	1132	MTHM

[268] Based on the data in *Commercial Spent Nuclear Fuel and High-Level Radioactive Waste Inventory Report: FCRD-NFST-2013-000263*, Rev. 4, June 30, 2016. The total site inventory is "as of" December 31, 2016, the dry storage inventory is "as of" May 7, 2016. See https://www.energy.gov/ne/downloads/dry-storage-cask-inventory-assessment-revision-2.

Annex D-1D Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Facilities[268]							
State	**Site**	**Facility (Installation)**	**Spent Fuel Function**	**Licensee**	**Regulator**	**Inventory**	**Units**
California		ISFSI	Dry Storage	Southern California Edison Co.	NRC	477	MTHM
Connecticut	Haddam Neck	ISFSI	Dry Storage	Connecticut Yankee Atomic Power Co.	NRC	414	MTHM
	Millstone	Millstone 1 (shutdown) Millstone 2 & 3	Wet Storage	Dominion Generation	NRC	1466	MTHM
		ISFSI	Dry Storage	Dominion Generation	NRC	339	MTHM
Florida	Crystal River	Crystal River 3 (shutdown)	Wet Storage	Duke Energy Florida, Inc.	NRC	582	MTHM
	Saint Lucie	Saint Lucie 1 & 2	Wet Storage	Florida Power & Light Co.	NRC	1087	MTHM
		ISFSI	Dry Storage	Florida Power & Light Co.	NRC	323	MTHM
	Turkey Point	Turkey Point 3 & 4	Wet Storage	Florida Power & Light Co.	NRC	1072	MTHM
		ISFSI	Dry Storage	Florida Power & Light Co.	NRC	263	MTHM
Georgia	Hatch	Hatch 1 & 2	Wet Storage	Southern Nuclear Operating Co., Inc.	NRC	809	MTHM
		ISFSI	Dry Storage	Southern Nuclear Operating Co., Inc.	NRC	808	MTHM
	Vogtle	Vogtle 1 & 2	Wet Storage	Southern Nuclear Operating Co., Inc.	NRC	1176	MTHM
		ISFSI	Dry Storage	Southern Nuclear Operating Co., Inc.	NRC	221	MTHM
Illinois	Braidwood	Braidwood 1 & 2	Wet Storage	Exelon Generation Co., LLC	NRC	1143	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	202	MTHM

Annex D-1D Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Facilities[268]							
State	**Site**	**Facility (Installation)**	**Spent Fuel Function**	**Licensee**	**Regulator**	**Inventory**	**Units**
Illinois	Byron	Byron 1 & 2	Wet Storage	Exelon Generation Co., LLC	NRC	1154	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	270	MTHM
	Clinton	Clinton 1	Wet Storage	Exelon Generation Co., LLC	NRC	644	MTHM
	Dresden	Dresden 1 (shutdown) Dresden 2 & 3	Wet Storage	Exelon Generation Co., LLC	NRC	988	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	770	MTHM
	La Salle	La Salle County 1 & 2	Wet Storage	Exelon Generation Co., LLC	NRC	1219	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	292	MTHM
	Morris	ISFSI	Wet Storage	GE-Hitachi Nuclear Energy Americas LLC	NRC	674	MTHM
	Quad Cities	Quad Cities 1 & 2	Wet Storage	Exelon Generation Co., LLC	NRC	1239	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	495	MTHM
	Zion	Zion 1 & 2 (shutdown)	Wet Storage	Zion Solutions	NRC	0	MTHM
		ISFSI	Dry Storage	Zion Solutions	NRC	1019	MTHM
Iowa	Duane Arnold	Duane Arnold	Wet Storage	NextEra Energy Duane Arnold, LLC	NRC	345	MTHM
		ISFSI	Dry Storage	NextEra Energy Duane Arnold, LLC	NRC	221	MTHM
Kansas	Wolf Creek	Wolf Creek 1	Wet Storage	Wolf Creek Nuclear Operating Corp.	NRC	772	MTHM

Annex D-1D Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Facilities[268]							
State	**Site**	**Facility (Installation)**	**Spent Fuel Function**	**Licensee**	**Regulator**	**Inventory**	**Units**
Louisiana	River Bend	River Bend 1	Wet Storage	Entergy Operations, Inc.	NRC	420	MTHM
		ISFSI	Dry Storage	Entergy Operations, Inc.	NRC	277	MTHM
	Waterford	Waterford 3	Wet Storage	Entergy Operations, Inc.	NRC	553	MTHM
		ISFSI	Dry Storage	Entergy Operations, Inc.	NRC	229	MTHM
Maine	Maine Yankee	ISFSI	Dry Storage	Maine Yankee Atomic Power Co.	NRC	542	MTHM
Maryland	Calvert Cliffs	Calvert Cliffs 1 & 2	Wet Storage	Constellation Energy	NRC	594	MTHM
		ISFSI	Dry Storage	Constellation Energy	NRC	826	MTHM
Massachusetts	Pilgrim	Pilgrim 1	Wet Storage	Entergy Nuclear Operations, Inc.	NRC	564	MTHM
		ISFSI	Dry Storage	Entergy Nuclear Operations, Inc.	NRC	36	MTHM
	Yankee Rowe	ISFSI	Dry Storage	Yankee Atomic Electric Co.	NRC	127	MTHM
Michigan	Big Rock Point	ISFSI	Dry Storage	Entergy Nuclear Operations Inc.	NRC	58	MTHM
	D.C. Cook	D.C. Cook 1 & 2	Wet Storage	Indiana Michigan Power Co.	NRC	1294	MTHM
		ISFSI	Dry Storage	Indiana Michigan Power Co.	NRC	393	MTHM
	Fermi	Enrico Fermi 2	Wet Storage	DTE Electric Co.	NRC	550	MTHM
		ISFSI	Dry Storage	DTE Electric Co	NRC	72	MTHM

Annex D-1D Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Facilities[268]							
State	**Site**	**Facility (Installation)**	**Spent Fuel Function**	**Licensee**	**Regulator**	**Inventory**	**Units**
Michigan	Palisades	Palisades	Wet Storage	Entergy Nuclear Operations, Inc.	NRC	244	MTHM
		ISFSI	Dry Storage	Entergy Nuclear Operations, Inc.	NRC	451	MTHM
Minnesota	Monticello	Monticello	Wet Storage	Northern States Power Co. Minnesota	NRC	256	MTHM
		ISFSI	Dry Storage	Northern States Power Co. Minnesota	NRC	159	MTHM
	Prairie Island	Prairie Island 1 & 2	Wet Storage	Northern States Power Co. Minnesota	NRC	385	MTHM
		ISFSI	Dry Storage	Northern States Power Co. Minnesota	NRC	584	MTHM
Mississippi	Grand Gulf	Grand Gulf 1	Wet Storage	Entergy Operations, Inc.	NRC	649	MTHM
		ISFSI	Dry Storage	Entergy Operations, Inc.	NRC	336	MTHM
Missouri	Callaway	Callaway	Wet Storage	Ameren UE	NRC	719	MTHM
		ISFSI	Dry Storage	Ameren UE.	NRC	94	MTHM
Nebraska	Cooper	Cooper	Wet Storage	Nebraska Public Power District	NRC	311	MTHM
		ISFSI	Dry Storage	Nebraska Public Power District	NRC	198	MTHM
	Fort Calhoun	Fort Calhoun (shutdown)	Wet Storage	Omaha Public Power District	NRC	378	MTHM
		ISFSI	Dry Storage	Omaha Public Power District	NRC	117	MTHM
New Hampshire	Seabrook	Seabrook 1	Wet Storage	NextEra Energy Seabrook, LLC	NRC	422	MTHM

Annex D-1D Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Facilities[268]							
State	**Site**	**Facility (Installation)**	**Spent Fuel Function**	**Licensee**	**Regulator**	**Inventory**	**Units**
New Hampshire		ISFSI	Dry Storage	NextEra Energy Seabrook, LLC	NRC	205	MTHM
New Jersey	Hope Creek/Salem[269]	Hope Creek, Salem 1 & 2	Wet Storage	PSE&G Nuclear, LLC	NRC	1601	MTHM
		ISFSI	Dry Storage	PSE&G Nuclear, LLC	NRC	665	MTHM
	Oyster Creek	Oyster Creek	Wet Storage	Exelon Generation Co., LLC	NRC	458	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	249	MTHM
New York	FitzPatrick	FitzPatrick	Wet Storage	Exelon Generation Co., LLC	NRC	477	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	258	MTHM
	Ginna	Ginna	Wet Storage	Constellation Energy	NRC	434	MTHM
		ISFSI	Dry Storage	Constellation Energy	NRC	71	MTHM
	Indian Point	Indian Point 1 (shutdown) Indian Point 2 & 3	Wet Storage	Entergy Nuclear Operations, Inc.	NRC	1025	MTHM
		ISFSI	Dry Storage	Entergy Nuclear Operations, Inc.	NRC	452	MTHM
	Nine Mile Point	Nine Mile Point 1 & 2	Wet Storage	Exelon Generation Co., LLC	NRC	1088	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	259	MTHM

[269] Hope Creek and Salem nuclear power plants have a combined ISFSI.

Annex D-1D Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Facilities[268]							
State	**Site**	**Facility (Installation)**	**Spent Fuel Function**	**Licensee**	**Regulator**	**Inventory**	**Units**
North Carolina	Brunswick	Brunswick 1 & 2	Wet Storage	Duke Energy Progress, LLC.	NRC	569	MTHM
		ISFSI	Dry Storage	Duke Energy Progress, LLC	NRC	232	MTHM
	McGuire	McGuire 1 & 2	Wet Storage	Duke Energy Carolinas, LLC	NRC	903	MTHM
		ISFSI	Dry Storage	Duke Energy Carolinas, LLC	NRC	629	MTHM
	Shearon Harris	Shearon Harris 1	Wet Storage	Duke Energy Progress, LLC	NRC	1575	MTHM
Ohio	Davis-Besse	Davis-Besse 1	Wet Storage	First Energy Nuclear Operating Co.	NRC	565	MTHM
		ISFSI	Dry Storage	First Energy Nuclear Operating Co.	NRC	34	MTHM
	Perry	Perry 1	Wet Storage	First Energy Nuclear Operating Co.	NRC	561	MTHM
		ISFSI	Dry Storage	First Energy Nuclear Operating Co.	NRC	172	MTHM
Oregon	Trojan	ISFSI	Dry Storage	Portland General Electric Corp.	NRC	359	MTHM
Pennsylvania	Beaver Valley	Beaver Valley 1 & 2	Wet Storage	First Energy Nuclear Operating Co.	NRC	1149	MTHM
		ISFSI	Dry Storage	First Energy Nuclear Operating Co.	NRC	68	MTHM
	Limerick	Limerick 1 & 2	Wet Storage	Exelon Generation Co., LLC	NRC	1149	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	359	MTHM
	Peach Bottom	Peach Bottom 2 & 3	Wet Storage	Exelon Generation Co., LLC	NRC	1054	MTHM

Annex D-1D Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Facilities[268]							
State	**Site**	**Facility (Installation)**	**Spent Fuel Function**	**Licensee**	**Regulator**	**Inventory**	**Units**
Pennsylvania		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	879	MTHM
	Susquehanna	Susquehanna 1 & 2	Wet Storage	Susquehanna Nuclear, LLC	NRC	784	MTHM
		ISFSI	Dry Storage	Susquehanna Nuclear, LLC	NRC	937	MTHM
	Three Mile Island	Three Mile Island 1	Wet Storage	Exelon Generation Co., LLC	NRC	667	MTHM
South Carolina	Catawba	Catawba 1 & 2	Wet Storage	Duke Energy Carolina, LLC	NRC	1077	MTHM
		ISFSI	Dry Storage	Duke Energy Carolina, LLC	NRC	357	MTHM
	Oconee	Oconee 1, 2, & 3	Wet Storage	Duke Energy Carolinas, LLC	NRC	925	MTHM
		ISFSI	Dry Storage	Duke Energy Carolinas, LLC	NRC	1532	MTHM
	Robinson	Robinson 2	Wet Storage	Duke Energy Progress, LLC	NRC	172	MTHM
		ISFSI	Dry Storage	Duke Energy Progress, LLC	NRC	211	MTHM
	Summer	Summer	Wet Storage	South Carolina Electric & Gas Co.	NRC	553	MTHM
		ISFSI	Dry Storage	South Carolina Electric & Gas Co.	NRC	63	MTHM
Tennessee	Sequoyah	Sequoyah 1 & 2	Wet Storage	Tennessee Valley Authority	NRC	745	MTHM
		ISFSI	Dry Storage	Tennessee Valley Authority	NRC	746	MTHM
	Watts Bar	Watts Bar 1 & 2	Wet Storage	Tennessee Valley Authority	NRC	489	MTHM

Annex D-1D Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Facilities[268]

State	Site	Facility (Installation)	Spent Fuel Function	Licensee	Regulator	Inventory	Units
Texas	Comanche Peak	Comanche Peak 1 & 2	Wet Storage	TEX Operations Company, LLC	NRC	901	MTHM
		ISFSI	Dry Storage	TEX Operations Company, LLC	NRC	323	MTHM
	South Texas	South Texas 1 & 2	Wet Storage	STP Nuclear Operating Co.	NRC	1412	MTHM
Vermont	Vermont Yankee (shutdown)	Vermont Yankee	Wet Storage	Entergy Nuclear Operations, Inc.	NRC	544	MTHM
		ISFSI	Dry Storage	Entergy Nuclear Operations, Inc.	NRC	160	MTHM
Virginia	North Anna	North Anna 1 & 2	Wet Storage	Dominion Generation	NRC	669	MTHM
		ISFSI	Dry Storage	Dominion Generation	NRC	771	MTHM
	Surry	Surry 1 & 2	Wet Storage	Dominion Generation	NRC	388	MTHM
		ISFSI	Dry Storage	Dominion Generation	NRC	1056	MTHM
Washington	Columbia Generating Station	Columbia Generating Station	Wet Storage	Energy Northwest	NRC	288	MTHM
		ISFSI	Dry Storage	Energy Northwest	NRC	431	MTHM
Wisconsin	Kewaunee	Kewaunee (shutdown)	Wet Storage	Dominion Energy Kewaunee, Inc.	NRC	345	MTHM
		ISFSI	Dry Storage	Dominion Energy Kewaunee, Inc.	NRC	174	MTHM
	LaCrosse	ISFSI	Dry Storage	Dairyland Power Cooperative	NRC	38	MTHM
	Point Beach	Point Beach 1 & 2	Wet Storage	NextEra Energy Point Beach, LLC	NRC	501	MTHM

Annex D-1D Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Facilities[268]							
State	**Site**	**Facility (Installation)**	**Spent Fuel Function**	**Licensee**	**Regulator**	**Inventory**	**Units**
Wisconsin		ISFSI	Dry Storage	NextEra Energy Point Beach, LLC	NRC	429	MTHM
Totals	All commercial NPP and ISFSI sites	All NPPs plus Morris ISFSI	Wet Storage	Various	NRC	50871	MTHM
		All other commercial ISFSIs	Dry Storage	Various	NRC	26971	MTHM
		All commercial NPPs and ISFSIs	Grand Total	Various	NRC	77842	MTHM

Annex D-2A Radioactive Waste Management Facilities: Government Facilities[270]

State	Installation	Licensee	Regulator [271]	Facility	Function	Waste Source	Waste/ Material Type	Inventory (m3)[272]	Estimated Activity (Bq)[273]	Rad Cat
California	Lawrence Berkeley National Laboratory	DOE	DOE	Various Waste Facilities	Storage	2	LLW/MLLW	1.31E+02		6
	Lawrence Livermore National Laboratory	DOE	DOE	Various Waste Facilities	Storage	1	LLW/MLLW	2.04E+03		1,2,3,4,5
						1	TRU	2.65E+02	4.92E+14	3
	Stanford Linear Accelerator	DOE	DOE	Various Waste Facilities	Storage	2	LLW/MLLW	9.54E+02		1
Idaho	Idaho National Laboratory	DOE	DOE/ID	HLW Tank Farm	Liquid Storage in underground tanks	1	HLW	3.41E+03	1.37E+18	2,3
		DOE	DOE	Calcined Solids Storage Facility	Storage in underground bins	1	HLW	4.40E+03	1.20E+18	2,3

[270] See Key to Annex D-2 on last page of this table.
[271] KY = Kentucky; NM = New Mexico; NY = New York; OH = Ohio; SC = South Carolina; TN = Tennessee; WA = Washington.
[272] Stored inventories for LLW/MLLW are as September 30, 2016 per DOE's FY 2017 BLDD. Stored and disposed (WIPP) inventories for TRU are as of December 31, 2015 per the Annual Transuranic Waste Inventory Report - 2016. Disposed inventories for LLW/MLLW in active facilities are as of September 30, 2016 per DOE's FY 2017 BLDD. Disposed inventory for LLW in Savannah River Saltstone Vaults based on the quarterly Saltstone Permit reports as of December 31,2016. Stored inventories of Savannah River HLW (Glass Waste Storage Building and HLW Tank Farms) based on site sources as of December 31,2016. Stored inventory of Hanford HLW based on based on the Waste Tank Summary Report for Month Ending December 31, 2016 (HNF-EP-0182).
[273] Estimated activities for TRU stored and disposed (WIPP) inventories are as of December 31,2015 per the Annual Transuranic Waste Inventory Report - 2016. Activities for other waste types are parametric estimates. Activity of Savanah River HLW (Glass Waste Storage Building and HLW Tank Farms) based on site sources as of December 31,2016. Activity of Hanford HLW based on the Best Basis Inventory data as of November 2015.

Annex D-2A Radioactive Waste Management Facilities: Government Facilities[270]

State	Installation	Licensee	Regulator [271]	Facility	Function	Waste Source	Waste/ Material Type	Inventory (m3)[272]	Estimated Activity (Bq)[273]	Rad Cat
Idaho		DOE	DOE/ID/ EPA	Idaho CERCLA Disposal Facility	Disposal in engineered surface disposal cell for D&D wastes	1	LLW	3.29E+05		1,2,3,4,5
	Idaho National Laboratory	DOE	DOE	Radioactive Waste Management Complex (Includes Remote-Handled waste vaults)	Disposal in shallow land disposal facility	1	LLW	6.64E+04	2.72E+17	1,2,3,4,5
		DOE	DOE/ID	Various Waste Facilities	Storage, characterization, treatment, packaging	1	LLW/MLLW	3.73E+03	9.39E+10	1,2,3,4,5
			DOE	TRU Waste Storage Facilities	Storage	1	TRU	1.92E+04	1.28E+16	2,3
Illinois	Argonne National Laboratory	DOE	DOE	Various Waste Facilities	Storage	2	LLW/MLLW	9.96E+01		1,2,3,4,5
				TRU Storage	Storage	1	TRU	5.66E+01	4.15E+14	2,3
	FermiLab	DOE	DOE	Various Waste Facilities	Storage	2	LLW/MLLW	6.35E+02		1
Kentucky	Paducah Gaseous Diffusion Plant	DOE	DOE/KY	Various Waste Facilities	Storage, characterization, treatment, packaging	1	LLW/MLLW	1.10E+04		4
Missouri	Weldon Springs	DOE	DOE	Onsite Disposal Cell (Closed)	Disposal in engineered, surface disposal cell (Closed)	1	Residual radioactive material	1.12E+06		4

Annex D-2A Radioactive Waste Management Facilities: Government Facilities[270]

State	Installation	Licensee	Regulator[271]	Facility	Function	Waste Source	Waste/ Material Type	Inventory (m3)[272]	Estimated Activity (Bq)[273]	Rad Cat
Multiple[274]	Other DOE	DOE	DOE/ various states	Various Waste Facilities	Storage, characterization, treatment, packaging	1	LLW/MLLW	2.70E+02		6
	Other DOE TRU Small Quantity Sites	DOE	DOE	TRU Waste Facilities (small)	Storage	1	TRU	1.72E+01	1.23E+12	3
Nevada	Nevada National Security Site	DOE	DOE	Area 3/Area 5 RWMS	Disposal in trenches and subsidence craters	1	LLW	1.26E+06	5.99E+17	1,2,3,4,5
	Nevada National Security Site	DOE	DOE/NV	LLW Storage Facility	Storage	1	LLW	1.98E+01		1,2,3,4,5
				MW Disposal Unit	Disposal in shallow trenches	1	MLLW	2.47E+04	1.14E+14	1,2,3,4,5
	Nevada National Security Site	DOE	DOE	Greater Confinement Disposal	Disposal in boreholes	1	TRU	2.00E+02	2.11E+15	1,2,3,4,5
				TRU Waste Facilities	Storage, characterization, packaging	1	TRU	5.99E+01	1.69E+13	3
New Mexico	Los Alamos National Laboratory	DOE	DOE	Technical Area 54/Area G	Disposal in shallow land disposal facility	1	LLW	2.63E+05	8.87E+16	1,2,3,4,5
		DOE	DOE	Various Waste Facilities	Storage	1	LLW/MLLW	0.00E+00		1,2,3,4,5

[274] Multiple includes LLW/MLLW stored inventories at Ames Laboratory, Iowa; Brookhaven Laboratory, New York; Kansas City Plant, Missouri; Pacific Northwest National Laboratory, Washington; Pantex Plant, Texas; Princeton Laboratory, New Jersey; Thomas Jefferson National Accelerator Facility, Virginia, and Waste Isolation Pilot Plant, New Mexico; Multiple includes TRU waste inventories at the Nuclear Radiation Development Site, Inc., New York; and the Separation Process Research Unit, New York.

Annex D-2A Radioactive Waste Management Facilities: Government Facilities[270]

State	Installation	Licensee	Regulator[271]	Facility	Function	Waste Source	Waste/ Material Type	Inventory (m3)[272]	Estimated Activity (Bq)[273]	Rad Cat
New Mexico	Los Alamos National Laboratory	DOE	DOE	Sealed Source Facilities	Disused Sealed Source Storage	1	Sealed Sources Container	3.00E+01		6
				TRU Waste Facilities	Storage, characterization, packaging	1	TRU	3.61E+03	2.05E+16	2,3
	Sandia National Laboratory	DOE	DOE/NM	Various Waste Facilities	Storage, characterization, treatment, packaging	1	LLW/MLLW	1.48E+02	1.07E+12	2,3,5
	Sandia National Laboratory	DOE	DOE	TRU Waste Facilities	Storage, characterization, packaging	1	TRU	1.61E+01	5.68E+13	3
	Waste Isolation Pilot Plant	DOE	DOE/NM EPA	WIPP Disposal	Disposal in deep salt formation	1	TRU	9.10E+04	8.73E+16	1,2,3,4,5
New York	Niagara Falls Storage Site (FUSRAP)	USACE	NY	Niagara Falls Storage Facility	Restoration Waste Storage	1	Residual radioactive material	1.99E+05		4
	Separations Process Research Unit	DOE	DOE/NY	Various Waste Facilities	Storage	1	LLW/MLLW	1.50E+02		2,3
	West Valley Demonstration Plant	DOE	DOE	HLW Dry Storage Pads	Interim storage of Vitrified HLW in a former process cell	3	HLW	2.08E+02	5.74E+17	2,3
	West Valley Demonstration Plant	DOE	DOE/NY	Various Waste Facilities	Storage, characterization, treatment, packaging	3	LLW/MLLW	5.12E+03		1,2,3
				TRU Waste Facilities	Storage	3	TRU	4.99E+03	1.40E+15	2,3

Annex D-2A Radioactive Waste Management Facilities: Government Facilities[270]

State	Installation	Licensee	Regulator [271]	Facility	Function	Waste Source	Waste/ Material Type	Inventory (m3)[272]	Estimated Activity (Bq)[273]	Rad Cat
Ohio	Fernald Environmental Management Project	DOE	DOE	Onsite Disposal Facility	Disposal (from D&D) in engineered surface disposal cell (Closed)	1	LLW	2.29E+06		4
	Portsmouth Gaseous Diffusion Plant	DOE	DOE/OH	Various Waste Facilities	Storage, treatment, packaging	1	LLW/MLLW	7.66E+03		4
South Carolina	Savanah River Site	DOE	DOE	Saltstone Vaults	Disposal of low-level waste in engineered cells	1	LLW	1.08E+05		1,2,3,4,5
	Savanah River Site	DOE	DOE	HLW Tank Farm	Liquid Storage in underground double-shell, stainless steel tanks	1	HLW	1.32E+05	9.73E+18	1,2,3,4,5
	Savanah River Site	DOE	DOE	Glass Waste Storage Building	Interim Storage of Vitrified HLW	1	HLW	3.28E+03	2.12E+18	1,2,3,4,5
	Savanah River Site	DOE	DOE	E-Area Disposal	Disposal in underground vaults and trenches	1	LLW	4.08E+05	6.33E+18	1,2,3,4,5
	Savanah River Site	DOE	DOE	Old Burial Ground	Historic disposal (Closed)	1	LLW	6.77E+05		1,2,3,4,5
	Savanah River Site	DOE	DOE/SC	Various Waste Facilities	Storage, characterization, treatment, packaging	1	LLW/MLLW	4.60E+01		1,2,3,4,5
	Savanah River Site	DOE	DOE	TRU Waste Facilities	Storage, characterization, packaging	1	TRU	7.59E+02	9.18E+16	2,3

Annex D-2A Radioactive Waste Management Facilities: Government Facilities[270]

State	Installation	Licensee	Regulator[271]	Facility	Function	Waste Source	Waste/ Material Type	Inventory (m3)[272]	Estimated Activity (Bq)[273]	Rad Cat
Tennessee	Oak Ridge Reservation	DOE	DOE	Hydro fracture	Historic disposal (Closed)	1	LLW	1.73E+04		1,2,3,4,5
				Old Burial Ground	Historic disposal (Closed)	1	LLW	4.41E+05		1,2,3,4,5
				Interim Waste Management Facility	Disposal in engineered aboveground facility (Closed)	1	LLW	3.70E+03	1.18E+13	1,2,3,4,5
	Oak Ridge Reservation	DOE	DOE/TN EPA	EMWMF	Disposal in engineered surface disposal cell for D&D wastes	1	LLW	1.54E+06		1,2,3,4,5
	Oak Ridge Reservation	DOE	DOE/TN	Various Waste Facilities	Storage (in building and on concrete pad), characterization, treatment, packaging	1	LLW/MLLW	9.96E+02		1,2,3,4,5
	Oak Ridge Reservation	DOE	DOE	TRU Waste Facilities	Storage, characterization, packaging, treatment	1	TRU	1.44E+03	1.63E+16	2,3

Annex D-2A Radioactive Waste Management Facilities: Government Facilities

State	Installation	Licensee	Regulator	Facility	Function	Waste Source	Waste/ Material Type	Inventory	State	Installation
Utah	Monticello Remedial Action Project	DOE	DOE	Monticello Disposal Cell	Disposal in engineered, surface disposal cell (Closed)	1	Residual radioactive material	1.91E+06		4
Washington	Hanford Site	DOE	DOE/WA	HLW Tank Farm	Liquid Storage in underground single-and double-shell tanks	1	HLW	2.05E+05	6.33E+18	1,2,3,4,5
	Hanford Site	DOE	DOE	200 Area Burial Grounds	Disposal in trenches	1	LLW	3.11E+05	1.68E+17	1,2,3,4,5
	Hanford Site	DOE	DOE/WA/ EPA	ERDF	Disposal (from D&D) in engineered surface disposal unit	1	LLW	9.15E+06		1,2,3,4,5
	Hanford Site	DOE	DOE	Decommissioned Submarine Hulls Disposal Area	Navy submarine hulls disposal in trenches	1	LLW	1.29E+02		1
	Hanford Site	DOE	DOE/WA	IDF	Disposal	1	LLW/MLLW	0.00E+00		1,2,3,4,5
	Hanford Site	DOE	DOE/WA	Various Waste Facilities	Storage, characterization, treatment, packaging	1	LLW/MLLW	1.62E+02		1,2,3,4,5
	Hanford Site	DOE	DOE/WA	RMW Trenches	Disposal in lined trenches	1	MLLW	1.21E+05	6.50E+16	1,2,3,4,5

Annex D-2A Radioactive Waste Management Facilities: Government Facilities										
Washington	Hanford Site	DOE	DOE	WESF	Cs-Sr Storage in hot cells and storage pool	1	Sealed Source Container	1.93E+03	2.85E+18	2
				TRU Waste Facilities	Storage, characterization, packaging	1	TRU	1.47E+04	4.93E+16	2,3

Annex D-2 Key				
Waste Source		Radionuclide Category		
		Category		Key Isotopes
1	Defense applications	1	Activation Products	Primarily ^{36}Cl, ^{55}Fe, ^{54}Mn, ^{65}Zn, ^{58}Co, ^{60}Co, ^{63}Ni,
2	Nuclear applications	2	Mixed Fission Products	Radioactive isotopes and daughters from ^{72}Zn to ^{158}Gd; primary longer-lived isotopes are ^{85}Kr, ^{89}Sr, ^{90}Y-^{90}Sr, ^{91}Y, ^{95}Zr, ^{95}Nb, ^{103}Rh, ^{103}Ru, ^{106}Rh-^{106}Ru, ^{125}Te-^{125}Sb, ^{137}Ba-^{137}Cs, ^{141}Ce, ^{144}Pr-^{144}Ce, ^{147}Pm, $m^{151}S$, and ^{155}Eu
3	Commercial	3	Transuranic Isotopes	Isotopes of Cf, Bk, Cm, Am, Pu, and Np, and their respective decay products.
		4	Naturally-Occurring Isotopes	^{238}PU, ^{235}U, ^{234}U, ^{232}Th, and their respective decay products (^{231}Pa, ^{227}Th, ^{228}Th, ^{230}Th, ^{231}Th, ^{234}Th, ^{227}Ac, ^{228}Ac, ^{223}Ra, ^{224}Ra, ^{226}Ra, ^{228}Ra, ^{223}Fr, ^{219}Rn, ^{220}Rn, ^{222}Rn, ^{215}At, ^{218}At, ^{219}At, ^{210}Po, ^{211}Po, ^{212}Po, ^{214}Po, ^{215}Po, ^{216}Po, ^{218}Po, ^{210}Bi, ^{211}Bi, ^{212}Bi, ^{214}Bi, ^{210}Pb, ^{211}Pb, ^{212}Pb, ^{214}Pb, ^{206}Tl, ^{207}Tl, ^{208}Tl, and ^{210}Tl), ^{14}C, ^{40}K, ^{40}V, ^{87}Rb, ^{115}In, ^{123}Te, ^{138}La, ^{142}Ce, ^{144}Nd, ^{147}Sm, ^{148}Sm, ^{149}Sm, ^{152}Gd, ^{156}Dy, ^{176}Lu, ^{174}Hf, ^{180}Ta, ^{187}Re, ^{190}Pt, ^{204}Pb, ^{215}Bi
		5	Tritium	^{3}H
		6	Various	Radioactivity from various sources and categories

Annex D-2B Radioactive Waste Management Facilities: Commercial/Other Facilities[275]

State	Installation	Licensee	Regulator [276]	Type	Function	Waste Source	Inventory (m^3)[277]	Estimated Activity (Bq)[278]	Rad Cat
California	Advanced Chemical Transport, Inc.	Advanced Chemical Transport, Inc.	CA	Commercial	Repackage/Broker/ Transporter	3	N/A		
	B&B Environmental Safety	B&B Environmental Safety	CA	Commercial	Broker/Transporter	3	N/A		
	Environmental Management & Controls, Inc.	Environmental Management & Controls, Inc	CA	Commercial	Broker/Transporter	3	N/A		
	Environmental Management Services, Inc.	Environmental Management Services, Inc.	CA	Commercial	Broker/Transporter	3	N/A		
	New World Technology	New World Technology	CA	Commercial	Processor – Waste Treatment Service (Other than compaction)	3	N/A		
	PWN Environmental	PWN Environmental	CA	Commercial	Broker/Processor/ Transporter	3	N/A		

[275] See Key to Annex D-2 on last page of this table.
[276] CA = California; CO = Colorado; FL = Florida; IL = Illinois; KY = Kentucky; MD = Maryland; NV = Nevada; NY = New York; OH = Ohio; PA = Pennsylvania; SC = South Carolina; TN = Tennessee; TX = Texas; UT = Utah; WA = Washington.
[277] Commercial disposal of inventories are as of 12/31/16 based on the Integrated Data Base Report (DOE/RW-0006, Rev.13) and the Manifest Information Management System (MIMS). GTCC stored inventories based on DOE/EIS/0375 (West Valley stored GTCC-like waste is reported as TRU – See Annex D-2A).
[278] Estimated activities associated with commercial disposed waste are as of January 31, 2013, on the Integrated Data Base Report (DOE/RW-0006, Rev. 13) and MIMS.

Annex D-2B Radioactive Waste Management Facilities: Commercial/Other Facilities[275]

State	Installation	Licensee	Regulator [276]	Type	Function	Waste Source	Inventory (m^3)[277]	Estimated Activity (Bq)[278]	Rad Cat
California	Thomas Grey Associates	Thomas Grey Associates	CA	Commercial	Processor – Processing of liquids and radium	3	N/A		
Colorado	Next Generation Solutions	Next Generation Solutions	CO	Commercial	Broker	3	N/A		
Connecticut	Cabrera Services, Inc.	Cabrera Services, Inc.	NRC	Commercial	Processor – Decontamination Services	3	N/A		
	Radiation Safety Associates	Radiation Safety Associates	NRC	Commercial	Processor	3	N/A		
Florida	Perma-Fix of Florida, Inc.	Perma-Fix	FL	Commercial	Processor	3	N/A		
Idaho	Qal-Tek Associates	Qal-Tek Associates	NRC	Commercial	Packaging/Broker (Sealed Sources)	3	N/A		
Illinois	ADCO Services Inc.	ADCO Services Inc.	IL	Commercial	Processor – Processing of uranium and thorium	3	N/A		
	Dept. of the Army Rock Island Arsenal	Dept. of the Army	NRC	Other Government	Processor/Storage – Waste Disposal Service Processing and/or Repackaging.	3	N/A		
	Sheffield	State of Illinois	IL	Commercial	LLW– All Classes (Closed)	3	8.83E+04	2.23E+15	1,2,3,4,5
Kentucky	Maxey Flats	State of Kentucky	KY	Commercial	LLW– All Classes (Closed)	3	1.35E+05	8.88E+16	1,2,3,4,5

Annex D-2B Radioactive Waste Management Facilities: Commercial/Other Facilities[275]

State	Installation	Licensee	Regulator[276]	Type	Function	Waste Source	Inventory (m^3)[277]	Estimated Activity (Bq)[278]	Rad Cat
Maryland	Chesapeake Nuclear Services, Inc.	Chesapeake Nuclear Services, Inc.	MD	Commercial	Broker	3	N/A		
	Clym Environmental Services, LLC	Clym Environmental Services, LLC	MD	Commercial	Broker	3	N/A		
	Dept. of the Army Ft. Detrick	Dept. of the Army	NRC	Other Government	Processor – Waste Disposal Service Processing and/or Repackaging.	3	N/A		
	Ecology Services	Ecology Services	MD	Commercial	Processor – Mixed waste processing	3	N/A		
	RSO, Inc.	RSO, Inc.	MD	Commercial	Broker/Transporter	3	N/A		
Michigan	Pharmacia and Upjohn Co.	Pharmacia and Upjohn Co.	NRC	Commercial	Processor – Manufacturing and Distribution Type A Broad	3	N/A		
Minnesota	University of Minnesota	University of Minnesota	MN	Academic	Processor – Waste Disposal Service Processing and/or Repackaging.	3	N/A		
Missouri	R.M. Wester	R.M. Wester	NRC	Commercial	Processor	3	N/A		

Annex D-2B Radioactive Waste Management Facilities: Commercial/Other Facilities[275]

State	Installation	Licensee	Regulator [276]	Type	Function	Waste Source	Inventory (m^3)[277]	Estimated Activity (Bq)[278]	Rad Cat
Missouri	R&R Trucking	R&R Trucking	NRC	Commercial	Broker/Transporter	3	N/A		
Montana	HHS, Dept. of Public Health Service, National Institute of Health, Rocky Mountain Laboratories	Dept. of Health & Human Services	NRC	Other Government	Processor – Research and Development Type A Broad	3	N/A		
Multiple	Multiple ISFSIs	Various Utilities and Commercial Sites	NRC	Commercial	GTCC Storage	3	1.30E+02	5.18E+16	1,3
Nevada	Beatty	None	NV	Commercial	LLW– All Classes (Closed)	3	1.37E+05	2.37E+16	1,2,3,4,5
New Jersey	BASF Corp.	BASF Corp.	NRC	Commercial	Processor – Research and Development Type A Broad	3	N/A		
New York	Radiac Research Corp.	Radiac Research Corp.	NY	Commercial	Processor – Waste Disposal Service Prepackaged only.	3	N/A		
	West Valley NRC-licensed Disposal Area and State-licensed Disposal Area	New York State Energy Research and Development Administration	NRC & NY	Commercial	LLW– All Classes (Closed)	3	7.71E+04	3.09 E +16	
North Carolina	HHS, Dept. of Public Health Service	Dept. of Health and Human Services	NRC	Other Government	Processor – Research and Development Type A Broad	3	N/A		

Annex D-2B Radioactive Waste Management Facilities: Commercial/Other Facilities[275]

State	Installation	Licensee	Regulator[276]	Type	Function	Waste Source	Inventory (m^3)[277]	Estimated Activity (Bq)[278]	Rad Cat
North Carolina	V.A. Medical Center	Dept. of Veterans Affairs	NRC	Other Government	Processor – Medical Institution Broad	3	N/A		
Ohio	Solutient Technologies	Solutient Technologies	OH	Commercial	Processor – Processing	3	N/A		
Pennsylvania	Alaron Corp.	Alaron Corp.	PA	Commercial	Processor – Waste Disposal Service Processing and/or Repackaging.	3	N/A		
	Applied Health Physics, Inc.	Applied Health Physics, Inc.	PA	Commercial	Processor – Waste Disposal Service Prepackaged only.	3	N/A		
	BWX Technologies, Inc.	BWX Technologies, Inc.	NRC	Commercial	Processor – Decommissioning of Advanced Fuel R&D and Pilot Plants	3	N/A		
	Fox Chase Cancer Center	Fox Chase Cancer Center	PA	Commercial	Processor – Medical Institution Broad	3	N/A		
	MHF Logistical Solutions, Inc.	MHF Logistical Solutions, Inc.	PA	Commercial	Broker/Transporter	3	N/A		
South Carolina	Energy*Solutions* (Barnwell)	Energy*Solutions* (Barnwell)	SC	Commercial	LLW Disposal Class A	3	7.19E+05	7.89E+17	1,2,3,4,5

Annex D-2B Radioactive Waste Management Facilities: Commercial/Other Facilities[275]

State	Installation	Licensee	Regulator [276]	Type	Function	Waste Source	Inventory (m^3)[277]	Estimated Activity (Bq)[278]	Rad Cat
South Carolina					LLW Disposal Class B	3	5.33E+04		
					LLW Disposal Class C	3	2.70E+04		
	GTS-Duratek/ Chem-Nuclear Systems, Inc.	GTS-Duratek, Inc.	SC	Commercial	Processor – Decommissioning of Byproduct Material Facilities	3	N/A		
	Hittman Transport Services	Energy*Solutions*	SC	Commercial	Transporter	3	N/A		
Tennessee	Ameriphysics, LLC	Ameriphysics, LLC	TN	Commercial	Broker	3	N/A		
	Bionomics	Bionomics	TN	Commercial	Processor	3	N/A		
	Chase Environmental	Chase Environmental Group, Inc.	TN	Commercial	Processor	3	N/A		
	DeNuke Services	DeNuke Services	TN	Commercial	Decon, decommissioning, mixed waste, encapsulation, transport	3	N/A		
	Diversified Technologies Services, Inc.	Diversified Technologies Services, Inc.	TN	Commercial	Processor (Liquid wastes)	3	N/A		
	Energy*Solutions* LLC	Energy*Solutions* Bear Creek	TN	Commercial	Processor	3	N/A		
	Energy*Solutions* LLC	Energy*Solutions* Gallagher Road	TN	Commercial	Processor	3	N/A		

Annex D-2B Radioactive Waste Management Facilities: Commercial/Other Facilities[275]

State	Installation	Licensee	Regulator [276]	Type	Function	Waste Source	Inventory (m^3)[277]	Estimated Activity (Bq)[278]	Rad Cat
Tennessee	Perma-Fix Diversified Scientific Services, Inc.	Perma-Fix	TN	Commercial	Processing of resins, sludges, and liquids	3	N/A		
	Perma-Fix Materials and Energy Corporation	Perma-Fix	TN	Commercial	Processing/ treatment of mixed wastes	3	N/A		
	Philotechnics	Philotechnics, Ltd.	TN	Commercial	Broker/Processor	3	N/A		
	Energy*Solutions*	Energy*Solutions*	TN	Commercial	Processor – Processing of large equipment	3	N/A		
			TN	Commercial	Processing Treatment	3	N/A		
	Toxco Incorporated	Toxco Incorporated	TN	Commercial	Processor	3	N/A		
	Veterans Affairs Medical Center	Dept. of Veterans Affairs	NRC	Other Government	Processor – High Dose Rate Remote After loader	3	N/A		
	Visionary Solutions	Visionary Solutions	TN	Commercial	Mixed waste, encapsulation, transport	3	N/A		
Texas	NSSI	NSSI	TX	Commercial	MLLW processing	3	N/A		
	USA Environment	USA Environment	TX	Commercial	Broker/Processor/Transporter	3	N/A		
	Waste Control Specialists LLC	Waste Control Specialists LLC	TX	Commercial	TRU Storage (DOE Temporary)	1	3.85E+02	3.10E+14	3

Annex D-2B Radioactive Waste Management Facilities: Commercial/Other Facilities[275]

State	Installation	Licensee	Regulator [276]	Type	Function	Waste Source	Inventory (m^3)[277]	Estimated Activity (Bq)[278]	Rad Cat
Texas					MLLW Treatment	3	N/A		
					11e.(2) Storage and Disposal	1	2.12E+04		4
	Waste Control Specialists LLC	Waste Control Specialists LLC	TX	Commercial	Commercial LLW Disposal	3	2.90E+03	1.44E+16	
					Federal LLW Disposal	1,2	5.95E+03		
					MLLW Treatment and Disposal	3	1.86E+05		1,2,3,4,5
Utah	Energy Solutions	Energy Solutions	UT	Commercial	LLW–Class A Disposal	3	3.44E+06	3.59E+15	1,2,3,4,5
					11e.(2) Disposal	3	1.46E+06		1,2,3,4,5
					Broker/Processor	3	NA		
	RWM – Utah, Inc.	RWM – Utah, Inc.	UT	Commercial	TRU Storage (DOE)	1	1.00E+01	7.81E+13	3
Virginia	B&W Energy Services	B&W Energy Services	NRC	Commercial	MLLW treatment and processing	3	N/A		1,2,3,4,5
Washington	Perma-Fix Northwest	Perma-Fix Northwest	WA	Commercial	LLW–Class A Disposal	3	3.93E+05	2.77E+17	
	US Ecology - Richland	US Ecology	WA	Commercial	LLW–Class B Disposal	3	3.74E+03	2.77E+17	
					LLW–Class C Disposal	3	2.82E+03		
					Sealed sources, leak testing	3	N/A		

Annex D-2B Radioactive Waste Management Facilities: Commercial/Other Facilities[275]

State	Installation	Licensee	Regulator[276]	Type	Function	Waste Source	Inventory (m^3)[277]	Estimated Activity (Bq)[278]	Rad Cat
Wisconsin	RAM Services	RAM Services	WI	Commercial	GTCC Storage	3	1.00E+00		1,3
Multiple	Multiple ISFSIs	Various utilities	NRC	Commercial	GTCC Storage	3	1.30E+02		1

Past Practices									
Ocean Disposal	Atlantic			Past Practice	LLW	1,2,3	8.60E+03	2.94E+15	
	Pacific			Past Practice	LLW	1,2,3	1.40E+04	5.54E+14	

Annex D-2 Key				
Waste Source		Radionuclide Category		
		Category		Key Isotopes
1	Defense applications	1	Activation Products	Primarily ^{36}Cl, ^{55}Fe, ^{54}Mn, ^{65}Zn, ^{58}Co, 60Co, ^{63}Ni
2	Nuclear applications	2	Mixed Fission Products	Radioactive isotopes and daughters from ^{72}Zn to ^{158}Gd; primary longer-lived isotopes are ^{85}Kr, ^{89}Sr, $^{90/}Y$-^{90}Sr, ^{91}Y, ^{95}Zr, ^{95}Nb, ^{103}Rh-^{103}Ru, ^{106}Rh-^{106}Ru, ^{125}Te-^{125}Sb, ^{137}Ba-^{137}Cs, ^{141}Ce, ^{144}Pr-^{144}Ce, ^{147}Pm, $m^{151}S$, and ^{155}Eu
3	Commercial	3	Transuranic Isotopes	Isotopes of Cf, Bk, Cm, Am, Pu, and Np, and their respective decay products.
		4	Naturally-Occurring Isotopes	^{238}U, ^{235}U, 234U, 232Th, and their respective decay products (^{231}Pa, ^{227}Th, ^{228}Th, ^{230}Th, ^{231}Th, ^{234}Th, ^{227}Ac, ^{228}Ac, ^{223}Ra, ^{224}Ra, ^{226}Ra, ^{228}Ra, ^{223}Fr, ^{219}Rn, ^{220}Rn, ^{222}Rn, ^{215}At, ^{218}At, ^{219}At, ^{210}Po, ^{211}Po, ^{212}Po, ^{214}Po, ^{215}Po, ^{216}Po, ^{218}Po, ^{210}Bi, ^{211}Bi, ^{212}Bi, ^{214}Bi, ^{210}Pb, ^{211}Pb, ^{212}Pb, ^{214}Pb, ^{206}Tl, ^{207}Tl, ^{208}Tl, and ^{210}Tl), ^{14}C, ^{40}K, ^{40}V, ^{87}Rb, ^{115}In, ^{123}Te, ^{138}La, ^{142}Ce, ^{144}Nd, ^{147}Sm, ^{148}Sm, ^{149}Sm, ^{152}Gd, ^{156}Dy, ^{176}Lu, ^{174}Hf, ^{180}Ta, ^{187}Re, ^{190}Pt, ^{204}Pb, ^{215}Bi
		5	Tritium	^{3}H
		6	Various	Radioactivity from various sources and categories

Annex D-3 Uranium Mill Tailings and Related Sites

State	Site Name/ Location	Licensee	Type	Status	Regulator	Regulatory Program	Quantity of Contaminated Material	Quantity Units[279]	^{226}Ra-Activity (TBq)
Arizona	Tuba City	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	2250000	Dry Tonnes	35
Colorado	Cheney Disposal Cell (residual radioactive material removed from the former Grand Junction Climax site)	DOE	Surface residual radioactive material disposal cell	Active until 2023 to accept residual radioactive material from other sites.	NRC	UMTRCA Title I	3414792	m^3	TBD
	Cotter	Cotter Corp.	Convention-al mill	Pursuing decommissioning, but no decommissioning activities are currently underway.	Colorado	UMTRCA Title II	5000000	Dry Tonnes	N/A
	Durango	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	3700000	Dry Tonnes	52
	Durita	Hecla Mining Company	Heap Leach	D&D is complete; NRC is reviewing final Completion Review Report.	Colorado	UMTRCA Title II	700000	Dry Tonnes	N/A

[279] 1 tonne = 1 metric ton

Annex D-3 Uranium Mill Tailings and Related Sites

State	Site Name/ Location	Licensee	Type	Status	Regulator	Regulatory Program	Quantity of Contaminated Material	Quantity Units[279]	^{226}Ra-Activity (TBq)
Colorado	Gunnison	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	1140000	Dry Tonnes	6.5
	Maybell	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	4291928	Dry Tonnes	17
	Maybell - West	DOE	11e.2 byproduct material disposal cell	Under general NRC license, in DOE LTSP.	NRC	UMTRCA Title II	1800000	Dry Tonnes	3.6
	Naturita	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	971762	Dry Tonnes	2.9
	Rifle	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	4967451	Dry Tonnes	101
	Slick Rock	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	1140000	Dry Tonnes	6.5
	Sweeney	Sweeney Mining & Milling Corp.	Convention-al mill	No activity; site under State Order.	Colorado	UMTRCA Title II	N/A		N/A
	UMETCO/ Uravan	EPA Superfund	Convention-al mill	Reclamation and decommissioning are completed;	Colorado	UMTRCA Title II	9500000	Dry Tonnes	N/A

Annex D-3 Uranium Mill Tailings and Related Sites

State	Site Name/ Location	Licensee	Type	Status	Regulator	Regulatory Program	Quantity of Contaminated Material	Quantity Units[279]	^{226}Ra-Activity (TBq)
Colorado				Completion Review Report is being prepared.					
Idaho	Lowman	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	222230	Dry Tonnes	0.4
Nebraska	Crow Butte	Crow Butte Resources, Inc.	In situ site	Operating	NRC	UMTRCA Title II	N/A	N/A	N/A
New Mexico	Ambrosia Lake	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	6931000	Dry Tonnes	69
	Ambrosia Lake	Rio Algom Mining LLC	Conventional mill	Not yet on LTSP. Completing reclamation; site closure is expected in 2020.	NRC	UMTRCA Title II	33,000,000	Dry Tonnes	N/A
	Bluewater	DOE	11e.2 byproduct material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title II	24000000	Dry Tonnes	457
	Church Rock	United Nuclear Corporation Mining and Milling	Conventional mill; groundwater restoration program	Co-disposal with mine waste and groundwater remain issues for EPA, NRC, New Mexico and the Navajo Nation. License amendment in progress.	NRC	UMTRCA Title II	3,500,000	Dry Tonnes	N/A

Annex D-3 Uranium Mill Tailings and Related Sites

State	Site Name/ Location	Licensee	Type	Status	Regulator	Regulatory Program	Quantity of Contaminated Material	Quantity Units[279]	^{226}Ra-Activity (TBq)
New Mexico	Crown Point	Hydro Resources, Inc.	In situ site	Licensed but not constructed.	NRC	UMTRCA Title II	N/A	N/A	N/A
	Homestake	Homestake Mining Co.	Conventional mill; groundwater restoration program	A Reclamation Plan under review by NRC. Expected closure 2022.	NRC	UMTRCA Title II	22,000,000	Dry Tonnes	N/A
	L-Bar (Sohio Western Mining)	DOE	11e.2 byproduct material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title II	1900000	Dry Tonnes	N/A
	Shiprock	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	2520000	Wet Tonnes	28
Oregon	Lakeview	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	736000	Dry Tonnes	1.6
Pennsylvania	Burrell	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	86000	Dry Tonnes	0.15
	Canonsburg	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	226000	Dry Tonnes	4

Annex D-3 Uranium Mill Tailings and Related Sites

State	Site Name/ Location	Licensee	Type	Status	Regulator	Regulatory Program	Quantity of Contaminated Material	Quantity Units[279]	^{226}Ra-Activity (TBq)
South Dakota	Edgemont	DOE	11e.2 byproduct material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title II	4000000	Dry Tonnes	19
	Dewey Burdock	Powertech Uranium Corp.	In situ site	Licensed but not constructed.	NRC	UMTRCA Title II	N/A	N/A	N/A
Texas	Conquista	Conoco Phillips Inc.	Convention-al mill	All structures and equipment have been removed. Settlement and groundwater issues remain to be resolved.	Texas	UMTRCA Title II	11800000	Dry Tonnes	N/A
	Hobson	South Texas Mining Venture	Resin processing	Operational	Texas	UMTRCA Title II	N/A		N/A
	La Palangana	South Texas Mining Venture	In situ site	Operational	Texas	UMTRCA Title II	N/A		N/A
	Ray Point	Exxon Mobil Corp.	Convention-al mill	Exxon needs to submit a license amendment to remove seepage monitoring program; all other reclamation has been completed.	Texas	UMTRCA Title II	400000	Dry Tonnes	N/A
	Falls City	DOE	Surface residual radioactive	Under general NRC license, in	NRC	UMTRCA Title I	7143000	Dry Tonnes	47

Annex D-3 Uranium Mill Tailings and Related Sites

State	Site Name/ Location	Licensee	Type	Status	Regulator	Regulatory Program	Quantity of Contaminated Material	Quantity Units[279]	^{226}Ra-Activity (TBq)
Texas			material disposal cell	DOE LTSP program.					
	Zamzow & Lamprech Projects /S. Texas	International Energy Corporation	In situ site	Licensee abandoned site without completing decommissioning; Texas is pursuing legal actions.	Texas	UMTRCA Title II	N/A		N/A
	Alta Mesa	EFR Alta Mesa LLC	In situ site	Operational	Texas	UMTRCA Title II	N/A		N/A
	RGR/Chevron (Panna Maria)	Rio Grande Resources Corporation	Convention-al mill	All structures and equipment have been removed. Licensee is seeking to revise groundwater protection standards based on background levels.	Texas	UMTRCA Title II	5900000	Dry Tonnes	N/A
	Hobson	Rio Grande Resources Corporation	Resin Processing	Licensed but not yet constructed.	Texas	UMTRCA Title II	N/A		N/A
	Kingsville Dome, Vasquez, and Rosita	URI	In situ site	Kingsville Dome: Ground-water restoration progressing in all 17 well fields. Vasquez: Groundwater restoration in progress for all 7 wellfields.	Texas	UMTRCA Title II	N/A		N/A

Annex D-3 Uranium Mill Tailings and Related Sites

State	Site Name/ Location	Licensee	Type	Status	Regulator	Regulatory Program	Quantity of Contaminated Material	Quantity Units[279]	^{226}Ra-Activity (TBq)
Texas				Rosita: Wells plugged in wellfields 1-6, wellfield 7 in restoration and wellfield 8 is in standby.					
	Goliad	UEC	In situ site	Licensed but not yet constructed.	Texas	UMTRCA Title II	N/A		N/A
	Brevard & Brown (locations)	Signal Equities, LLC	In situ site	Licensed but not yet constructed.	Texas	UMTRCA Title II	N/A		N/A
Utah	Moab/ Crescent Junction	DOE	11e.(2) byproduct material disposal site	Transportation of Moab (Atlas) tailings to the Crescent Junction disposal site is approximately only 41% complete.	NRC	UMTRCA Title I	6270000	Dry Tonnes	N/A
	Green River	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	501000	Dry Tonnes	1.1
	Lisbon	Rio Algom Mining Corp.	Convention-al mill	Structures have been removed and radioactive material has been disposed in the two tailings embankments that have final cover. Process to transfer site expected to initiate in 2018.	Utah	UMTRCA Title II	3500000	Dry Tonnes	N/A

Annex D-3 Uranium Mill Tailings and Related Sites

State	Site Name/ Location	Licensee	Type	Status	Regulator	Regulatory Program	Quantity of Contaminated Material	Quantity Units[279]	^{226}Ra-Activity (TBq)
Utah				This is a candidate for restart.					
	Mexican Hat	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	4400000	Dry Tonnes	67
	Moab	DOE	Uranium Mill Tailings Disposal Cell	Under active reclamation by DOE; site will not come under general license in 10 CFR 40.27 until surface reclamation is complete.	NRC	UMTRCA Title I	7668000	Dry Tonnes	N/A
	Salt Lake City Disposal Cell (Clive)	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	2798000	Dry Tonnes	57
	Shootaring Canyon	Anfield Resources Holding Corp.	Convention-al uranium mill	Site has been on standby since 1982. A License Renewal Application is currently under review by the Utah DEQ.	Utah	UMTRCA Title II	78000	Dry Tonnes	N/A

Annex D-3 Uranium Mill Tailings and Related Sites

State	Site Name/ Location	Licensee	Type	Status	Regulator	Regulatory Program	Quantity of Contaminated Material	Quantity Units[279]	^{226}Ra-Activity (TBq)
Utah	White Mesa	Energy Fuels Resources (USA) Inc.	Conventional uranium mill[280]	Operating and processing alternate feed.	Utah	UMTRCA Title II	3500000	Dry Tonnes	N/A
Washington	Dawn Mining	Dawn Mining Co.	Conventional uranium mill	Three of four final radon barriers will be completed in 2017. The fourth impoundment has an interim cover. All major surface reclamation will be completed in 2017. Continuing groundwater issues are unresolved.	WA[281]	UMTRCA Title II	2800000	Dry Tonnes	N/A
	WNI Sherwood	DOE	11e.(2) byproduct material disposal site	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title II	2600000	Dry Tonnes	17
Wyoming	Bear Creek	Bear Creek Uranium Co.	11e.(2) byproduct material disposal site	DOE has deed to the site, and is in the process of taking site as LTSP custodian. Estimated date for closure 2019.	NRC	UMTRCA Title II	4,700,000	Dry Tonnes	N/A
	Gas Hills West	American Nuclear Corp.	11e.(2) byproduct material disposal site	Reclamation incomplete due to insolvency. Reclamation lead taken by	NRC	UMTRCA Title II	N/A	N/A	N/A

[280] The White Mesa facility also accepts material from other uranium recovery sites.
[281] WA – State of Washington.

Annex D-3 Uranium Mill Tailings and Related Sites

State	Site Name/ Location	Licensee	Type	Status	Regulator	Regulatory Program	Quantity of Contaminated Material	Quantity Units[279]	^{226}Ra-Activity (TBq)
Wyoming				Wyoming; but funds to complete reclamation are lacking. Closure TBD.					
	Gas Hills North	Pathfinder Mines Corp -- Lucky MC	11e.(2) byproduct material disposal site	Not yet on LTSP. Estimated date for closure 2017.	NRC	UMTRCA Title II	N/A	N/A	N/A
	Gas Hills East	Umetco Minerals Corp.	11e.(2) byproduct material disposal site	Not yet on LTSP. NRC approved Construction Completion Report. DOE & Bureau of Land Management land transfer process. Estimated date for closure 2018.	NRC	UMTRCA Title II	15,169,698	Dry Tonnes	3,699
	Highlands	Exxon Mobil Corp.	11e.(2) byproduct material disposal site	Reclamation hampered by surface water contamination offsite.	NRC	UMTRCA Title II	N/A	N/A	N/A
	Willow Creek Project (formerly Christensen Ranch)	Uranium One	In situ site	Operating	NRC	UMTRCA Title II	N/A	N/A	N/A
	Moore Ranch	Uranium One	In situ site	Licensed but not constructed.	NRC	UMTRCA Title II	N/A	N/A	N/A
	Nichols Ranch	Uranerz Energy	In situ site	Operating	NRC	UMTRCA Title II	N/A	N/A	N/A
	Lost Creek	Lost Creek	In situ site	Operating	NRC	UMTRCA Title II	N/A	N/A	N/A

Annex D-3 Uranium Mill Tailings and Related Sites

State	Site Name/ Location	Licensee	Type	Status	Regulator	Regulatory Program	Quantity of Contaminated Material	Quantity Units[279]	^{226}Ra-Activity (TBq)
Wyoming	Ross	Strata Energy, Inc	In situ site	Operating	NRC	UMTRCA Title II	N/A	N/A	N/A
	Shirley Basin–North	Pathfinder Mines Corp.	11e.(2) byproduct material disposal site	Operating	NRC	UMTRCA Title II	N/A	N/A	N/A
	Shirley Basin – South	DOE	11e.(2) byproduct material disposal site	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title II	6300000	Dry Tonnes	N/A
	Smith Ranch – Highland	Power Resources, Inc.	In situ site	Operating	NRC	UMTRCA Title II	N/A	N/A	N/A
	Split Rock	Western Nuclear Inc.	11e.(2) byproduct material disposal site	Groundwater model issues need to be resolved before transfer to DOE.	NRC	UMTRCA Title II	7,700,000	Dry Tonnes	2,750
	Spook	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	1500000	M^3	N/A
	Sweetwater	Kennecott Uranium Co.	Convention-al uranium mill	On standby status.	NRC	UMTRCA Title II	2500000	Dry Tonnes	N/A

Sources: https://www.lm.doe.gov/pro_doc/references/framework.htm; https://www.radiationcontrol.utah.gov/; https://www.eia.doe.gov/cneaf/nuclear/dupr/dupr.html; http://www.doh.wa.gov/; https://www.nrc.gov/

Annex D-4. Formerly Utilized Sites Remedial Action Program Sites in Progress[282, 283]

State	Site	Status
Connecticut	Combustion Engineering Site (Windsor)	Remediation Complete, Transfer to DOE Pending
Indiana	Joslyn Manufacturing and Supply Company (Fort Wayne)	Remedial Investigation Contract Pending
Iowa	Iowa Army Ammunition Plant (Middletown)	Ongoing Remediation
Maryland	W.R. Grace Site (Baltimore)	Remediation Decision Pending
Massachusetts	Shpack Landfill (Norton/Attleboro)	Remediation Complete, Transfer to DOE Pending
Missouri	Latty Avenue Properties (Hazelwood)	Ongoing Remediation
	St. Louis Airport Site (St. Louis)	Remediation Complete; Groundwater Monitoring and Long-term Management Activities Continue
	St. Louis Airport Site Vicinity Properties (St. Louis)	Ongoing Remediation
	St. Louis Downtown Site (St. Louis)	Ongoing Remediation
New Jersey	Maywood Chemical Superfund Site (Maywood)	Ongoing Remediation
	Middlesex Sampling Plant (Middlesex)	Remedial Investigation
	Middlesex Municipal Landfill (Middlesex)	Remedial Investigation
	DuPont Chamber Works (Deepwater)	Remediation Pending
New York	Niagara Falls Storage Site (Lewiston)	Ongoing Remediation

[282] U.S. Army Corps of Engineers, *Formerly Utilized Sites Remedial Action Program Update 2016* available at: http://www.usace.army.mil/Portals/2/docs/Environmental/FUSRAP/FUSRAP_Stakeholder_Report_2016.pdf.
[283] Some of these sites are also included in the Materials Decommissioning Program (Annex D-6).

Annex D-4. Formerly Utilized Sites Remedial Action Program Sites in Progress[282, 283]

State	Site	Status
New York	Former Linde Air Products (Tonawanda)	Remediation Complete, Transfer to DOE Pending
	Guterl Specialty Steel (Lockport)	Remedial Investigation
	Seaway Industrial Park (Tonawanda)	Ongoing Remediation
	Colonie Site (Colonie)	Remedial Investigation Complete, Remediation Contract Pending
	Sylvania Corning Plant (Hicksville)	Remedial Investigation
	Tonawanda Landfill	Remedial Investigation
Ohio	Luckey Site (Luckey)	Ongoing Remediation
	Painesville Site (Painesville)	Remediation Complete, Transferred to DOE 2016
	Harshaw Chemical Company (Cleveland)	Remedial Investigation
Pennsylvania	Shallow Land Disposal Area (Parks Township)	Remediation Contract Pending
	Superior Steel (Carnegie)	Remedial Investigation

Source: U.S. Army Corps of Engineers, *Formerly Utilized Sites Remedial Action Program Update 2016,* 2017.

Annex D-5. Decommissioning of Complex Licensed Materials Sites[284]

State	Installation	Location	Decommissioning Status[285]
NRC Regulated Sites			
California	Hunter's Point Naval Shipyard[286]	San Francisco	Estimated closure to be determined
	Alameda Naval Air Station	Alameda	Estimated closure to be determined
	McClellan (former Air Force Base)[287]	Sacramento	Estimated closure to be determined
Connecticut	UNC Naval Products (a.k.a. United Nuclear)	New Haven	Estimated closure to be determined
Indiana	Jefferson Proving Ground (Department of the Army)	Madison	Estimated closure to be determined
Maryland	Beltsville Agricultural Research Laboratory	Beltsville	Estimated closure in 2017, under unrestricted release
Missouri	Sigma-Aldrich	Maryland Heights	Estimated closure in 2019 under unrestricted release
	Westinghouse Electric Corp. (Hematite Facility)	Festus	Estimated closure to be determined
New Jersey	Department of the Army, U.S. Armament Research Development and Engineering Center	Picatinny	Estimated closure to be determined
New York	West Valley Demonstration Project	West Valley	Estimated closure to be determined
Oklahoma	FMRI (Fansteel), Inc.	Muskogee	Estimated closure after 2023, under unrestricted release
	Kerr-McGee – Cimarron	Cimarron	Estimated closure in 2018 under unrestricted release
Pennsylvania	Babcock & Wilcox SLDA[288]	Vandergrift	Estimated closure to be determined

[284] *Status of the Decommissioning Program 2016 Annual Report* is available at NRC's ADAMS, under ML16285A197.
[285] To be determined; closure dates are pending resolution of site-specific regulatory provisions; e.g., financial assurance, waste management arrangements.
[286] The Navy's Hunter's Point Shipyard site is being remediated by the Navy, under the required CERCLA process and EPA oversight. NRC has not licensed this site, but monitors cleanup efforts and will rely on the ongoing CERCLA process and EPA oversight.
[287] The Air Force's McClellan site is being remediated by the Air Force, under the required CERCLA process and EPA oversight. NRC has not licensed this site, but monitors cleanup efforts and will rely on the ongoing CERCLA process and EPA oversight.
[288] NRC retains regulatory authority, including decommissioning phase, at sites having special nuclear material in quantities sufficient to form a critical mass.

Annex D-5. Decommissioning of Complex Licensed Materials Sites[284]			
State	**Installation**	**Location**	**Decommissioning Status[285]**
Agreement State Regulated Sites			
California	Halaco	Oxnard	EPA Superfund Site – Estimated closure to be determined (TBD)
	The Boeing Company	Simi Valley	Dual jurisdiction and mixed waste have complicated the decommissioning
	Chevron Mining, Inc. (Formerly Molycorp)	Mountain Pass	Ongoing, awaiting final status survey
	Isotope Specialties	Burbank	Ongoing
	Magnesium Alloy Products	Compton	Ongoing
Florida	Iluka Resources, Inc.	Green Cove Springs	TBD – D&D activities underway
Illinois	ADCO Services	Tinley Park	Ongoing
	Weston Solutions (Formerly Kerr-McGee)	West Chicago	TBD – pending results from groundwater contamination monitoring and corrective action; under EPA superfund
Kansas	Beta Chem	Lenexa	TBD
Massachusetts	Shpack Landfill	Norton	TBD – complicated by multiple jurisdictions
	BASF (Formerly Engelhard Corporation)	Plainville	TBD
	Starmet Corp. (Formerly Nuclear Metals)	Concord	TBD
	Wyman Gordon Co.	North Grafton	TBD
	Texas Instruments	Attleboro	TBD
	Norton/St. Gobain	Worcester	TBD – environmental remediation ongoing

Annex D-5. Decommissioning of Complex Licensed Materials Sites[284]			
State	**Installation**	**Location**	**Decommissioning Status[285]**
New Jersey	Shieldalloy Metallurgical Corp.[289]	Newfield	NRC reinstated New Jersey's authority to regulate Shieldalloy Metallurgical Corporation on August 5, 2013. TBD
Ohio	Ineos USA, LLC (Formerly BP Chemical)	Lima	TBD - D&D resumption delayed until 2019; due to state prohibitions
	Advanced Medical Systems, Inc.	Cleveland	TBD
Oregon	TDY Industries (Doing business as Wah Chang)	Albany	Ongoing
	PCC Structurals, Inc.	Portland	Continuous monitored sewer sediment collection and cleanup
Pennsylvania	Curtiss-Wright	Cheswick	TBD
	Keystone Metals Reduction	Cheswick	TBD – undergoing analysis of remediation alternatives
	Karnish Instruments	Lock Haven	TBD
	Global Tungsten & Powders Corporation	Towanda	TBD
	Remacor	West Pittsburg	Undergoing characterization
	Superbolt (formerly Superior Steel)	Carnegie	TBD – USACE waiting funding to proceed with site cleanup activities
	Safety Light Corporation	Bloomsburg	TBD –Transferred to EPA – conducting cleanups & stabilizing waste piles
	Strube Incorporated	Lancaster County	TBD – awaiting financial influx for proceeding with cleanup
	Westinghouse Electric Corp. (Waltz Mill)	Madison	TBD
	Whittaker Corporation	Greenville	Ongoing
Tennessee	CB&I Federal Services	Knoxville	Ongoing
Texas	ASARCO	Houston	Investigation and cleanup ongoing

[289] Transfer of regulatory authority of the Shieldalloy site was set aside by a federal appellate decision in *Shieldalloy Metallurigical Corp v. NRC*, 768 F. 3d 1205 (2014).

Annex D-5. Decommissioning of Complex Licensed Materials Sites[284]			
State	**Installation**	**Location**	**Decommissioning Status[285]**
Texas	Pearland-Manvel Landfill	Pearland	No additional work or sampling has occurred at the site
	Iso-Tex Diagnostics	Houston	Working to resolve outstanding issues before the site can be released

Source: NRC, *Status of the Decommissioning Program 2016 Annual Report*, 2017.

Annex D-6. Nuclear Regulatory Commission-Licensed Power and Demonstration Reactors Under Decommissioning

State	Facility	Reactor Type	Power	D&D Status
Commercial Power Reactors				
California	General Electric Co.- Vallecitos	Experimental Superheat Reactor (VESR)	12.5 MW	SAFSTOR Possession Only
	General Electric Co - Vallecitos	Boiling Light-Water Reactor (VBWR)	24 MWe	SAFSTOR
	Humboldt Bay 3	Boiling Light-Water Reactor	65 MWe	DECON
	San Onofre – Unit 1	Pressurized Light-Water Reactor	436 MWe	SAFSTOR
	San Onofre – Unit 2	Pressurized Light-Water Reactor	1070 MWe	PSDAR
	San Onofre – Unit 3	Pressurized Light-Water Reactor	1070 MWe	PSDAR
Connecticut	Millstone – Unit 1	Boiling Light-Water Reactor	660 MWe	SAFSTOR
Florida	Crystal River	Pressurized Light-Water Reactor	825 MWe	SAFSTOR
Illinois	Dresden – Unit 1	Boiling Light-Water Reactor	192 MWe	SAFSTOR
	Zion – Unit 1	Pressurized Light-Water Reactor	1040 MWe	DECON
	Zion – Unit 2	Pressurized Light-Water Reactor	1040 MWe	DECON
Maryland	Nuclear Ship Savannah	Pressurized Light-Water Reactor	74 MW	SAFSTOR
Michigan	Fermi – Unit 1	Liquid Metal Fast Breeder Reactor	60 MWe	DECON
Nebraska	Fort Calhoun	Pressurized Light-Water Reactor	484 MWe	SAFSTOR
New York	Indian Point – Unit 1	Pressurized Light-Water Reactor	265 MWe	SAFSTOR
Pennsylvania	Peach Bottom – Unit 1	High Temperature Gas Reactor	40 MWe	SAFSTOR
	Three Mile Island – Unit 2	Pressurized Light-Water Reactor	906 MWe	Monitored SAFSTOR
Vermont	Vermont Yankee	Boiling Light-Water Reactor	514 MWe	SAFSTOR
Wisconsin	La Crosse	Boiling Light-Water Reactor	50 MWe	SAFSTOR
	Kewaunee	Pressurized Light-Water Reactor	535 MWe	SAFSTOR
Research and Test Reactors				

Annex D-6. Nuclear Regulatory Commission-Licensed Power and Demonstration Reactors Under Decommissioning

State	Facility	Reactor Type	Power	D&D Status
California	General Atomics	TRIGA Mark F	1500 kW	DECON
	General Atomics	TRIGA Mark I	250 kW	SAFSTOR
	General Electric Co.	GETR (Tank)	5000 kW	SAFSTOR Possession Only
New York	University of Buffalo	Pool	2 MW	SAFSTOR Possession Only

Annex F. Requirements for Notifying Nuclear Regulatory Commission of Emergency and Non-Emergency Events[290]

Requirements for Notifying NRC of Emergency and Non-Emergency Events
Specific requirements for NRC-licensed radioactive materials[291]
Standards for Protection Against Radiation (10 CFR Part 20):
• Section 20.1906 Procedures for receiving and opening packages. [Section 20.1906(d) notification of removable radioactive surface contamination]
• Section 20.2201 Reports of theft or loss of licensed material.
• Section 20.2202 Notification of incidents.
• Section 20.2203 Reports of exposures, radiation levels, and concentrations of radioactive material exceeding the constraints or limits.
• Section 20.2204 Reports of planned special exposures.
Domestic Licensing of Byproduct Material (10 CFR Part 30):
• Section 30.50 Reporting requirements.
• Section 30.55 Tritium reports.
Domestic Licensing of Source Material (10 CFR Part 40):
• Section 40.60 Reporting requirements.
• Section 40.64 Reports. [Section 40.64(c)(2) notification for any attempt of theft or unlawful diversion]
Domestic Licensing of Production and Utilization Facilities (10 CFR Part 50):
• Section 50.72 Immediate notification requirements for operating nuclear power reactors.
• Section 50.73 Licensee event reporting system.
Disposal of High-Level Radioactive Wastes in Geologic Repositories (10 CFR 60.78, Material Control and Accounting Records and Reports).
Disposal of High-Level Radioactive Wastes in A Geologic Repository at Yucca Mountain, Nevada (10 CFR 63.73, Reports of Deficiencies).
Domestic Licensing of Special Nuclear Material (10 CFR Part 70):
• Section 70.50 Reporting requirements.
• Section 70.52 Reports of accidental criticality.
• Section 70.74 Additional reporting requirements. (Appendix A - Reportable Safety Events)

[290] This list is not all-inclusive.
[291] There are equivalent requirements for the relevant Agreement States.

Annex F. Requirements for Notifying Nuclear Regulatory Commission of Emergency and Non-Emergency Events[290]

Requirements for Notifying NRC of Emergency and Non-Emergency Events
• Appendix A to Part 70--Reportable Safety Events.
Packaging and Transportation of Radioactive Material (10 CFR 71.95 Reports).
Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater-than-Class C Waste (10 CFR Part 72):
• Section 72.32 Emergency Plan. (8) Notification and coordination.
• Section 72.74 Reports of accidental criticality or loss of special nuclear material.
• Section 72.75 Reporting requirements for specific events and condition.
Physical Protection of Plants and Materials (10 CFR Part 73):
• Section 73.27 Notification requirements.
• Section 73.67 Licensee fixed site and in-transit requirements for the physical protection of special nuclear material of moderate and low strategic significance.
• Section 73.71 Reporting of safeguards events.
Appendix G to Part 73--Reportable Safeguards Events
Material Control and Accounting of Special Nuclear Material (10 CFR 74.11 Reports of loss or theft or attempted theft or unauthorized production of special nuclear material)
Certification of Gaseous Diffusion Plants (10 CFR 76.120 Reporting requirements)
Export and Import of Nuclear Equipment and Material (10 CFR 110.50 Terms)
Examples of non-reactor incident reports
NUREG-1405, Inadvertent Shipment of a Radiographic Source from Korea to Amersham Corporation, Burlington, Massachusetts (Publication Date: May 1990)
NUREG-1450, Potential Criticality Accident at the General Electric Nuclear Fuel and Component Manufacturing Facility, May 29, 1991 (Publication Date: August 1991)
NUREG-1480, Loss of an Iridium-192 Source and Therapy Misadministration at Indiana Regional Cancer Center Indiana, Pennsylvania on November 16, 1992 (Publication Date: February 1993)
NUREG-1535, Ingestion of Phosphorus-32 at Massachusetts Institute of Technology, Cambridge, Massachusetts, Identified on August 19, 1995 (Publication Date: December 1995).
Links to Additional Information on Response to Incidents
Federal Emergency Management Agency (FEMA) State Offices and Agencies of Emergency Management: https://www.fema.gov/emergency-management-agencies.
FEMA: https://www.fema.gov/
Department of Energy (DOE): https://energy.gov
U.S. Environmental Protection Agency (EPA): https://www.epa.gov/
Department of Agriculture (USDA): https://www.usda.gov/
Department of Health and Human Services (HHS): https://www.hhs.gov/

Annex F. Requirements for Notifying Nuclear Regulatory Commission of Emergency and Non-Emergency Events[290]

Requirements for Notifying NRC of Emergency and Non-Emergency Events
Department of State (DOS): https://www.state.gov/
Federal Bureau of Investigation (FBI): https://www.fbi.gov/

LIST OF ACRONYMS AND ABBREVIATIONS

Acronym/ Abbreviation	Name
ADAMS	Agencywide Documents Access and Management System (NRC)
AEA	Atomic Energy Act of 1954, as amended
AEC	Atomic Energy Commission
ALARA	As Low as Reasonably Achievable
AMIPA	American Medical Isotopes Production Act of 2012
ANSI	American National Standards Institute
ANS-8	American Nuclear Society Standards Subcommittee 8
ASERs	Annual Site Environmental Reports
AU	DOE Office of Environment, Health, Safety and Security
BLDD	Baseline Disposition Data
Bq	Becquerel
CAA	Clean Air Act
CA BTP	Concentration Averaging and Encapsulation Branch Technical Position
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CoC	Certificate of Compliance
CSD	Considered Sites Database
D&D	Decontamination & Decommissioning
DECON	Immediate Dismantlement
DHS	Department of Homeland Security
DNFSB	Defense Nuclear Facilities Safety Board
DOE	Department of Energy
DOL	Department of Labor
DoS	Department of State
DP	Decommissioning Plan
DU	Depleted Uranium
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency

Acronym/ Abbreviation	Name
EPAct05	Energy Policy Act of 2005
EPAct92	Energy Policy Act of 1992
EPRI	Electric Power Research Institute
ESCP	Extended Storage Collaboration Program
FBI	Federal Bureau of Investigation
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FFA	Federal Facility Agreements
FIU	Florida International University
FRMAC	Federal Radiological Monitoring and Assessment Center
FR	*Federal Register*
FSAR	Final Safety Analysis Report
FTE	Full-Time Equivalent
FWF	Federal Waste Facility
FUSRAP	Formerly Utilized Sites Remedial Action Program
FY	Fiscal Year
GIS	Geographic Information System
GTCC	Greater-than-Class C Low-Level Waste
HEU	Highly-Enriched Uranium
HHS	Department of Health and Human Services
HLW	High-Level Waste
HWFP	Hazardous Waste Facility Permit
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IFNEC	International Framework for Nuclear Energy Cooperation
IMPEP	Integrated Materials Performance Evaluation Program
INES	International Nuclear Event Scale
INL	Idaho National Laboratory
IRRS	Integrated Regulatory Review Service
ISFSI	Independent Spent Fuel Storage Installation
ISR	In Situ Recovery

Acronym/ Abbreviation	Name
KgU	Kilogram of Uranium
LAW	Low-Activity Waste
LEU	Low-Enriched Uranium
LFRG	Low-Level Waste Disposal Facility Federal Review Group
LLRWPAA	Low-Level Radioactive Waste Policy Amendments Act of 1985
LLW	Low-Level Waste
LSN	Licensing Support Network
LTP	License Termination Plan
LTSP	Long-Term Surveillance Plan
LWA	Land Withdrawal Act
m^3	Cubic Meters
MLLW	Mixed Low-Level Waste
MOU	Memorandum of Understanding
MRB	Management Review Board
MT	Metric Tons
MTHM	Metric Tons Heavy Metal
NAS	National Academy of Sciences
N/A	Not Applicable or Not Available
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NNSA	National Nuclear Security Administration
NORM	Naturally Occurring Radioactive Materials
NOV	Notices of Violations
NPDES	National Pollution Discharge Elimination System
NPL	National Priorities List for CERCLA
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission
NRF	National Response Framework
NRIA	Nuclear/Radiological Incident Annex
NUREG	Nuclear Regulatory Commission Regulation Technical Report Designation

Acronym/ Abbreviation	Name
NWF	Nuclear Waste Fund
NWPA	Nuclear Waste Policy Act of 1982, as amended
NWTRB	Nuclear Waste Technical Review Board
OPM	Office of Personnel Management
ORISE	Oak Ridge Institute for Science and Education
ORR	Oak Ridge Reservation
OSHA	Occupational Safety and Health Administration
PA	Performance Assessments
PAGs	Protective Action Guides
PSDAR	Post-Shutdown Decommissioning Activity Report
QA	Quality Assurance
RCRA	Resource Conservation and Recovery Act of 1976
REIRS	Radiation Exposure Information and Reporting System
RG	Regulatory Guide
RESRAD	RESidual RADiation
R&D	Research and Development
SAFSTOR	A method of decommissioning in which a nuclear facility is placed and maintained in a condition that allows the facility to be safely stored and subsequently decontaminated (deferred decontamination) to levels that permit release for unrestricted use.
SNL	Sandia National Laboratory
SRS	Savannah River Site
SSAB	Site-Specific Advisory Boards
Superfund	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
Sv	Sievert
SWPF	Salt Waste Processing Facility
TBD	To be determined
TED	Total Effective Dose
TEDE	Total Effective Dose Equivalent
TENORM	Technologically Enhanced NORM
TRU	Transuranic
ULTB	Uranium Lease and Take-Back Program

Acronym/ Abbreviation	Name
UMTRCA	Uranium Mill Tailings Radiation Control Act
URL	Uniform Resource Locator
U.S.	United States of America
USACE	U.S. Army Corps of Engineers
U&Th	Uranium and Thorium
VLLW	Very Low-Level Waste
WCS	Waste Control Specialists LLC
WIPP	Waste Isolation Pilot Plant
WIPP LWA	Waste Isolation Pilot Plant Land Withdrawal Act of 1992, as amended

ADDITIONAL REFERENCES

Numerous references to laws, regulations, regulatory guides, standards, and DOE Orders are provided throughout this report and are not repeated here (see Table E-1 and Table E-2) for brevity. Internet web sites are also provided in Table A-2. The following additional resources were used:

American National Standards Institute. Surface and Volume Radioactivity Standards for Clearance, ANSI/HPS N13.12-2013. May 2013, Update.

International Atomic Energy Agency. *Classification of Radioactive Waste*; General Safety Guide Series No. GSG-1. Vienna, Austria. December 2009.

International Atomic Energy Agency. *Governmental, Legal and Regulatory Framework for Safety General Safety Requirements* Part 1; Series No. GSR Part 1. Vienna, Austria. October 2010.

International Atomic Energy Agency. Guidelines Regarding the Form and Structure of National Reports: Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, INFCIRC/604/Rev.2. Vienna, Austria. September 2012.

International Atomic Energy Agency. Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, INFCIRC/546. Vienna, Austria. December 1997.

International Atomic Energy Agency. WORKING MATERIAL. Synopsis of relevant IAEA Safety Standards that relate to the issues addressed by Articles of the Joint Convention. Vienna, Austria. 2008.

U.S. Department of Energy. Preliminary Report on Operational Guidelines Developed for Use in Emergency Preparedness and Response to a Radiological Dispersal Device Incident, DOE/HS-0001; ANL/EVS/TM/09-1. February 2009.

U.S. Department of Energy. Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste. January 2013.

U.S. Department of Energy, Energy Information Administration. Decommissioning of U.S. Uranium Production Facilities, DOE/EIA-0592. Washington, DC, USA. February 1995.

U.S. Department of Energy. Waste Management Data, database maintained by Florida International University (users have to register). http://emwims.org/

U.S. Department of Energy. Low-Level Waste Disposal Capacity Report, (2000). https://energy.gov/em/downloads/122000-low-level-waste-disposal-capacity-report-version-2

U.S. Department of Energy. Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste, Vols 1 and 2, DOE/EIS-0375-D. Washington, DC, USA. February 2016.

U.S. Department of Energy. National Spent Fuel Database. 2008. U.S. Department of Energy. Grand Junction Office. https://www.em.doe.gov/bemr/BEMRSites/gjpo.aspx

U.S. Federal Emergency Management Agency (FEMA). Radiological Emergency Preparedness Program Manual. January 2016.

U.S. Environmental Protection Agency. Office of Radiation Programs. Fact Sheet on Ocean Dumping of Radioactive Waste Materials. Washington, DC, USA. November 1980.

U.S. Environmental Protection Agency. Office of Radiation Programs. Data from Studies of Previous Radioactive Waste Disposal in Massachusetts Bay (520/1-84-031). Washington, DC, USA. 1984. (PB85 170 066/AS).

U.S. Environmental Protection Agency. Radiation Protection Division. Technologically Enhanced Naturally-Occurring Radioactive Materials from Uranium Mining, Vol. 1: Mining and Reclamation Background, EPA 402-R-05-007. Washington, DC, USA. June 2006 updated June 2007.

U.S. Environmental Protection Agency. Radiation Protection Division. Uranium Location Database Compilation, EPA 402-R-05-009. Washington, DC, USA. August 2006.

U.S. Environmental Protection Agency. Radiation Protection Division. Technologically Enhanced Naturally Occurring Radioactive Materials from Uranium Mining, Vol. 2: Investigation of Potential Health, Geographic, and Environmental Issues of Abandoned Uranium Mines, EPA 402-R-05-008. Washington, DC, USA. April 2008.

U.S. Nuclear Regulatory Commission. *History and Framework of Commercial Low-Level Radioactive Waste Management in the U.S. ACNW White Paper* (NUREG-1853). Washington, DC, USA. January 2007. Agencywide Documents Access and Management System (ADAMS) Accession No.: ML070600684.

U.S. Nuclear Regulatory Commission. *Radioactive Waste: Production, Storage, Disposal* (NUREG/BR-0216). Rev. 2. Washington, DC, USA. May 2002. ADAMS Accession No.: ML15127A029.

U.S. Nuclear Regulatory Commission. *The United States of America Seventh National Report for the Convention on Nuclear Safety* (NUREG-1650). Rev. 6. Washington, DC, USA. October 2016. https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1650/

U.S. Nuclear Regulatory Commission. *Information Digest 2016-2017 Edition* (NUREG-1350). Vol.28. Washington, DC, USA. September 2016. https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/

U.S. Nuclear Regulatory Commission. *Examination of Spent PWR Fuel Rods after 15 Years in Dry Storage* (NUREG/CR-6381). Washington, DC, USA. September 2003. https://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr6831

U.S. Nuclear Regulatory Commission. Recommendations for Enhancing Reactor Safety in the 21st Century. The Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident. July 2011. ADAMS Accession No.: ML111861807.

This page intentionally left blank.