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National Report for the Seventh Review Meeting of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

U.S. Department of Energy

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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, May 2015, and May 2018 in Vienna, Austria. This U.S. National Report for the Seventh Review Meeting describes 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.

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A. INTRODUCTION

This seventh United States of America (U.S.) National Report updates the National Report published in October 2017, 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 2020.

The main developments since the previous National Report include:

- Progress in Spent Fuel and High-Level Waste (HLW) disposition including Department of Energy's (DOE's) interpretation of the statutory definition of HLW and the Nuclear Regulatory Commission's (NRC's) review of applications for interim storage (see Section A.3.1).
- Progress in radioactive waste management including issuing guidance and policy on Very Low-Level Waste (VLLW) disposal (see Section A.3.2).
- Continued recovery and disposition of disused sealed sources (see Section A.3.4).
- Continued safe decommissioning of facilities (see Section D.3 and F.6).
- Progress on improvements to the decommissioning process (see Section A.3.7).
- Progress in developing a disposal pathway and regulatory basis for greater-than-class C (GTCC) Low-Level Waste (LLW) disposal (see Sections A.3.8, K.1.2.3, and K.2.2.1).
- Consideration of the challenges and suggestions mentioned in previous Review Meetings and efforts to improve safety (see Section K.2).
- Continued efforts to ensure openness and transparency of the Joint Convention activities (see Section K.4).

A.1 Purpose and Structure

This report satisfies the requirements of the Joint Convention for reporting on policies and practices used to ensure safety of spent fuel and radioactive waste management within the U.S.[2]

This DOE report was prepared by a working group composed of staff from DOE, Department of State (DoS), Environmental Protection Agency (EPA), and 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

[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 previous U.S. National Report.

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

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 are available to the public and are accurate as of June 2020. These uniform resource locators (URLs) may change over time and may become unavailable.

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

Topic	URL
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-2020-title10-vol1/pdf/CFR-2020-title10-vol1.pdf https://www.gpo.gov/fdsys/pkg/CFR-2019-title10-vol2/pdf/CFR-2019-title10-vol2.pdf https://www.gpo.gov/fdsys/pkg/CFR-2020-title10-vol3/pdf/CFR-2020-title10-vol3.pdf https://www.gpo.gov/fdsys/pkg/CFR-2020-title10-vol4/pdf/CFR-2020-title10-vol4.pdf
Protection of the Environment, Title 40	https://www.gpo.gov/fdsys/pkg/CFR-2019-title40-vol2/pdf/CFR-2019-title40-vol2-chapI.pdf https://www.gpo.gov/fdsys/pkg/CFR-2019-title40-vol7/pdf/CFR-2019-title40-vol7-chapI.pdf https://www.gpo.gov/fdsys/pkg/CFR-2019-title40-vol30/pdf/CFR-2019-title40-vol30-chapI.pdf https://www.gpo.gov/fdsys/pkg/CFR-2019-title40-vol34/pdf/CFR-2019-title40-vol34-chapI.pdf https://www.gpo.gov/fdsys/pkg/CFR-2019-title40-vol36/pdf/CFR-2019-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://www.energy.gov/nnsa/national-nuclear-security-administration
Directives, Guidance, and Delegations	https://www.directives.doe.gov
Waste Isolation Pilot Plant	https://www.wipp.energy.gov/
Off-Site Source Recovery Project	https://osrp.lanl.gov

Topic	URL
U.S. Nuclear Regulatory Commission	
Homepage	https://www.nrc.gov/
Regulations	https://www.nrc.gov/reading-rm/doc-collections/cfr/
Regulatory guides	https://www.nrc.gov/reading-rm/doc-collections/reg-guides/
Governing 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	https://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

Topic	URL
Other	
U.S. Department of State: Bureau of International Security and Nonproliferation	https://www.state.gov/t/isn
U.S. Defense Nuclear Facilities Safety Board	https://www.dnfsb.gov/
National Academies	https://www.nationalacademies.org/
National Council on Radiation Protection and Measurements	https://www.ncrponline.org/
U.S. Nuclear Waste Technical Review Board	https://www.nwtrb.gov/
Conference of Radiation Control Program Directors, Inc.	https://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	https://www.usace.army.mil/Media/FactSheets/FactSheetArticleView/tabid/219/Article/816/formerly-utilized-sites-remedial-action-program.aspx
Organization of Agreement States	https://www.agreementstates.org/
Interagency Steering Committee on Radiation Standards	http://www.iscors.org/index.htm
Radiation Source Protection and Security Task Force Report	https://www.nrc.gov/security/byproduct/task-force.html

A.2 Common Issues Identified in the Sixth Review Meeting Summary Report

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

1. Implementation of national strategies for spent fuel and radioactive waste management.
2. Safety implications of the long-term management of spent fuel.
3. Linking long-term management and disposal of disused sealed sources.
4. Remediation of legacy sites and facilities.

A.2.1 Implementation of National Strategies for Spent Fuel and Radioactive Waste Management

The U.S. safely manages spent fuel and radioactive waste at many sites throughout the country and has enacted national legislation to address long-term disposal for this material. Planning, analysis, and research and development (R&D) work to support implementation of consolidated interim storage of commercial spent fuel and deep geologic disposal continues to be conducted by DOE. Progress on specific Federal Government storage or disposal facilities awaits direction and funding from the U.S. Congress.

The U.S. has decades of experience in managing spent fuel and radioactive waste and understands the importance of early and sustainable management strategies. The U.S. develops strategies for spent fuel and radioactive waste 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 the reactor (see Section B.3.1 for additional information). In addition, the U.S. has a policy in place to minimize the generation of waste. When developing a spent fuel and radioactive waste strategy, the U.S. considers several factors including: safety, regulatory requirements, environmental protection, emergency preparedness, need for storage and/or disposal facilities, cost, and schedule.

A.2.2 Safety Implications of the Long-Term Management of Spent Fuel

The U.S. continues the safe and secure storage of spent fuel. The U.S. maintains a policy of direct geologic disposal of spent fuel without reprocessing, although legacy reprocessing wastes exist from research, defense, and limited commercial activities. However, the continuing uncertainty in the repository program and the recent premature retirements of several nuclear power plants (NPPs) require that current attention is focused on ensuring safety in storage. The long-term management of spent fuel in any combination of storage (spent fuel pools or dry cask storage systems) will continue as a licensed activity under regulatory controls and oversight. This situation continues even at the NPPs that are fully decommissioned, save for spent fuel storage.

Nuclear power reactor operator experience with the actual storage of spent fuel under NRC's oversight and regulatory framework, and the continued application of proven fuel storage methodologies ensures spent fuel will be safely managed until a repository for disposal is available. Continued safe storage of spent fuel relies on a strong regulatory framework including both licensee compliance and regulatory oversight. NRC's regulatory framework provides for monitoring and oversight to address the potential for evolving issues. Examples of NRC's response to evolving circumstances, technological advances, and industry initiatives include approval and widespread implementation of dry cask storage systems; the rulemaking on "Continued Storage" (see Section B.3.3 of the Sixth U.S. National Report); and the current efforts to evaluate applications for Consolidated Interim Storage Facilities (CISF), as described in Section A.3.1.3. In addition, industry-led efforts such as the Extended Storage Collaboration Program (ESCP), coordinated by the Electric Power Research Institute (EPRI), are also focused on the safety of continued storage and subsequent transportation of spent fuel (see Section A.3.1.2).

A.2.3 Linking Long-Term Management and Disposal 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 managed safely and securely. Within the U.S., the management may include reuse, recycling, disposal, or storage. Section J of this report provides an overview of the programs in place to manage such sources domestically and internationally, while Section A.3.4 discusses recent progress in activities related to sealed source management.

A.2.4 Remediation of Legacy Sites and Facilities

The U.S. has a mature program for addressing the identification and remediation of legacy sites. For example, the U.S. program includes the Formerly Utilized Sites Remedial Action Program (FUSRAP) for defense-related sites, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), also known as Superfund, for other commercial and government sites, as well as Title 1 of the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) for abandoned uranium mills. In addition, in 1990 the U.S. undertook a program to identify and remediate NRC-licensed sites under the Site Decommissioning Management Plan.[3] Section K.2.3 of this report discusses the U.S. management of legacy sites.

A.3 What is New Since Last Report

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

[3] See https://www.nrc.gov/waste/decommissioning/program-docs.html.

A.3.1 Spent Fuel and High-Level Waste Disposition

A.3.1.1 Yucca Mountain Repository

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

The U.S. believes there should be a path forward towards disposal of spent fuel, and DOE is committed to fulfilling the Federal Government's legal and moral obligations to properly manage and dispose of the nation's spent fuel and HLW. The President's Fiscal Year (FY) 2021 Budget requests appropriations from the Nuclear Waste Fund (NWF) that would prioritize the development and implementation of an interim storage program for nuclear waste. It would lay the groundwork necessary for near-term deployment of interim storage to ensure safe and effective consolidation and temporary storage of spent fuel. Coupled with the funding for spent fuel to support R&D and analysis of storage, transportation, and disposal technologies and pathways, the President's request supports the development of a durable, predictable yet flexible plan that addresses more efficiently storing waste temporarily in the near term, followed by permanent disposal.

A.3.1.2 Department of Energy Research and Development Activities for Spent Fuel and High-Level Waste

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. See Section A.3.1.2 of the Sixth National Report for more information.

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.1.1).

As part of this international coordination, the ESCP is a consortium of organizations coordinated by the EPRI to investigate aging effects and mitigation options for the extended storage of spent fuel, followed by transportation. In November 2019, 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 cask 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. See Section A.3.1.2 of the U.S. Sixth National Report for more information on ESCP.

A.3.1.3 Consolidated Interim Storage of Spent Fuel and Reactor-Related Greater-than-Class C Low-Level Waste

CISFs are facilities proposed for the interim storage of spent fuel and reactor-related GTCC LLW prior to final disposal in a deep geologic disposal facility. The CISFs would be similar to existing Independent Spent Fuel Storage Installations (ISFSIs), providing dry storage of spent fuel with integrated shielding structures. CISFs will be regulated under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 72, and as proposed, would not be co-located with a power reactor.[4]

In April 2016, Waste Control Specialists LLC (WCS) submitted an application to NRC for a specific license to construct and operate a CISF at its site in Andrews, Texas. The dry cask storage system proposed to be used at the site will be an aboveground design. In January 2017, NRC accepted the WCS 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. In April 2017, WCS requested that NRC temporarily suspend all safety and environmental reviews, as well as public participation activities associated with the license application.

WCS was sold in January 2018, and the new applicant, Interim Storage Partners, LLC, requested the review be resumed. As requested, NRC resumed its technical and environmental reviews. NRC received intervention petitions and established an Atomic Safety and Licensing Board to rule on the hearing requests. Matters related to the adjudicatory proceeding remain pending. In May 2020, NRC issued a Draft Environmental Impact Statement (EIS) for Interim Storage Partners, LLC's, Proposed CISF for Spent Nuclear Fuel in Andrews County, Texas.[5] NRC anticipates completing its safety, security, and environmental reviews in 2021.

In March 2017, Holtec International submitted an application to NRC for a specific license to construct and operate the HI-STORE CISF, to be located in Lea County, New Mexico. The dry cask storage system proposed to be used at the site will be a below-grade design. In February 2018, NRC accepted 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. NRC received intervention petitions and established an Atomic Safety and Licensing Board to rule on the hearing requests. Matters related to the adjudicatory proceeding remain pending. In March 2020, NRC issued a Draft EIS for Holtec International's Proposed CISF for Spent Nuclear Fuel and High-Level Waste in Lea County, New Mexico.[6] NRC anticipates completing its safety, security, and environmental reviews in 2021.

The U.S. recognizes nuclear waste storage requires a flexible plan to address an efficient process. To that end, the President's Budget requests would prioritize the development and

[4] Additional information on CISFs may be found at: https://www.nrc.gov/waste/spent-fuel-storage/cis.html.
[5] The document is available at NRC's ADAMS, under ML20122A220.
[6] The document is available at NRC's ADAMS, under ML20069G420.

implementation of an interim storage program for nuclear waste. See Section A.3.1.1 for additional information.

A.3.1.4 Department of Energy Interpretation of the High-Level Waste Definition

DOE currently manages waste that resulted from the reprocessing of spent fuel as HLW. The Atomic Energy Act of 1954 (AEA) and the Nuclear Waste Policy Act of 1982, as amended, (NWPA) define HLW, and the NWPA requires that HLW be permanently disposed of in a deep geological repository. This primarily source-based approach to managing reprocessing waste has constrained DOE from taking important actions to safely and permanently dispose of certain waste streams that would reduce risk to workers and the environment. As a result, on October 18, 2018, DOE issued a *Federal Register* (FR) Notice requesting public comments on DOE's interpretation of the statutory term "High-Level Radioactive Waste." On June 10, 2019, a supplemental FR Notice was issued providing additional clarification of DOE's HLW interpretation based on public comments received.[7] DOE may determine that waste is not "highly radioactive" and is therefore not HLW if the waste:

- Does not exceed concentration limits for Class C LLW as set out in 10 CFR 61.55, and meets the performance objectives of a disposal facility; or
- Does not require disposal in a deep geologic repository and meets the performance objectives of a disposal facility as demonstrated through a performance assessment (PA) conducted in accordance with applicable requirements.

Waste meeting either of these criteria could be classified based on its radiological content and disposed of in accordance with the disposal facility waste acceptance criteria (WAC); allowable radionuclide content; waste form and packaging; and required waste generator certifications and approvals.

DOE's HLW interpretation intends to facilitate safe disposal activities of reprocessing waste based on the radiological characteristics of the waste, and whether it can be disposed of safely in a facility other than a deep geologic repository, regardless of origin or previous categorization. DOE and the commercial nuclear industry have decades of experience with the safe and effective disposal of LLW. This approach aligns the U.S. with international guidelines for the management and disposal of radioactive waste based on radiological risk.

In August 2020, DOE completed an evaluation of the first waste stream under the National Environmental Policy Act (NEPA) for a proposed action applying DOE's HLW interpretation.[8] DOE will continue in the normal course to evaluate its waste inventories and related management and disposal options, and expects to engage openly with stakeholders regarding

[7] See *Request for Public Comment on the U.S. Department of Energy Interpretation of High-Level Radioactive Waste*, 83 FR 50909 (October 10, 2018), and *Supplemental Notice Concerning U.S. Department of Energy Interpretation of High-Level Radioactive Waste*, 84 FR 26835 (June 10, 2019).

[8] Additional information on the application of the HLW interpretation to this waste stream (Savannah River Site Defense Waste Processing Facility recycle wastewater) can be found at: https://www.energy.gov/em/program-scope/high-level-radioactive-waste-hlw-interpretation.

potential future opportunities to apply the HLW interpretation to other specific waste streams. Any potential additional implementation of the HLW interpretation would be evaluated on a waste stream by waste stream basis, and DOE would work closely with local officials, regulators and stakeholders where reprocessing waste is stored and where such waste might be disposed of, before any disposal decisions were made.

A.3.2 Commercial Low-Level Waste Disposal.

The following are some issues government, industry, and others are addressing to facilitate disposal of commercial LLW.

A.3.2.1 Review of Alternative Disposal Requests

On April 9, 2020, NRC issued a final guidance document, “Guidance for the Reviews of Proposed Disposal Procedures and Transfers of Radioactive Material Under 10 CFR 20.2002 and 10 CFR 40.13(a).”[9] This guidance document describes NRC’s process for documenting, reviewing, and approving (on a case-by-case basis) requests for alternative disposals under 10 CFR 20.2002 and 40.13. The term “alternative” is used in this case because pursuant to 20.2002, the licensee or applicant could propose to dispose of the licensed material by a procedure other than those methods provided in the regulations (e.g., an alternative to disposal in a facility licensed under 10 CFR Part 61). This document includes discussion and guidance on the following topics: (1) relevant regulations and guidance documents; (2) the approval process; (3) technical reviews; (4) environmental reviews; (5) coordination and communications with State and Federal agencies; and (6) non-licensee reviews.

A.3.2.2 Very Low-Level Waste Scoping Study

NRC regulations in 10 CFR Part 61 classify LLW in the commercial sector as Class A, Class B, and Class C (see Section B.2.3.2). While VLLW, also known as "low-activity waste (LAW)," is not defined in NRC regulations, it is generally considered to be the lowest portion of Class A waste. NRC is conducting a scoping study to address VLLW management (see Section H.3.1). The purpose of the scoping study is to identify whether the NRC should take actions to strengthen its regulatory framework for 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. Current disposal options for VLLW are at an LLW disposal facility or alternate disposal facility, pursuant to disposal procedures approved under 10 CFR 20.2002 (see Section A.3.2.1), and 10 CFR 20.2003.

The regulatory focus of the scoping study is to develop a framework for accommodating the large volumes of VLLW associated with decommissioning of NPPs. The scoping study will also consider the impact of large quantities of VLLW that would result from cleanup if a radiological

[9] The document is available at NRC’s ADAMS, under ML19295F109.

dispersal device or similar device were used in the U.S. In March 2017, February 2018, and March 2018, NRC held public meetings to receive initial stakeholder comments. NRC is evaluating stakeholder comments, lessons learned from historical VLLW initiatives, and best practices of other countries with respect to VLLW disposal.

A.3.2.3 Depleted Uranium Disposal

Depleted uranium (DU) is a source material as defined by the AEA, and, when declared a waste, would be considered LLW. DOE has a DU inventory and operates facilities to convert DU hexafluoride to a DU oxide conversion product for disposal. Recent DOE efforts to disposition DU oxide include issuing a decision for disposition of DU oxide conversion product generated from the DOE inventory of DU at the Paducah, Kentucky, and Portsmouth, Ohio, sites. If declared waste, DOE may disposition the DU oxide at one or more of the following disposal sites: the Energy*Solutions* LLW disposal facility near Clive, Utah; the WCS LLW disposal facility in Andrews, Texas; and the DOE-owned LLW disposal facility at the Nevada National Security Site (NNSS) in Nye County, Nevada.

Any disposal site(s) must have a current authorization to dispose of DU oxide at the time shipping to the site is initiated. DOE intends to use authorized commercial facilities for initial shipments. Pre-licensing planning by Energy*Solutions* and the State of Utah is underway to develop a new LLW cell for DU and other Federal LLW at the Energy*Solutions* site near Clive, Utah.

A.3.2.4 Revisions to the Uniform Waste Manifest

In June 2020, NRC issued NUREG/BR-0204, Rev. 3, *Instructions for Completing the U.S. Nuclear Regulatory Commission's Uniform Low-Level Radioactive Waste Manifest.*[10] NUREG/BR-0204, Rev. 3, provides updated instructions to reflect changes to the Uniform Manifest forms, updated references to Department of Transportation regulations, and overall improvements to document clarity. This document provides instructions on the use of NRC Form 540 (Uniform Low-Level Radioactive Waste Manifest [Shipping Paper]), NRC Form 541 (Uniform Low-Level Radioactive Waste Manifest [Container and Waste Description]), and NRC Form 542 (Uniform Low-Level Radioactive Waste Manifest [Manifest Index and Regional Compact Tabulation]). NRC Forms 540 and 541 must be prepared for the shipment of LLW intended for ultimate disposal at a licensed LLW land disposal facility. NRC Form 542 is required only if processors and collectors of LLW are shipping LLW attributed to others for disposal at a licensed LLW land disposal facility. The revised document also provides additional discussion on the reporting of inventories based on the lower limit of detection values, the potential use of indirect methods to determine these inventories, the use of indirect methods in waste classification calculations, and other changes.

[10] The document is available at NRC's ADAMS, under ML20178A433.

A.3.3 Federal Low-Level Waste Disposal

Currently, six DOE sites (see Figure D-2) 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. At the Portsmouth site, an LLW disposal facility has been "authorized" and is in the process of being "constructed." In addition, another LLW disposal facility is being planned to support future cleanup and site operations at the Oak Ridge Reservation.

In June 2013, WCS opened the Federal Waste Disposal Facility (FWDF) near Andrews, Texas, which is designed, permitted, and constructed for disposal of Class A, B, and C LLW. The FWDF accepts only waste that is the responsibility of the Federal Government as defined by the Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLWPAA). The FWDF is licensed through September 2024, with provision for 10-year renewals. DOE has signed an agreement to take ownership of the FWDF for perpetual long-term stewardship care after decommissioning and final closure of the FWDF.

A.3.4 Sealed Source Management

Since initiation of the Off-Site Source Recovery Program (OSRP), DOE/National Nuclear Security Administration (NNSA) has recovered over 44000 sources consisting of over 5.3E+16 Becquerel (Bq) of radioactive material that posed a potential risk to national security and/or public health and safety. Additionally, DOE/NNSA has facilitated the recovery of 29000 sources consisting of over 5.2E+13 Bq of radioactive material by working with non-government partners. In total, DOE/NNSA in conjunction with non-government partners has recovered more than 70000 radioactive sealed sources from more than 1600 sites in the U.S. and over 3400 U.S. origin legacy sources have been repatriated from 48 sites in 27 other countries.

From September 2012 through June 2020, 294 recovery shipments of Category 1 and 2 sources have been completed. In addition, DOE/NNSA continues to support states in a nationwide program to recover and commercially dispose of 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 are available for 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. Two additional 435-B containers have since been fabricated. The 380-B container design has also been certified by NRC and fabrication of the first unit was completed in October 2019.

A.3.5 Nuclear Material Return to the United States of America and Russia

DOE/NNSA works in partnership with the International Atomic Energy Agency (IAEA), the Russian Federation, and other nations to remove and protect vulnerable nuclear material

located at civilian sites worldwide. Since the last report, all highly enriched uranium (HEU) has been removed from Argentina, 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.

The original Foreign Research Reactor Spent Nuclear Fuel Acceptance Program (Acceptance Program)—where the U.S. accepted eligible spent fuel and target material containing uranium of U.S. origin—ended on May 12, 2019. The Acceptance Program was successful in meeting the goal of reducing the amount of HEU in civil commerce by returning U.S. origin HEU to the U.S. for secure storage, management, and disposition. To demonstrate continued commitment to nonproliferation goals, the NNSA Administrator signed the Policy on Exemptions to the Acceptance Program ("Policy on Exemptions") on December 22, 2016. This extends a portion of the Acceptance Program through May 12, 2029. Proposed receipts will be considered on a case-by-case basis and undertaken only when there is clear justification to do so. The Policy on Exemptions provides three examples of factors NNSA will consider when deciding whether to grant an exemption:

1. An HEU research reactor is shut down or converted to operate with low-enriched uranium (LEU).

2. A clear nonproliferation justification exists, including the removal of a significant amount of HEU and/or separated plutonium from a nuclear facility.

3. A facility meets the criteria of the Acceptance Program prior to the deadline in 2019 but is unable to complete the shipping campaign for reasons outside of its control.

NNSA will base the length of an exemption, if granted, on the commitment of the country involved to the goals of the Acceptance Program, technical issues related to any reactor conversion to LEU fuel or shutdown, and logistical issues such as transportation and U.S. storage availability. The exemption will be commensurate with the amount, purity, and vulnerability of the material involved. Options for ultimate disposition of the material will also be a factor in determining whether to grant an exemption.

A.3.6 Waste Disposition for Commercial Medical Isotope Production

In support of the national initiative to establish a domestic supply of molybdenum-99 (^{99}Mo), and in accordance with its statutory responsibilities, NRC is responsible for licensing utilization facilities; production facilities; and special nuclear, byproduct, and source material. As such, NRC considers both initial license applications and license amendment requests for nuclear reactors, subcritical operating assemblies, and processing facilities. These technologies may be used for irradiating either molybdenum or LEU targets and processing irradiated LEU targets to separate ^{99}Mo from other fission products. For the technologies within its jurisdiction, NRC is

also responsible for regulating the storage and disposition of waste associated with commercial medical isotope production consistent with applicable laws and regulations.

In February 2016 and May 2018, NRC issued construction permits to SHINE Medical Technologies, LLC (SHINE) and Northwest Medical Isotopes, LLC, respectively, authorizing construction of facilities for production of medical isotopes using LEU.

Subsequently, SHINE submitted an operating license application in July 2019, which was accepted for review by NRC in October 2019. As part of its reviews of these and other applications for medical isotope facilities using LEU, NRC considers the requirements of the NWPA, the American Medical Isotopes Production Act of 2012 (AMIPA), as well as the relevant regulations in 10 CFR. As part of its review of initial license applications, NRC evaluates compliance with Section 302(b)(1)(B) of the NWPA for disposal of high-level radioactive wastes and spent fuel, including an evaluation of any agreements an applicant or licensee may have with DOE for the disposal of high-level radioactive wastes and spent fuel.

However, consistent with Section 3, paragraph (f) of AMIPA, “radioactive material resulting from the production of medical isotopes that has been permanently removed from a reactor or subcritical assembly and for which there is no further use shall be considered low-level radioactive waste if the material is acceptable under Federal requirements for disposal as low-level radioactive waste.” As such, NRC evaluates commercial disposition of radioactive waste for medical isotope facilities consistent with its regulations in 10 CFR Part 20, Subpart K, as part of its reviews of license applications.

In November 2018, NorthStar Medical Radioisotopes (NorthStar) became the first commercial domestic supplier of ^{99}Mo since 1989. NorthStar developed the RadioGenix technetium-99m (^{99m}Tc) generator system for use with low-specific activity ^{99}Mo produced from the irradiation of ^{98}Mo or ^{100}Mo targets. Medical use licensees that possess the RadioGenix generator and are subject to the requirements of 10 CFR Part 35 may hold short half-life radionuclides, such as ^{99}Mo and ^{99m}Tc, for decay-in-storage before disposal without regard to radioactivity. Licensees must perform surveys to verify that the radioactivity cannot be distinguished from background before disposal.

DOE is responsible for planning and carrying out programs for establishing a uranium lease and take-back (ULTB) program associated with ^{99}Mo production. As directed by AMIPA, DOE established the ^{99}Mo ULTB program in January 2016. The ULTB program makes LEU available through lease contracts for the production of ^{99}Mo for medical uses. AMIPA also specifies DOE will (1) retain responsibility for the final disposition of spent fuel, and (2) 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.

A.3.7 Decommissioning Activities

A.3.7.1 Potential Rulemaking on Regulatory Improvements for Nuclear Power Plants 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 Activities Report (PSDAR), and the required timeframes for the various decommissioning methods. Several U.S. NPPs have announced the transition to a decommissioned status earlier than the expected end of operational life of the plant.

On March 15, 2017, NRC published the draft rulemaking regulatory basis for public comment.[11] NRC received more than 1000 comments from stakeholders in every area under consideration in the draft regulatory basis and used these comments to inform the final regulatory basis, which was published on November 27, 2017.[12]

The regulatory basis was used to develop the draft proposed rule package, which is under review by the Commission.[13]

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 in military operations. The Department of Defense (DoD) is actively cleaning up radium contamination, contamination involving other unlicensed radioactive material, and non-radioactive contamination at several sites under CERCLA. To avoid overlapping regulatory oversight at these sites, in 2016 NRC entered into a Memorandum of Understanding (MOU)[14] 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. NRC has dispositioned all the sites that were identified with potential contamination from historical radium use in non-Agreement States. NRC worked with site owners and Federal,

[11] The document is available at NRC's ADAMS, under ML17047A413.
[12] See *Regulatory Improvements for Power Reactors Transitioning to Decommissioning*, 82 FR 55954 (November 27, 2017).
[13] The document is available at NRC's ADAMS, under ML18012A019.
[14] The document is available at NRC's ADAMS, under ML16092A294.

State, and local officials, as needed, to properly disposition the sites to ensure that each site either meets the applicable criteria for unrestricted use or has controls in place to limit access during remediation so that no site poses a risk to public health and safety and the environment. Five of the sites identified had calculated doses from radium contamination that exceed unrestricted use standards, requiring remediation. Moving forward, the effort will be focused on working with the site owners on remediation. Two of the sites have been cleaned up and the remaining three are in various phases of remediation. The AEA provides for the transfer of regulatory authority to individual states to regulate these radioactive materials under specific conditions. These states are referred to as Agreement States (see Section E.2.4.2 for more information on Agreement States). As of September 30, 2019, more than half of the Agreement States had completed their investigation activities, had dispositioned all the sites on their lists, and had no further plans for additional investigations. The remaining Agreement States continue to conduct prioritized reviews of the sites within their jurisdictions, focusing on the most risk-significant sites.

A.3.7.3 Power Plant Acquisitions for Decommissioning

NRC has a robust regulatory framework, licensing, and oversight for power reactor decommissioning. The regulations in 10 CFR 50.82 require that power reactor decommissioning be completed within 60 years of permanent cessation of operations. This may be accomplished through prompt decommissioning (DECON) or it may include extended periods of inactivity (SAFSTOR), during which residual radioactivity is allowed to decay, making eventual cleanup easier and more efficient. Over the last decade, the models for accomplishing decommissioning have expanded to include the transfer of the facility license to a decommissioning company, either temporarily or permanently. Currently, power reactor licensees are following one of four decommissioning models:

1. The Licensee Model: The licensee for the reactor when it was operating maintains the license in decommissioning and performs the decommissioning (e.g., Humboldt Bay). The licensee could be an electric utility or a merchant plant.

2. The Decommissioning Contract Model: The licensee for the reactor when it was operating maintains the license in decommissioning and manages a decommissioning contractor (e.g., Fort Calhoun, San Onofre).

3. The Temporary License Transfer Model: The licensee for the reactor when it was operating requests a transfer of the license to a decommissioning company for accelerated decommissioning. At the completion of the decommissioning, the license and property are transferred back to the original licensee for spent fuel management (e.g., Zion, La Crosse).

4. The Permanent License Transfer Model: The licensee for the reactor when it was operating requests a transfer of the license as part of an asset sale of the NPP, associated land, and spent fuel to a decommissioning company for accelerated

decommissioning and spent fuel management (e.g., Vermont Yankee, Oyster Creek, Pilgrim).

Recently, NRC has seen an increase in the number of license transfer requests for plants entering or in decommissioning and, as a result, an increase in the number of plants moving into active decommissioning under accelerated schedules. NRC reviews both the financial and technical qualifications of the decommissioning company to ensure that they meet all applicable regulatory requirements.

A.3.7.4 Local Community Advisory Board Best Practices

Section 108 of the Nuclear Energy Innovation and Modernization Act,[15] signed into law on January 14, 2019, requires NRC to provide a report to the U.S. Congress identifying best practices for establishing and operating local community advisory boards, including lessons learned from existing boards. These boards are aimed at fostering communication and information exchange between NRC licensee and members of the community that decommissioning may affect.

As part of developing the report, NRC hosted 11 public meetings in the vicinity of reactors and two webinars to consult with host States, local government organizations, communities within the emergency planning zone of a nuclear power reactor, existing local community advisory boards, and similarly situated external stakeholders.

The final report was issued to Congress in July 2020.[16]

A.3.8 Greater-than-Class C Low-Level Waste Disposal

In February 2016, DOE issued the Final EIS for the Disposal of GTCC LLW 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 Waste Isolation Pilot Plant (WIPP) geological repository (see Section D.2.2.1). The Final EIS does not constitute a decision on GTCC LLW disposal.

In November 2017, DOE submitted the *Alternatives for the Disposal of Greater-Than-Class C Low-Level Radioactive Waste and Greater-Than-Class C-Like Waste Report to Congress*, as required by Section 631 of the EPAct05. This Report to Congress provides an overview of the disposal alternatives for GTCC LLW and GTCC-like waste that were analyzed in the Final EIS. The Report to Congress noted that DOE is primarily considering disposal in generic commercial

[15] See Pub. L. 115-439, § 108, 132 Stat. 5565, 5577-79 (2019).
[16] The document is available at NRC's ADAMS, under ML20113E857.
[17] See http://www.gtcceis.anl.gov/documents/index.cfm. GTCC-like is a term used by DOE to describe radioactive waste that is owned or generated by DOE (including LLW and non-defense transuranic (TRU) waste) and has characteristic similar to those of GTCC LLW.

facilities. In accordance with the EPAct05, DOE must await Congressional action before making a final decision on disposal for GTCC LLW.

In October 2018, DOE issued the Environmental Assessment (EA) for the Disposal of GTCC LLW and GTCC-Like Waste at WCS, Andrews County, Texas. The EA provides a site-specific analysis of the potential environmental impacts of disposing the entire inventory—12000 cubic meters (m^3)—of GTCC LLW and GTCC-like waste at WCS.

In July 2019, NRC issued, for public comment, a draft regulatory basis evaluating the suitability of certain categories of GTCC LLW for near-surface disposal.[18] See Section K.1.2.3 for additional information.

A.3.9 United States of America 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 Sixth 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.

[18] See *Greater-Than-Class-C and Transuranic Waste*, 84 FR 35037 (July 22, 2019).

Table A-3. Overview of U.S. Spent Fuel and Radioactive Waste Management[19]

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.2.2, A.3.1, B.3.1, B.3.2, G.1, G.3, G.7, K.2.1.	The Standard Contract between utilities and DOE for the disposal of spent fuel requires utilities to pay fees into the NWF 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 was 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. Acceptance of foreign and domestic research reactor fuel. See Sections A.2.2, A.3.5, B.2.2, 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, B.3.1, B.3.2, D.1.2, G, K.1.3, K.2.1.
Nuclear fuel cycle wastes (all LLW included in Non-Nuclear fuel cycle wastes for brevity)	HLW: See above. Uranium and thorium recovery sites: Near-surface disposal. See Sections A.3.2, B.4, E.2.2.4.	All: Producer pays. Uranium and thorium recovery sites: Long Term Surveillance Fund. Financial assurance required by license. See Section F.2.3.3.	HLW: See above. Uranium and thorium recovery sites: Near-surface disposal locally. See Sections B.2.3.2, B.4, D.2.2.3, E.2.1.1, E.2.2.4, F.4.2.5, H.4, Annex D-3 (uranium and thorium).	HLW: See above. Uranium and thorium recovery sites: additional license applications expected. See Sections B.4., D.2.2.3.

[19] 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[19]

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.3.1.4, A.3.2, A.3.8, B.1, B.2.3.2, B.4, K.1.2, K.2.2.1.	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 A.3.2, A.3.3, 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, K.2.2.1, Annexes D-2A and D-2B.	Defense HLW Disposal: See above. Additional Defense HLW Treatment Facilities. GTCC LLW final EIS completed; DOE sent report to Congress as required by law and awaits Congressional action prior to implementation of a Record of Decision for GTCC LLW Disposal. NRC issued, for public comment, a draft regulatory basis evaluating the suitability of certain categories of GTCC LLW for near-surface disposal. See Sections A.3.8, D.2.1, K.2.2.1.
Decommissioning liabilities	NPPs: Decontamination & Decommissioning (D&D) to be completed within 60 years. Defense, uranium and thorium recovery and other sites: Based on risk. See Sections B.5, D.3, E.2.1.4, F.6, F.7.2, H.3.1.	NPPs: D&D fund required by law. Non-legacy Sites: Producer pays. Defense sites: Public funds for defense liabilities. See Sections F.2.3.4, F.2.3.5.	Large number of facilities undergoing decommissioning/ remediation. See Sections A.3.7, 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[19]

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.2.3, A.3.4, A.3.8, B.1, B.2.2, J.	(1) Licensee; or (2) Government, if disposed by government in support of public health, safety, or national security. See Sections A.3.4, J.	Disposal at commercial disposal sites and government sites. Storage of sources onsite by licensees pending disposal. OSRP. Source Collection and Threat Reduction Program. See Sections A.3.4, B.2.2, D.2.2, I.1, J.	GTCC LLW disposal EIS and report to Congress completed; by law, DOE must await Congressional action prior to implementation. NRC issued, for public comment, a draft regulatory basis evaluating the suitability of certain categories of GTCC LLW for near-surface disposal. See Sections A.3.4, A.3.8, D.2.2, K.1.2.3, K.2.2.1.

B. POLICIES AND PRACTICES

This section summarizes U.S. policies and practices for spent fuel and radioactive waste management and related nuclear activities.

B.1 United States of America 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.

NRC is an independent agency authorized to regulate the commercial sector and certain government nuclear facilities. NRC regulates the possession and use of nuclear materials, as well as the siting, construction, operation and decommissioning 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.[20]

NRC is also responsible for licensing commercial nuclear waste management facilities, independent spent fuel storage facilities, and disposal facilities for HLW and spent fuel. Agreement States can regulate commercial nuclear waste management facilities but cannot regulate storage or disposal of HLW, including spent fuel. See Section E.2.4.2 for further information on Agreement State authorities.

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 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

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

transuranic (TRU) waste. EPA promulgates standards for and certifies compliance at the WIPP for disposal of defense-generated TRU waste. EPA standards, under the Clean Air Act (CAA), 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 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 from domestic and foreign research 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 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 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 NWPA defines "spent nuclear fuel" (spent fuel) as fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which 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. Uranium or thorium 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.[21] NRC and Agreement States also have jurisdiction over certain categories of naturally occurring radioactive materials (NORM) and Technologically Enhanced NORM (TENORM). 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.[22] 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. Existing NRC regulations at 10 CFR 61.55 specify criteria for classifying LLW for land disposal at a near-surface facility. The original development of 10 CFR 61.55 did not explicitly consider the impacts resulting from the disposal of unique waste streams, such as significant quantities of DU metal from the operation of a commercial uranium enrichment facility. When 10 CFR Part 61 was initially developed, no commercial facilities were generating significant quantities of DU waste streams. The analysis only

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

[22] 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 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.

considered the limited amount and types of uranium-bearing waste streams being typically disposed of by licensees at the time.

NRC has 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. In 2009, NRC began developing a rulemaking (i.e., proposed revisions to 10 CFR Part 61) to specify a requirement for a site-specific analysis and associated technical requirements for waste streams containing significant quantities of DU.

The proposed rule was published on March 26, 2015.[23] NRC is also proposing guidance with the rule that, when combined with existing guidance, would provide acceptable methods for demonstrating that the requirements of the proposed rule, if promulgated, would be met. See Section K.1.2 for additional information. Table B-1 below provides commercial waste classes.

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

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	In accordance with 10 CFR 61.55(a)(2)(ii), Class B waste must meet more rigorous requirements on waste form than Class A waste to ensure stability after disposal. The physical form and characteristics of Class B waste must meet both the minimum and stability requirements set forth in 10 CFR 61.56.
Class C LLW	In accordance with 10 CFR 61.55(a)(2)(ii), Class C waste 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.[24]

[23] See *Low-Level Radioactive Waste Disposal, Proposed Rule*, 80 FR 16082 (March 26, 2015).
[24] 10 CFR 40.4.

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 10 nanocuries per gram [370 Bq/g], or in such other concentrations as NRC may prescribe to protect the public health and safety." [25] The AEA definition differs from DOE's definition of TRU waste which is derived from the Waste Isolation Pilot Plant Land Withdrawal Act, as amended (WIPP LWA), which define TRU waste as "waste containing more than 100 nanocuries [3700 Bq] of alpha-emitting TRU isotopes per gram of waste, with half-lives greater than 20 years, except for: (A) high-level radioactive waste; (B) waste that [DOE] has determined, with the concurrence of [EPA], does not need the degree of isolation required by the disposal regulations; or (C) waste that the [NRC] has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61." In NRC's regulations, at 10 CFR 61.2, the definition of LLW specifically excludes TRU waste.[26] However, in SRM-SECY-15-0094,[27] the Commission directed NRC staff to undertake a rulemaking to address TRU waste in 10 CFR Part 61. NRC is in the process of revising its regulations in 10 CFR Part 61 to recognize the current International Commission on Radiological Protection (ICRP) recommendations, to allow for site-specific analyses, and to accommodate disposal of previously unanticipated waste streams.

NRC regulations in 10 CFR Part 61 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 CFR Part 61 do not provide specific limitations on concentration averaging. NRC developed the *Concentration Averaging and Encapsulation Branch Technical Position Revision 1* (CA BTP) Vols. 1 and 2, which was published in February 2015. 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 WAC of a commercial facility accepting Class A waste. 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.

[25] 42 U.S.C. § 2014(ee).

[26] 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 an LLW facility pursuant to Table 1 in 10 CFR 61.55.

[27] The document is available at NRC's ADAMS, under ML15356A623.

DOE does not use the 10 CFR Part 61 classification system except when the waste is disposed of in a 10 CFR Part 61 facility or a facility licensed under the Agreement State regulatory counterpart to 10 CFR Part 61.[28] Radioactive waste owned or generated by DOE is classified as HLW, TRU waste, or LLW.[29] In addition, DOE manages large quantities of uranium mill tailings and other residual radioactive material.[30] Radioactive waste may also contain a hazardous waste component subject to the Resource Conservation and Recovery Act (RCRA). Waste with both a radioactive waste component and a non-radioactive hazardous waste component in the U.S. is called "mixed" waste (mixed LLW or mixed TRU waste).

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 EPAct05 to include discrete sources of ^{226}Ra, accelerator-produced radioactive material, and certain NORM as described in AEA sections 11e.(3) and 11e.(4).[31] When determined to be waste, 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 DOD entered into an MOU in 2016.[32] The MOU is intended to minimize the dual regulation of military environmental remediation sites under both CERCLA (see Section D.3.4) and AEA while ensuring the protection of public health, safety, and the environment. See additional information in the U.S. Sixth National Report, Section B.2.3.3.

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 the general license. Non-U.S. origin disused sealed sources generally do fall within the regulatory definition of radioactive waste. Accordingly, import into the U.S. of foreign-origin disused sealed sources can generally only be accomplished by a specific license. See Sections I and J.1 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

[28] Currently, there are four operating LLW land disposal facilities in the U.S. See Section D.2.2.2.

[29] DOE considers LLW to be radioactive waste that is not spent fuel, HLW, TRU waste, or byproduct material as defined in 42 U.S.C. §§ 2014(e)(2)-(4). See DOE O 435.1 Section 4-1.

[30] This residual radioactive material was the result of the Manhattan Project and the Nation's early atomic energy program and is managed under Title I of UMTRCA. See Section D.2.2.3.

[31] 42 U.S.C. §§ 2014(e)(3)-(4).

[32] The document is available at NRC's ADAMS, under ML16092A294.

and individual states have jurisdiction. Other types of extraction mining and refinement operations for metals and phosphates, may concentrate naturally occurring radionuclides in tailings materials. NRC licenses mineral extraction processes when the extraction process results in the use, or concentration of material above 0.05 percent by weight of source material, for example, rare earth processers have been licensed. 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 and manages spent fuel from commercial NPPs, defense activities, and research reactors. As of June 2020, 95 licensed commercial reactors operating at 56 NPP sites 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.[33] All operating NPPs are storing spent fuel in NRC-licensed onsite spent fuel pools and all but three NPPs are storing spent fuel in NRC-licensed 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 cask storage systems at licensed NPPs, under either a 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 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 three years, no new specific licenses for ISFSIs have been issued; however, there is one new general licensee (South Texas Project in January 2019) authorized for storing spent fuel in dry cask storage systems at current or former NPP sites.

As of June 2020, six renewal applications for dry cask storage system certificates of compliance (CoCs) (HI-STAR 100, HI-STORM 100, Standardized Advanced NUHOMS®, TN-32, TN-68, and

[33] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1650.

NAC-MPC) and one ISFSI specific license (GE-Hitachi Morris Operation ISFSI) are under review. NRC has issued renewals for two dry cask storage system certificates of compliance and 12 ISFSI specific licenses. The current NRC regulations provide that storage casks can be initially licensed for up to 40 years with possible renewals of up to 40 years, with no restriction on the number of renewals. At present, there are a total of 73[34] separate ISFSIs, including four that have both general and specific licenses. Thirty-four states have at least one ISFSI.

There are approximately 2500 MTHM of SNF stored in DOE-managed facilities in either wet or dry storage facilities. DOE manages spent fuel from defense activities and domestic and foreign research reactors, and limited quantities of spent fuel from commercial activities in wet pools and dry storage facilities. Most of this spent fuel is stored at Savannah River Site, Hanford Site, Idaho National Laboratory, and Fort St. Vrain prior to further disposition. DOE continues to receive spent fuel from foreign and domestic research reactors. The original program for receipt of foreign research reactor spent fuel ended in 2019. To demonstrate commitment to nonproliferation goals, a portion of the Acceptance Program was extended through May 12, 2029. Proposed receipts will be considered on a case-by-case basis and undertaken only when there is clear justification to do so. No date has been set for completing receipt of spent fuel from domestic research reactors.

B.3.2 Spent Fuel Disposal

The 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 for disposal.
- 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.

Each Federal agency makes an independent decision with respect to NWPA assigned roles and responsibilities and available information; however, the Federal agencies, consistent with the roles and responsibilities, are allowed to exchange information on the relevant issues to ensure each agency's views and potential concerns are understood.

DOE's license application includes its designs and procedures for the development of the repository and how its approach complies with NRC regulations. NRC's safety review is based on the information provided in DOE's license application; however, NRC can request additional information from DOE if needed to complete the review. See Section A.3.1 for the current

[34] NRC has licensed an ISFSI at Private Fuel Storage and Idaho Spent Fuel Facility. However, neither ISFSI has been constructed or operated and the total of 73 does not include the two ISFSIs. This count reflects a shared ISFSI for Hope Creek and Salem NPPs.

status of U.S. spent fuel and HLW disposition, including the status of the Yucca Mountain Application Review.

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. Also, wastes are often treated to reduce the final disposal volume through compaction and incineration. If the waste is being disposed in an 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 commercial LLW at one of the four currently licensed commercial LLW near-surface disposal facilities (i.e., a land disposal facility where radioactive waste is disposed within the upper 30 meters of the earth's surface).[35] 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 Class C LLW.[36] 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 ^{99}Mo).

The LLWPAA assigned responsibility for the disposal of GTCC LLW to the Federal government. Currently, there are no facilities licensed to accept GTCC LLW for disposal. NRC has developed a draft regulatory basis for GTCC LLW disposal at licensed facilities. See Section A.3.8 for more information.

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 past 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 (Savannah River Site, Hanford Site, and Idaho National Laboratory).

Uranium recovery is the extraction or concentration of uranium from any ore processed primarily for its source material content.[37] The uranium recovery processes result in wastes that typically contain relatively low concentrations of radioactive materials associated with the natural

[35] See footnote 28 above which discusses the current four operating LLW land disposal facilities.

[36] 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.

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

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 the classification of radioactive waste. For conventional mills, the waste is primarily the onsite disposal of tailings (residual ore after the uranium was leached).

UMTRCA (Public Law 95-604) amended the AEA for the purpose of providing long-term stabilization, control, and disposal of uranium mill tailings or wastes that result from the extraction or concentration of uranium from any ore processed primarily for its source material content.[38] UMTRCA classifies such uranium mill tailings or wastes as a form of byproduct material. In this regard, UMTRCA amended the AEA by adding this category of byproduct material to the definition of byproduct material, specifically AEA Section 11e.(2). 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.

Under section 275 of the AEA[39] (added by UMTRCA), EPA sets generally applicable standards for Title I and Title II uranium recovery facilities. NRC, or the appropriate Agreement State, implements the generally applicable standards and is responsible for licensing and regulating the uranium recovery facilities.[40] The facility closure 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 typically transferred to a governmental entity for long-term care. For ISR facilities, no tailings are generated and as such, no permanent surface disposal options are licensed.

The product from uranium recovery facilities is enriched to enhance the fissile content. Tailings containing 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 has been and continues to be a resource for a variety of applications and uses.

Currently, DOE and commercial corporations (e.g., 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 of in DOE or commercial LLW disposal facilities, provided the waste meets the facilities' waste acceptance requirements. See Section B.2.3.2 for more discussion of management of DU as LLW.

[38] See https://www.energy.gov/sites/prod/files/2018/12/f58/UMTRCAFactSheet.pdf.

[39] 42 U.S.C. § 2114. 2022.

[40] NRC's authority under UMTRCA is primarily set forth in AEA Section 84 (42 U.S.C. § 2114). If NRC promulgates regulations to carry out its responsibilities under Section 84, Agreement States must then promulgate compatible regulations.

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 in Section B.2.3.2. See Section F.6 for additional information.

Applicants for licenses are required to describe how facility design and procedures will facilitate eventual decommissioning.[41] NRC has published regulatory guidance in Regulatory Guide (RG) 4.21, *Minimization of Contamination and Radioactive Waste Generation: Life Cycle Planning*, June 2008, for implementing this requirement.[42] 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, in addition to 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. Agreement States regulate some of these activities (see Section E.2.4.2 for information on Agreement States authorities). NRC regulates and oversees these processes to ensure that stakeholders are informed and involved in the process. Each year, NRC terminates approximately 100 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 (see Section D.3.3 for additional information).

[41] Regulations are stipulated in 10 CFR 20.1406.

[42] The document is available at NRC's ADAMS, under ML080500187.

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C. SCOPE OF APPLICATION

This section covers the application of the Joint Convention in the 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, 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 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. See the U.S. Sixth National Report at Section B.3.4 for additional information.

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 AEA. NRC regulates 11e.(3) and 11e.(4) byproduct material under 10 CFR Part 30. These materials include discrete sources of ^{226}Ra and other NORM, as well as accelerator-produced material. Certain concentrations and quantities are exempt from the regulations.[43] 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. However, spent fuel and radioactive waste from military programs fall within the Joint Convention when transferred for permanent disposal in facilities operated by DOE.

U.S. military programs are primarily in DoD and 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 the authority to regulate military ^{226}Ra contamination resulting from discrete sources of ^{226}Ra if ^{226}Ra is no longer used or intended for

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

use in military operations. Spent fuel and radioactive waste in military programs are managed in accordance with the 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 scope of 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 a waste generator collects their own LLW for shipment or processing before sending it to a treatment or disposal facility. This includes facilities such as NPPs, 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 and any associated LLW inventory, 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 U.S. nuclear power industry has generated approximately 84000 metric tons (MT) heavy metal (MTHM) of spent fuel as of the end of 2019. Of this, 39000 MTHM is in dry storage at NPP sites. Most of the 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. DOE's inventory of spent fuel is approximately 2500 MTHM. Spent fuel storage facilities include those used to store defense-related spent fuel, and U.S. and foreign 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. The length of time that spent fuel resides in wet storage varies based on the specific NPP facility. In general, spent fuel cools for a minimum of three to five years in wet storage, and then each NPP facility strives to maintain at least one full core off-load of fuel pool storage capacity. However, not all spent fuel generated in the U.S. is from power production reactors. DOE spent fuel is also stored in either wet pool or dry storage systems. Approximately 13% (volume) DOE-owned spent fuel is stored in wet storage facilities. DOE wet storage facilities are mainly used as long-term storage facilities until final disposition becomes available. In general, for DOE wet storage facilities, the water serves as shielding to protect workers from radiation. Research reactors also have wet storage facilities at the reactor. Once the spent fuel cools down, the spent fuel is transported to a DOE spent fuel storage facility. Dry cask 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.[44] 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.[45] Spent fuel storage cask designers, manufacturers, and licensees must comply with the quality assurance (QA) requirements in 10 CFR Part 72, Subpart G. 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.

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

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 ISFSI and HLW storage facilities.

NRC regulations in 10 CFR Part 72 provide a general license to store spent fuel in dry cask 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 cask storage systems potential licensees may consider. These systems have CoCs 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.

D.1.2 Spent Fuel Disposal

The U.S. currently has no facility for spent fuel disposal. In 2008, DOE applied to NRC for authorization to construct a geologic repository at Yucca Mountain, Nevada, for spent fuel and HLW disposal. The adjudication on the application is suspended.

Table D-1. Spent Fuel Storage Facilities

Function	Number of Facilities[46]	Inventory[47]	Units	Annex
Government				
Wet Storage	8	30	MTHM	D-1A
Dry Storage[48]	6	2413	MTHM	D-1A
University Research Facilities				
Wet Storage	20	1161	kg HM	D-1B
Dry Storage	0	0	kg HM	D-1B
Other Research and Nuclear Fuel Cycle Facilities				
Wet Storage	3	36	kg HM	D-1C
Dry Storage	1	44	kg HM	D-1C
Onsite Storage at NPPs[49]				
Wet Storage	62	45065	MTHM	D-1D
Dry Storage	70	39207	MTHM	D-1D

[46] 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.
[47] See relevant Annex for data sources and inventory dates.
[48] This includes NRC-licensed facilities at Idaho National Laboratory, Fort St. Vrain in Colorado, and wet and dry storage at the Sandia National Laboratory.
[49] This includes ISFSIs for dry storage of spent fuel located at shutdown or operating NPPs. It also includes the GE-Hitachi Morris ISFSI which is not located at an NPP site but provides wet storage for NPP spent fuel.

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

D.2 Radioactive Waste Management

The U.S. systematically plans, documents, executes, and evaluates radioactive waste management activities. The U.S. takes these measures to protect workers, the public, and the environment from exposure to radiation from radioactive materials. Through compliance with applicable Federal, State, Tribal, and local laws and regulations, as well as with applicable Executive Orders and other DOE directives, the U.S. has requirements in place for safely managing radioactive waste.

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 humans and the environment. The U.S. does not commonly make a distinction between "treatment" and "conditioning," although the distinction is made 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. 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.[50] Annex D-2B also includes a listing of waste processors.[51]

[50] 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.

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

Table D-2. Radioactive Waste Storage and Treatment Facilities						
Sector	**Function**	**Material Type**	**Number[52]**	**Inventory**	**Units**	**Annex**
Government	Storage/ Treatment	HLW	6	3.50E+05	m^3	D-2A
		TRU	11	3.85E+04	m^3	D-2A
		LLW[53]	17	1.20E+05	m^3	D-2A
		11e.(2)	1	1.99E+05	m^3	D-2A
		Sealed Sources	2	1.99E+03	Containers/ Sources	D-2A
Commercial/ Other	Treatment/ Processing	LLW	74	Small volumes for collection		D-2B
	Storage	GTCC LLW	Multiple ISFSIs	1.30E+02	m^3	D-2B

DOE is building the world's largest radioactive waste treatment plant at the Hanford Site in southeastern Washington State. The facility, called the Waste Treatment and Immobilization Plant, will be used to treat defense waste from reprocessing, stored for decades in 177 large underground tanks. The waste processed through these facilities will be vitrified and the molten glass 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, Section D.2.1.3.

DOE also has managed or is constructing large treatment facilities for tank waste at the Idaho National Laboratory and the Savannah River Site. At the Idaho National Laboratory, 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 the 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 National Laboratory, allowing closure of the four remaining underground tanks.

Tank waste continues to be treated at Savannah River Site. 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.

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

[53] This includes MLLW.

In addition, treatment and certification of TRU waste continue at multiple DOE sites in preparation for disposal. Large treatment facilities are operating, for example, the Transuranic Waste Processing Center at Oak Ridge. Some of the other sites processing TRU waste include Argonne National Laboratory, Los Alamos National Laboratory, Hanford Site, and Savannah River Site. 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 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.

D.2.2.1 Transuranic Waste Disposal

WIPP is a geologic repository used to safely and permanently dispose TRU waste generated by atomic energy defense activities.[54] WIPP began operations on March 26, 1999, after more than 20 years of scientific study, public input, and regulatory review.

WIPP is located in southeastern New Mexico, about 42 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).

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. Over 7.0E+04 m^3 TRU waste was emplaced as of January 31, 2020. Additional information on these events can be found in the U.S. Sixth National Report.

[54] More information on WIPP can be found at https://wipp.energy.gov.

Table D-3. Radioactive Waste Disposal Facilities						
Sector	**Facility Type**	**Waste Type**	**Number**	**Inventory**	**Units**	**Annex**
Government	Geologic Repository (WIPP)	TRU	1	9.81E+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[55]	18	1.77E+07	m^3	D-2A
				1.35E+02	Reactor Compartments	D-2A
Commercial	Operating Near-Surface Disposal	LLW (Class A, B, C)	4	5.28E+06	m^3	D-2B
		AEA Section 11e.(2)	2	1.53E+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	2.30E+08	Dry MT[56]	D-3
Commercial	Title II UMTRCA Disposal[57]	AEA Section 11e.(2)	45			D-3
Government	Other Closed Disposal Cells (Weldon Spring Site and Monticello)	Residual Radioactive Material (tailings)	2	3.03E+06	m^3	D-2A

[55] Includes MLLW.

[56] Annex D-3 reports additional quantities in units other than dry MT.

[57] This includes 15 ISR and resin recovery facilities.

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 LLW disposal sites are in Agreement States and are licensed by their respective states. The Agreement State's regulatory programs are subject to NRC's Agreement State program oversight. 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 accepts radium and other NORM and accelerator-produced radioactive waste without compact restrictions.
- Energy*Solutions* (Clive, Utah) – with some restrictions, accepts Class A LLW and Mixed Low-Level Waste (MLLW) from LLW generators throughout the country. For example, Class A LLW from the Northwest and Rocky Mountain Compact states can only be accepted with Compact approval.
- WCS (near Andrews, Texas) – accepts Class A, B, and C LLW from generators within the Texas Compact (Texas and Vermont). LLW from generators outside the Texas Compact is accepted for disposal by approval of the Compact. WCS accepts waste from both commercial and government generators with separate disposal facilities for each.

There are four closed commercial LLW sites: 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.[58]

NRC or the appropriate Agreement State is responsible for regulating the receipt, possession, storage, and disposal of commercial LLW regardless of the radioactive waste concentrations. The default disposal pathway for commercial LLW is disposal at one of the four land disposal facilities currently licensed by Agreement States. NRC regulations also 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 LAW. Figure D-2 depicts the location of U.S. LLW and MLLW disposal sites. MLLW is LLW that also contains a hazardous (non-radiological) waste component.

[58] For additional detail on commercially-disposed LLW, refer to https://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 generally processed solely for sale to the U.S. Government. Groundwater remediation is ongoing at several UMTRCA Title I sites. Residual radioactive material, rather than radioactive waste, is the term used to describe radioactive uranium mill tailings from the original operations at Title I sites. This material 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 conventional UMTRCA Title II facilities are or have been licensed and consist of conventional uranium mills and other related facilities. Thirty-three facilities are located within and regulated by Agreement States.[59] Seven Agreement States (Colorado, Illinois, Texas, Utah, Washington, Ohio, and Wyoming) license AEA Section 11e.(2) byproduct material. NRC regulates the remaining 12 facilities, which are located in Nebraska, New Mexico, Wyoming (the ANC site was not transferred when Wyoming became an Agreement State) and South Dakota.[60] 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

Uranium 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.[61] Although there are about 4000 mines with documented production, a

[59] NRC is required to determine applicable standards and requirements have been met before termination of the licenses at sites located in Agreement States.

[60] The WNI Sherwood Site in the state of Washington is regulated under NRC general license to DOE for long-term surveillance.

[61] Unless otherwise noted, this information can be found at https://www.epa.gov/radiation/tenorm-uranium-mining-wastes.

database compiled by EPA with information from other Federal, State, and tribal governmental lands, includes 15000 mine locations, mostly in 14 western states.[62]

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 ore bodies. There were no conventional mines and five ISR facilities operating at the end of 2018 according to DOE's Energy Information Administration.[63] Mining of uranium ores by surface and underground methods produces large amounts of radioactive waste material classified as NORM or TENORM, including overburden, un-reclaimed sub-economic ores (protore),[64] "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.[65] 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.

[62] EPA, *Uranium Location Database Compilation*, EPA 402-R-05-009, August 2006.

[63] Energy Information Administration, *2018 Domestic Uranium Production Report*, May 2019. See https://www.eia.gov/uranium/production/annual/pdf/dupr.pdf.

[64] 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.

[65] EPA, *Technologically Enhanced Naturally Occurring Radioactive Materials from Uranium Mining; Vol. 1: Mining and Reclamation Background*, EPA 402-R-08-005, Revised April 2008. https://www.epa.gov/sites/production/files/2015-05/documents/402-r-08-005-v1.pdf.

Table D-4. Summary of Decommissioning Activities in Progress		
Sector	**Type**	**Number**
Government	DOE Nuclear/Radioactive Facilities for which Decommissioning is Ongoing or Pending	842
Government/ Commercial	Formerly Utilized Sites Remedial Action Program	23[66]
	Decommissioning Materials Sites Regulated by NRC	12
	Decommissioning Material Sites in NRC Agreement States	30
Commercial	Nuclear Power Plants	24
	Other Non-Power Reactor Facilities	3
	Uranium Recovery Facilities (NRC)	5
	Uranium Recovery Facilities (Agreement States)	15

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 R&D 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,[67] 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.

[66] U.S. Army Corps of Engineers, *Formerly Utilized Sites Remedial Action Program Update*, 2018.
[67] See https://energy.gov/em/cleanup-sites.

D.3.2 Formerly Utilized Sites Remedial Action Program

FUSRAP began in 1974 to identify, investigate, and clean up or control sites where the Manhattan Engineer District and later, the Atomic Energy Commission (AEC), 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 identified by DOE or assigned by Congress. FUSRAP sites are distinct from the formerly licensed facilities addressed in Section H.1.2.[68] 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 when remediation is completed.[69] The contaminants at FUSRAP sites are primarily low levels of uranium, thorium, and radium, and 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, FUSRAP sites are also considered complex material decommissioning sites and are also listed in Annex D-5.

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 12 sites,[70] located in nine states. See Section F.6.1 for additional information.

As of September 30, 2019, 24 nuclear power and early demonstration reactors, 3 research and test reactors, 12 complex materials sites, 1 fuel cycle facility, and 5 Title II uranium recovery facilities are undergoing non-routine decommissioning. In addition, 20 UMTRCA Title I and 6 Title II sites are in long-term care and maintenance by DOE, with NRC oversight or under NRC jurisdiction pursuant to a general license issued under 10 CFR 40.27 and 40.28. Annex D-5 provides a list of these "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,[71] including specific status information for each complex site.

[68] Additional FUSRAP information can be found at: https://www.usace.army.mil/Missions/Environmental/FUSRAP/.

[69] 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 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/.

[70] In June 2019, Centrus withdrew its request to terminate the Lead Cascade license. In September the NRC confirmed that the site met the 10 CFR Part 20 limits and approved the cancellation of the Lead Cascade decommissioning fund. Annex D-5 does not include the Lead Cascade facility

[71] See https://www.nrc.gov/waste/decommissioning.html.

Currently, 12 of the 39 Agreement States are regulating the decommissioning of 30 complex materials sites, with technical support from NRC's regional offices, as needed.[72] 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 three 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 per 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 is one fuel cycle facility undergoing partial decommissioning—the Nuclear Fuels Services site in Erwin, Tennessee.

In FY2018, NRC terminated the materials license for the Westinghouse Electric-Hematite site in Festus, Missouri, and the operating license for the State University of New York at Buffalo research reactor in Buffalo, New York. In FY2019, NRC terminated the materials license for the General Atomics facility in San Diego, California. See Section D for additional radioactive waste and spent fuel management specific information.

D.3.4 Environmental Protection Agency Site Remediation

EPA remediates radiologically-contaminated sites using its CERCLA authority. Under the same authority, it can also require "potentially responsible parties" to clean up or fund the clean-up of those sites. Since the passage of CERCLA in 1980, 60 radiologically-contaminated sites have been placed on the National Priorities List (NPL) for CERCLA (out of 1760 sites listed, 1335 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 40 of the radiologically-contaminated sites. Radiologically-contaminated NPL sites have included uranium mines, DOE facilities, NRC licensees, and sites being addressed through FUSRAP.

[72] See https://www.nrc.gov/about-nrc/state-tribal/agreement-states.html.

E. LEGISLATIVE AND REGULATORY SYSTEMS

E.1 Legislative System

The policy on regulatory control of radioactive waste management in the U.S. has evolved through a series of laws establishing Federal responsibility 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[73] 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: NRC regulates the commercial nuclear sector; EPA establishes environmental standards; and DOE regulates its own government programs. NRC has regulatory authority over spent fuel, special nuclear material sufficient to form a critical mass, and HLW. Some states[74] assume the regulatory authority over certain (1) byproduct materials (as defined in AEA section 11e.),[75] (2) source materials, and (3) special nuclear materials in quantities not sufficient to form a critical mass through NRC's Agreement State program. These states are referred to as Agreement States (see Section E.2.4.2). The regulatory authority that can be discontinued by NRC and assumed by an Agreement State includes the regulation of commercial LLW disposal sites, uranium mill tailings sites, and the disposal of uranium mill tailings. Some states also have regulatory authority delegated to them by EPA, under various statutes such as the Clean Water Act and the CAA, such as for discharges from some industrial or mining activities. These are referred to as EPA Authorized States (see Section E.2.4.1).

The general regulations for the three Federal agencies primarily responsible for radioactive waste regulation are contained in 10 CFR (for NRC and DOE) and 40 CFR (for EPA). U.S. Government regulations are developed and promulgated through notice and comment rulemaking under the Administrative Procedure Act, in which the public has the opportunity to comment on proposed rules. Both the proposed rule and the final rule are published in the *Federal Register*. Links to specific regulations and other information for each agency are provided in Table E-1.

DOE Orders are internal directives that function similarly 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.

[73] See https://energy.gov/em/downloads/fourth-national-report-joint-convention-safety-spent-fuel-management-and-safety.
[74] AEA section 274n. defines the term "State" to mean "any State, Territory, or possession of the United States, the Canal Zone, Puerto Rico, and the District of Columbia." 42 U.S.C. § 2021(n).
[75] 42 U.S.C. § 2014(e).

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 that were previously distributed among several other agencies, including NRC's and DOE's common predecessor, the AEC.

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
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/

Table E-1. Spent Fuel, Radioactive Waste, and Disused Sealed Sources Management Regulations, Guidance, and Communications

U.S. Department of Energy
For DOE Directives, refer to https://www.directives.doe.gov/ 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:
Policy 226.1B, *Department of Energy Oversight Policy* Policy 450.4A, *Integrated Safety Management Policy* Policy 454, *Use of Institutional Controls* Order 151.1D, *Comprehensive Emergency Management System* 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* Order 422.1, *Conduct of Operations* Order 425.1D, *Startup and Restart of Nuclear Facilities* Order 426.2, Personnel Selection, Training, Qualification and Certification Requirements for DOE Nuclear Facilities Order 430.1C, Real Property Asset Management Order 433.1B, *Maintenance Management Program for DOE Nuclear Facilities* 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 462.1, *Import and Export of Category 1 and 2 Radioactive Sources and Aggregated Quantities.* Guide 421.1-2A, *Implementation Guide for Use in Developing Documented Safety Analyses to Meet Subpart B of 10 CFR 830* Guide 423.1-1B, *Implementation Guide for Use in Developing Technical Safety Requirements* Guide 424.1-1B, *Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements*

Table E-1. Spent Fuel, Radioactive Waste, and Disused Sealed Sources Management Regulations, Guidance, and Communications
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#airstandards
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
40 CFR Part 191, *Environmental Radiation Protection Standards for Management and Disposal of Spent 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/public-health-and-environmental-radiation-protection-standards-yucca-mountain-nevada-40
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/national-primary-drinking-water-regulations 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/superfund/superfund-regulations 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 by Congress from the former AEC under Title II of the Energy Reorganization Act of 1974, as amended.[76] In accordance with the AEA, NRC is responsible for ensuring the protection of public health and safety and promoting 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.
- Certain DOE activities and facilities over which Congress has provided NRC licensing and related regulatory authority.

NRC regulates the 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 the management and disposal of LLW, HLW, spent fuel, and D&D of 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.

Inspection and enforcement are important aspects of NRC's regulatory program. NRC has four regional offices that inspect licensed facilities in their regions, including nuclear waste facilities.[77] 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

NRC is responsible for planning and implementing regulatory programs under UMTRCA (see Section B.4 for general overview of UMTRCA). UMTRCA amended the AEA to require EPA to issue generally applicable standards for controlling uranium mill tailings or wastes. 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 I, must evaluate DOE designs and concur that DOE actions

[76] 42 U.S.C. §§ 5841 *et seq*.
[77] Specific information on NRC regional offices can be accessed at: https://www.nrc.gov/about-nrc/organization.html.

meet standards set by EPA when decommissioning is completed. NRC and DOE have an MOU to clarify their roles and responsibilities and to minimize or eliminate duplication of effort between the two agencies.[78]

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 applies to sites regulated by NRC or Agreement States. NRC's implementing regulations are in 10 CFR Part 40 and 10 CFR Part 40, Appendix A, and implement the generally applicable standards that EPA established. NRC has authority under Title II to control radiological and non-radiological hazards and to ensure NRC-licensed and Agreement State-licensed sites meet all standards and requirements during operations and before termination of licenses. NRC reviews, evaluates, and either approves or disapproves uranium milling license applications (including amendments and renewals), regulates decommissioning and facility closures, and implements EPA standards for the protection of groundwater that may be potentially impacted by uranium milling activities. NRC also reviews annual surety updates to ensure that sufficient funds are secured for decommissioning such sites.

NRC 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 ISR process. On October 30, 2018, EPA withdrew its proposed rule. NRC staff has recommended restarting a proposed rulemaking effort that would establish risk-informed regulatory requirements that specifically address ISR activities. The recommendation is under review by the Commission.

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 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. 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

[78] DOE, *Memorandum of Understanding between the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission*, GM04-85AL26037, November 1990.

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 (see Sections D.2.2.2 and E.2.4.2 for more information), based on NRC health and safety regulations governing waste disposal quantities, forms, and activity levels (10 CFR Part 61). The 10 CFR Part 61 regulations establish the procedures, criteria, and terms and conditions for the issuance of licenses for land disposal of LLW. Four performance objectives, including protection of an individual who may inadvertently intrude into the waste disposal site after the period of active institutional controls, define the overall level of safety to be demonstrated by the licensee.[79]

The classes of LLW (Class A, Class B, Class C, and GTCC) are defined in 10 CFR 61.55 (see Table B-1 of this report). The LLWPAA assigns to the States the responsibility for the disposal of LLW generated within their borders (except for certain waste generated by the Federal Government). The LLWPAA authorizes 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 NPP decommissioning and license termination. Depending on the type of site, decommissioning requirements are included in 10 CFR Parts 30, 40, 70, and 72. Subpart E of 10 CFR Part 20, 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 be in place to address the unique features associated with the different types of sites and activities involved in the decommissioning.[80] A unique consideration for decommissioning in the U.S. is a timeliness provision; i.e., specific time periods for decommissioning various licensed 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.

[79] 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 after closure. 10 CFR Part 61, Subpart C.

[80] See https://www.nrc.gov/waste/decommissioning/reg-guides-comm/regulations.html.

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,*[81] and NUREG-1700, Rev. *2, Standard Review Plan for Evaluating Nuclear Power Reactor License Termination Plans,*[82] NUREG-1620, *Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act of 1978*,[83] and NUREG-1623, *Design of Erosion Protection for Long-Term Stabilization*.[84] For additional information on these activities, please refer to past issues of the U.S. National Report and the *Status of the Decommissioning Program 2019 Annual Report*.[85] 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 RG 4.22, *Decommissioning Planning during Operations*, December 2012. Additional information on NRC's decommissioning approach is provided in Section F.6.1.

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

Integrated Materials Performance Evaluation Program (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.
- Technical Quality of Incident and Allegation Activities.

Additional areas are identified as non-common performance indicators (Legislation, Regulations, and Other Program Elements, 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

[81] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1757.
[82] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1700/.
[83] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1620/.
[84] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1623/.
[85] See https://www.nrc.gov/waste/decommissioning.html.

lessons learned, which are made available to all regulatory programs.[86] 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 WIPP LWA, as amended, requires EPA to issue final regulations for disposal of spent fuel, HLW, and TRU waste. The WIPP LWA also gives EPA authority to develop criteria implementing final WIPP radioactive waste disposal standards. The WIPP LWA also specifies that every five years EPA must determine 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 CAA and the Solid Waste Disposal Act.

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 qualitative 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 in 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 fourth Compliance Recertification Application in 2019.

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

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 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 WIPP also contains hazardous waste components, subjecting it to the regulations developed under RCRA.

EPA conducts inspections of both TRU waste generators and WIPP operations. Separate inspections may be conducted for waste characterization activities, QA, 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. DOE submitted a draft *WIPP Hazardous Waste Facility Permit Ten-Year Renewal Application* in March 2020.

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. See Section A.3.1 for the current status of U.S. spent fuel and HLW disposition, including the status of the Yucca Mountain Application 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.
- 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.

EPA has also established the National Emission Standards for Hazardous Air Pollutants (NESHAPs) Program 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.[87] 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 millisievert per year (mSv/yr) 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 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 CERCLA 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 an 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.[88]

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

[88] 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.

- Coordinating with state radiation protection agencies to protect the environment, workers, and the public from NORM exposed or concentrated by mining or processing.
- Coordinating with DOE, NRC and states on orphaned sources, recycled materials, and controlling imports to prevent radioactively contaminated scrap from entering the U.S.[89] 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, DOE Standards), and external recommendations by the Defense Nuclear Facilities Safety Board (DNFSB). The major applicable Federal regulations include 10 CFR Part 820,[90] 10 CFR Part 830,[91] and 10 CFR Part 835[92] (see Section F.4.3.).

DOE also regulates facility operations and radiation protection through standards and requirements that complement the established DOE Orders. The major applicable Orders include DOE O 458.1[93] (see Section F.4.3) and DOE O 435.1.[94] Table E-1 provides a list of spent fuel and radioactive waste management Federal regulations and DOE Orders.

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)[95] 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

[89] Coast Guard and DHS 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.
[90] See https://www.gpo.gov/fdsys/granule/CFR-2011-title10-vol4/CFR-2011-title10-vol4-part820.
[91] See https://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title10/10cfr830_main_02.tpl.
[92] See https://www.gpo.gov/fdsys/granule/CFR-2011-title10-vol4/CFR-2011-title10-vol4-part835.
[93] See https://www.directives.doe.gov/directives-documents/400-series/0458.1-BOrder.
[94] See https://www.directives.doe.gov/certification-memos/doe-o435.1-1chg1-and-m435.1-1chg1-certification.
[95] See https://energy.gov/ehss/environment-health-safety-security.

with Department of Labor (DOL) Occupational Safety and Health Administration (OSHA) and NRC on health and safety regulation reviews and pending regulatory reform.

DOE Office of Enterprise Assessment[96] 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 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, cybersecurity, emergency management, environment, safety, and health.
- Conducting independent reviews of DOE sites, facilities, organizations, and operations in the areas of safety and emergency management.
- 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.

Oversight activities are further described in DOE O 227.1A[97] and DOE O 226.1B.[98]

The Low-Level Waste Disposal Facility Federal Review Group (LFRG)[99] 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 PAs, composite analyses (CA), 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.

[96] See https://www.energy.gov/ea/office-enterprise-assessments.
[97] See https://www.directives.doe.gov/directives-documents/0227.1-BOrder.
[98] See https://www.directives.doe.gov/directives-documents/0226.1-BOrder-b.
[99] See https://energy.gov/em/low-level-waste-disposal-facility-federal-review-group-lfrg.

DOE's Office of the General Counsel (and the NNSA 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

In 1988, Congress established the DNFSB as an independent Federal organization within the executive branch of the U.S. Government. It is responsible for providing recommendations and advice to the President and the Secretary of Energy, regarding public health and safety issues at DOE defense nuclear facilities. It also provides independent analysis to the Secretary of Energy, the operator and regulator of DOE defense nuclear facilities, responsible for providing adequate protection of public health and safety at such 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 works to ensure adequate safety measures are taken at all DOE Defense Nuclear Facilities for workers at these DOE sites and members of the public who may be affected by being located in close proximity to sites that contain hazardous nuclear materials.

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 FY2005, NRC has a consultation and monitoring role over reprocessing waste 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 reprocessing waste determined not be HLW can be treated as LLW. After the Secretary's determination, NRC and the state monitor DOE disposal actions of this waste 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.

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 by the dates specifying that

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.[100]

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 (NAS) 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 discontinue portions of its regulatory authority over certain types of radioactive material and allow individual states to assume this authority. The authority to regulate more complex facilities such as NPPs cannot be discontinued by NRC and assumed by Agreement States. Regional NRC and EPA offices allow closer coordination of regulated activities that are not close to a regulator's headquarters location. These arrangements are not required if the State can demonstrate adequate competencies for its program.

[100] 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 NESHAP's 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 and 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 June 2020, 39 of the 50 states have entered into agreements with NRC. These states are called Agreement States. NRC and the Agreement States work together as co-regulators to ensure the uniform protection of public health and safety across the U.S. from the use of radioactive materials. Collectively, this collaborative effort between NRC and Agreement States is referred to as the National Materials Program.

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.[101] The state will adopt compatible legislation and regulations in accordance with their legal system. The state will also develop a program that includes procedures, licensing, inspection, 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 authority similar to NRC for the regulation of agreement materials and facilities within the state, while NRC retains overall program review authority.

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 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 maintain compatibility with NRC's program. See Section E.2.1.5 on NRC's IMPEP.

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[102] and the Conference of Radiation Control Program Directors, Inc.,[103] 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.

[101] The process by which a state becomes an Agreement State is described in https://www.nrc.gov/about-nrc/state-tribal/become-agreement.html.
[102] See https://www.agreementstates.org/.
[103] See https://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.
- QA.
- Operational radiation protection.
- Emergency preparedness.
- 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.
- Facility operation.

See additional background and specific information in the U.S. Sixth National Report, Section F.[104]

Sections G and H of this report address these same areas plus Articles 10 and 17 of the Joint Convention for Disposal of Spent Fuel and Institutional Measures after Closure. Section G provides additional information specific to management of spent fuel, while Section H focuses on management of 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.

F.1 License Holder Responsibilities (Article 21)

The Joint Convention specifies each Contracting Party must ensure the prime responsibility for the 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. NRC and Agreement State regulations ensure licensees are responsible for the safe management of radioactive waste. NRC regulations

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

ensure licensees are responsible for the safety of 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[105] through two regulatory frameworks, one for LLW disposal (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 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 FY2021 Congressional Budget Justification.[106]

Table F-1. Distribution of the Nuclear Regulatory Commission's Full-Time Equivalent as Submitted within the Fiscal Year 2021 Congressional Budget Justification

Budgeted Program	FTE Requested
Nuclear Reactor Safety	1755
Nuclear Materials and Waste Safety	462
Corporate Support	588
Inspector General	63
Total	**2868**

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 462 FTEs. Approximately 80 FTEs or 17 percent are allocated to oversight and enforcement activities.

[105] On January 19, 2001, the Utah Radiation Control Board granted Energy*Solutions* Utah an exemption to the state and Federal land ownership rule.

[106] The document is available at NRC's ADAMS, under ML20024D764.

Table F-2. Nuclear Regulatory Commission Staffing for Materials and Waste Management	
Regulatory Program[107]	**FTEs Requested for FY2021**
Fuel Facilities	73
Nuclear Materials Users	201
High Level Waste Repository	0
Spent Fuel Storage and Transportation	102
Decommissioning and LLW	86
Materials and Waste Safety Total	**462**
Oversight (includes Enforcement)	**FTEs Requested for FY2021**
Spent Fuel Storage and Transportation	13
Decommissioning and LLW	21
Nuclear Materials Users	46
Oversight Total	**80**

NUREG-2220, Vol. 3,[108] provides financial and summary performance information in accordance with Office of Management and Budget Circular A-136, "Financial Reporting Requirements." This report is an account of NRC's stewardship of its resources during FY2019, which covers the period from October 1, 2018, to September 30, 2019. This report is part of a larger effort to implement openness and transparency in NRC's program performance and financial management information.[109]

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 may be 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. The U.S. Sixth National Report at Section F.2 discusses in detail the issues of staffing, staff development, reliability of funding, and other human resource areas, as this was a theme for all Contracting Parties to address during the Sixth Cycle of the Joint Convention.

[107] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1100/v32/.

[108] The document is available at NRC's ADAMS, under ML19322A345.

[109] Additional detailed information on NRC's approach to open government is accessible at: https://www.nrc.gov/public-involve/open.html.

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 to ensure the licensee's staff is competent to engage in the licensed activities. The licensee must additionally conduct a personnel training program and 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.[110]

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.[111] 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 applicants seeking to operate commercial LLW facilities must be sufficient to demonstrate that the applicant's financial qualifications are adequate to carry out the activities for which the license is sought and to meet other financial obligations (e.g., the requirement in 10 CFR 61.63 to ensure that sufficient funds will be available to cover the costs of monitoring and any required maintenance during the institutional control period). 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. See the Sixth National Report at Section F.2.3.1 for additional information.

[110] See https://energy.gov/em/downloads/fourth-national-report-joint-convention-safety-spent-fuel-management-and-safety.
[111] See https://energy.gov/ehss/worker-health-safety-policy-guidance-reports/federal-technical-capability-program-ftcp.

Currently, all operating commercial LLW disposal sites are located in and licensed by Agreement States. Agreement States with licensed, operating commercial LLW disposal sites have promulgated regulations that are compatible with NRC's financial surety requirements at 10 CFR 61.62 and 61.63. The surety requirements ensure 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 license 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 NWPA requires utilities having a contract with DOE for the disposal of spent fuel or HLW to pay fees into the NWF sufficient to cover the costs associated with disposal activities for spent fuel and HLW. Funds in the NWF are to be used for purposes of waste management disposal activities under titles I and II of the NWPA including non-generic research, development, and demonstration activities under the Act. All utilities in the U.S. that generate or possess spent fuel from civilian nuclear power reactors have contracts with the Federal government for the disposal of the commercial spent fuel.

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 the provision at 10 CFR 72.22 for specific licensees to be financially qualified to construct, operate, and eventually decommission their ISFSIs. The provision in 10 CFR 72.30 requires funds to be available for future decommissioning activities for both ISFSI specific and general licensees. Specific and general licensees develop ISFSI decommissioning funding plans, which include decommissioning cost estimates and information on how funds will be available for decommissioning, and provide them to NRC for review. NRC regulations at 10 CFR 72.30 also require that specific and general licensees update their decommissioning funding plans every third year during operations. NRC reviews the updated decommissioning funding plans. Financial mechanisms used include prepayment, surety, insurance or other guarantee methods, government statement of intent, and external sinking fund.

F.2.3.3 Uranium Recovery Waste Management Facilities

NRC regulations (and applicable Agreement State 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 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 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.
- 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 $250000 (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.[112] 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 for in the surety amount. This process yields a surety sufficient to cover the current costs of decommissioning and reclamation of the areas expected to be disturbed.

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’s decommissioning planning and financial assurance

[112] 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).

requirements[113] cover aspects of licensee operations to minimize or prevent future legacy sites.[114] 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.[115]

NRC regulations at 10 CFR 20.1406 specifically require that new applications describe how design and operations will minimize contamination and facilitate eventual decommissioning. NRC's financial assurance and decommissioning planning regulations focus on ensuring that licensees have adequate financial assurance to complete decommissioning and that licensees have an adequate groundwater monitoring program in place and will implement measures to minimize groundwater contamination. 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, Section II, 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*.[116]

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 and 10 CFR 50.82. 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, an external sinking fund, a surety, insurance, or other guarantee, a statement of intent (only for Federal, State, or local government licensees), a contractual obligation, or a combination of these methods, which are described in 10 CFR 50.75(e)(1). 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 or the prepayment of funds methods to provide for their decommissioning financial assurance.

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

[113] 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.
[114] Lessons learned from NRC's experiences in decommissioning can be accessed at: https://www.nrc.gov/waste/decommissioning/lessons-learned.html.
[115] See https://www.nrc.gov/waste/decommissioning/process.html.
[116] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1757/v3/index.html.

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 annual 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, power reactor licensees report their decommissioning fund status biennially and, within 5 years of the projected end of operations and thereafter, report their decommissioning fund status annually. Additionally, at or about 5 years prior to the projected end of operations, power reactor licensees are required to submit a preliminary site-specific decommissioning cost estimate, which includes an up-to-date assessment of the major factors that could affect the cost to decommission. And, in accordance with 10 CFR 50.82(a)(4), prior to or within 2 years following permanent cessation of operations, power reactor licensees are required to submit a PSDAR to NRC, and a copy to affected state(s). The PSDAR must contain a description of the planned 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 EISs, and a site-specific decommissioning cost estimate, including the projected cost of managing irradiated fuel. Power reactor licensees must make up any funding shortfalls identified in decommissioning fund status reports or as a result of decommissioning cost estimates.

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 for an LLW disposal facility needs to provide specific technical information that demonstrates NRC's performance objectives and the other regulatory requirements in 10 CFR Part 61 will be met. This 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."[117]

Guidance to applicants on how to meet the QA regulatory requirements in 10 CFR Part 61 is provided in NUREG-1293, Rev. 1, *Quality Assurance Guidance for a Low-Level Radioactive Waste Disposal Facility*, April 1991.[118] The criteria in NUREG-1293 are similar to the criteria in 10 CFR Part 50, Appendix B. In addition, 10 CFR Part 20, Appendix G, requires any licensee who transfers radioactive waste to a land disposal facility or a licensed waste collector shall conduct a QA program to ensure compliance with 10 CFR 61.55 and 10 CFR 61.56 (waste classification and waste characteristics).

The QA program for storage of spent fuel, HLW, and reactor related 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.*[119] The QA requirements for packaging and transportation of licensed radioactive material are provided in 10 CFR Part 71, Subpart H. NRC 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.[120]

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

[117] See 10 CFR 61.12(j).
[118] The document is available at NRC's ADAMS, under ML11242A180.
[119] The document is available at NRC's ADAMS, under ML012600315.
[120] The document is available at NRC's ADAMS, under ML14064A505.

10 CFR 50.82(b) and guidance is available in NUREG-1757, *Consolidated Decommissioning Guidance: Decommissioning Process for Materials Licensees*.

NRC has internal procedures in place to control the quality of its technical research and regulatory activities. NRC's Management Directives System contains policies and procedures that govern the agency's system of internal NRC functions.[121] Management Directives are drafted by subject-matter experts, undergo internal administrative and policy review, and are approved for issuance by agency management. Additionally, NRC's Office of Inspector General (OIG) performs audits and investigations designed to promote economy, efficiency, and effectiveness within NRC, and to prevent and detect fraud, waste, abuse, and mismanagement in agency programs and operations. OIG recommends corrective actions to be taken and reports on progress made in implementing those actions.

F.3.2 Department of Energy Quality Assurance

Most DOE activities are subject to QA requirements found in DOE Orders and other regulations. DOE regulatory requirements are specified at 10 CFR Part 830, Subpart A, *Quality Assurance Requirements*.[122] DOE programs must also implement the QA criteria specified in DOE O 414.1D, Chg 1, *Quality Assurance*, 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 NAS/National Research Council, the NWTRB[123] (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 Nuclear and Radiation Studies Board's focus includes waste management and disposal.

[121] See https://www.nrc.gov/reading-rm/doc-collections/management-directives/.
[122] See https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=0ff13ff88267ae6eb5baf5d8d5cca9cc&mc=true&n=pt10.4.830&r=PART&ty=HTML#sp10.4.830.a
[123] See www.nwtrb.gov.

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.

Primary radiation protection regulations for spent fuel management include 40 CFR Parts 190 and 191.

Another radiation protection regulation related to 40 CFR Part 191, pertaining to TRU waste (not spent fuel) management at DOE's WIPP geologic repository, is found in 40 CFR Part 194. 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. Most recently, in August 2019 EPA issued Federal Guidance Report No. 15 (FGR 15), *External Exposure to Radionuclides in Air, Water and Soil*. FGR 15 updates and expands upon the 1993 FGR 12, providing age-specific reference person effective dose rate coefficients for 1252 radionuclides. FGR 15 incorporates six different age groups and other updates as recommended by ICRP. 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.[124] Specific dose limits are provided in Table F-3.

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. These regulations include requirements for:

- Dose limits for radiation workers and members of the public.
- Surveys and monitoring.
- Respiratory protection and to restrict internal exposure in restricted areas.
- Radiation criteria for license termination.
- Storage, control and labeling of radioactive materials.
- Posting radiation areas.
- Radioactive waste disposal.
- Recordkeeping.
- Reporting, including for the theft or loss of radioactive material.
- Tables of individual radionuclide exposure limits.

[124] For key radiation protection guidance documents, see https://www.epa.gov/radiation/federal-guidance-radiation-protection.

NRC regulates commercial nuclear power generation, as well as medical, academic, and industrial uses of radioactive material.[125] NRC promulgates safety regulations expressed in annual total effective dose equivalent (TEDE),[126] as well as air and liquid effluent release concentrations. See Table F-3 for occupational and public health protection standards.

In all aspects of its radiation protection program, NRC relies upon the "as low as reasonably achievable" or ALARA standard. Under the ALARA standard, each licensee must make every reasonable effort to reduce both occupational and public doses as far below the specified limits as is practical, taking into account the state of technology and economic and other factors.[127]

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)). Additionally, table 1 in Appendix B of 10 CFR Part 20, sets forth occupational dose limits, by radionuclide, for inhalation (annual limits on intake and the derived air concentrations).

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.[128] An example of this information is provided in Figure F-1 that provides historical TEDEs for ISFSIs.[129] In accordance with 10 CFR 72.106, the limit is 0.05 sievert (Sv)/yr.

F.4.2.2 Public Dose Limits

NRC's regulations concerning public dose limits are in 10 CFR Part 20, Subpart D. NRC requires that each of its licensees conduct its operations such that the total effective dose

[125] 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.
[126] 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.
[127] NRC defines ALARA as "making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest." 10 CFR 20.1003.
[128] NRC's REIRS for Radiation Workers are accessible at http://www.reirs.com.
[129] This document is published as NUREG-0713, *Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities* 2018, Vol. 40, NRC, March 2020, available at: https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0713/.

equivalent to individual members of the public does not exceed 0.1 rem (1 mSv) in a year.[130] This dose limit is exclusive of the dose contributions from background radiation, from any medical administration that the individual has received, from exposure to individuals administered radioactive material and released under 10 CFR 35.75, from voluntary participation in medical research programs, and from the licensee's disposal of radioactive material into sanitary sewerage in accordance with 10 CFR 20.2003. Public individual dose limits are provided in Table F-3.

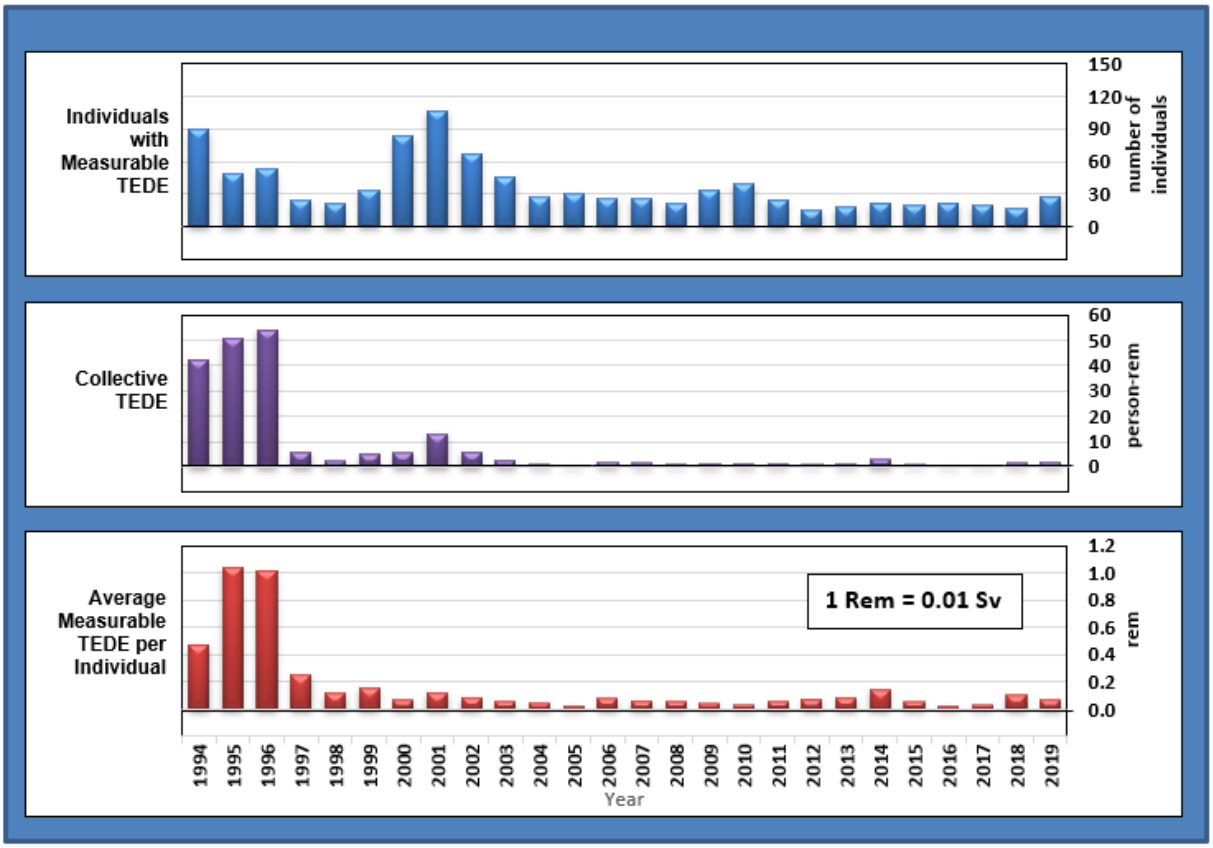

Figure F-1. Average Annual Values at Independent Spent Fuel Storage Facilities, 1994-2018.

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).

[130] See 10 CFR 20.1301(a)(1).

F.4.2.4 Low-Level Waste Disposal Sites

Under 10 CFR 61.41, doses to members of the public due to releases from an 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. See Table F-3 for specific applications of dose.

F.4.2.5 Uranium Mill Tailings Disposal Sites

Uranium mill tailings disposal sites are subject to the requirements set forth in 10 CFR Part 40, Appendix A, including site and design criteria and a requirement for emplacing a final radon barrier on uranium mill tailings piles or impoundments, at the end of uranium milling operations, such that levels of release of radon-222 do not exceed 20 pCi/m^{2}s (0.699 Bq/m^{2}s) when averaged over the entire pile or impoundment.[131] See Table F-3 for dose limits associated with uranium mill tailings disposal sites. The 20 pCi/m^{2}s (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. Appendix A also has several groundwater protection requirements, including the Criterion 5C groundwater concentration limits for certain radionuclides and other hazardous constituents.

F.4.3 Department of Energy Radiation Protection

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 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 O 458.1 Chg 3 establishes the requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of DOE pursuant to the AEA of 1954, as amended. DOE-STD-1196-2011, *Derived Concentration Technical Standards*,[132] is a DOE Standard that supports the implementation of 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).

[131] See 10 CFR Part 40, App. A, Criterion 6(4).
[132] See https://energy.gov/sites/prod/files/2013/06/f1/DOE-STD-1196-2011.pdf.

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])[133] 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, Standards, and Manuals.

F.4.3.1 Dose to Maximally Exposed Individual and Collective Dose to the Public Around DOE Sites

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. Offsite individual doses (for all pathway doses) or Maximally Exposed Individual (MEI) remain well below the 100 mrem (1mSv) annual all sources and pathway dose limit, the 25 mrem (0.25 mSv) all pathways dose constraint for DOE sources, and EPA's NESHAPs compliance limits [10 mrem/yr (0.1 mSv/yr)]. Figure F-2 provides the average dose to an MEI reported for years 2015 through 2018, showing that the average dose over the years to an MEI from all DOE sites, are less than 0.7 mrem/yr (0.007 mSv/yr).

[133] See http://web.ead.anl.gov/resrad/home2/.

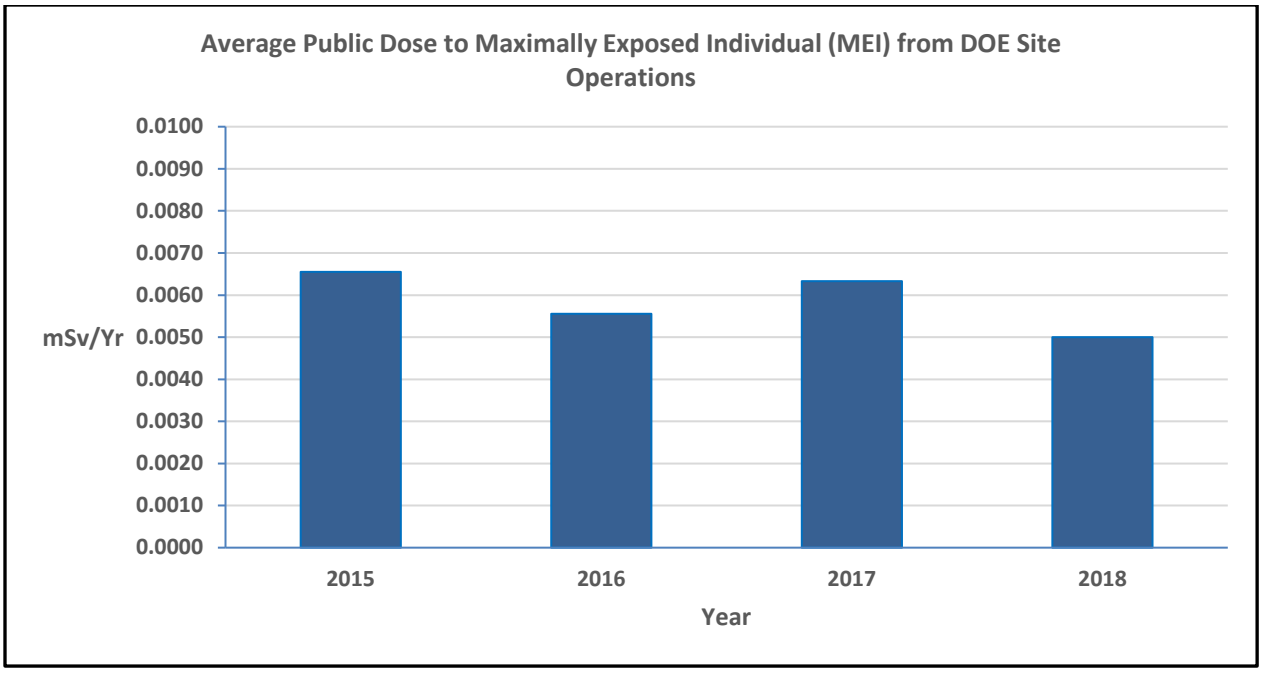

Figure F-2. Average Public Dose to Maximally Exposed Individual from DOE Site Operations.

Public collective doses to the regions surrounding each site are also evaluated at 80 km (50 miles) from each site. Figure F-3 shows the historical trend for public collective doses at all DOE sites combined.

To put the estimated public annual collective dose around DOE sites in perspective, the collective background dose from exposure to natural sources of radiation in the U.S. (9.33E5 person-Sv[134] [9.33E7 person-rem]) is at least 5 orders of magnitude greater than the highest collective doses resulting from DOE site emissions (0.75 person-Sv [75 person-rem] [Figure F-3]). For later years the collective dose is reduced to even lower values below 0.69 person-Sv (69 person-rem).

[134] NCRP Report No. 160, *Ionizing Radiation Exposure of the Population of the United Sates*, 2009.

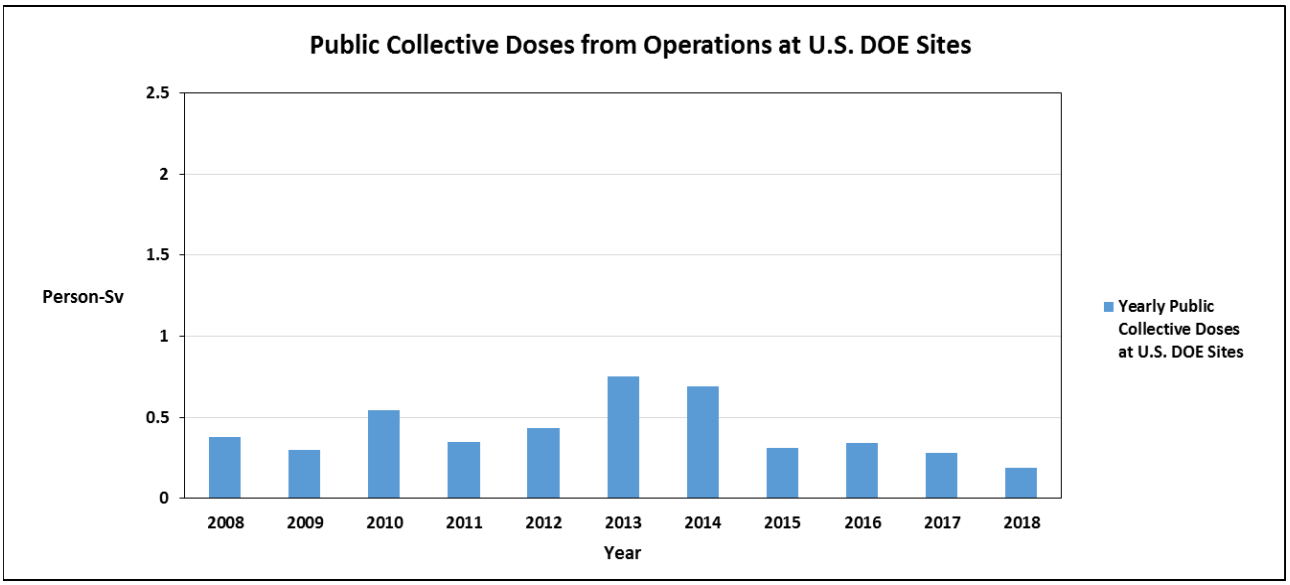

Figure F-3. Public Collective Doses from Operations at U.S. DOE Sites.

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. Less than 15 percent (11587 out of 76000) of DOE workers monitored for radiation dose received a measurable dose between 2010 and 2018.

Figure F-4 shows the average of the measurable total effective dose received by DOE workers for the period from 2010 to 2018. No individual DOE worker exceeded the 20 mSv/yr (2 rem/yr) administrative limit required by DOE regulatory requirements, and average annual total effective dose (TED) equivalent was less than 0.74 mSv/yr (0.074 mrem/yr) for all DOE workers for year 2015. To place DOE worker dose in perspective, the average American receives approximately 6.2 mSv/yr from natural and manmade sources.[135] The majority of DOE workers with a measurable dose between 2008 and 2018, received on average less than 0.64 mSv/yr (0.064 mrem/yr) TED equivalent. Thousands of people work in radiation areas every day without receiving significant radiation exposure, which may be attributable to the effectiveness of ALARA controls.

[135] National Council on Radiation Protection and Measurements, *Ionizing Radiation Exposure of the Population of the U.S*, Report No. 160, 2009.

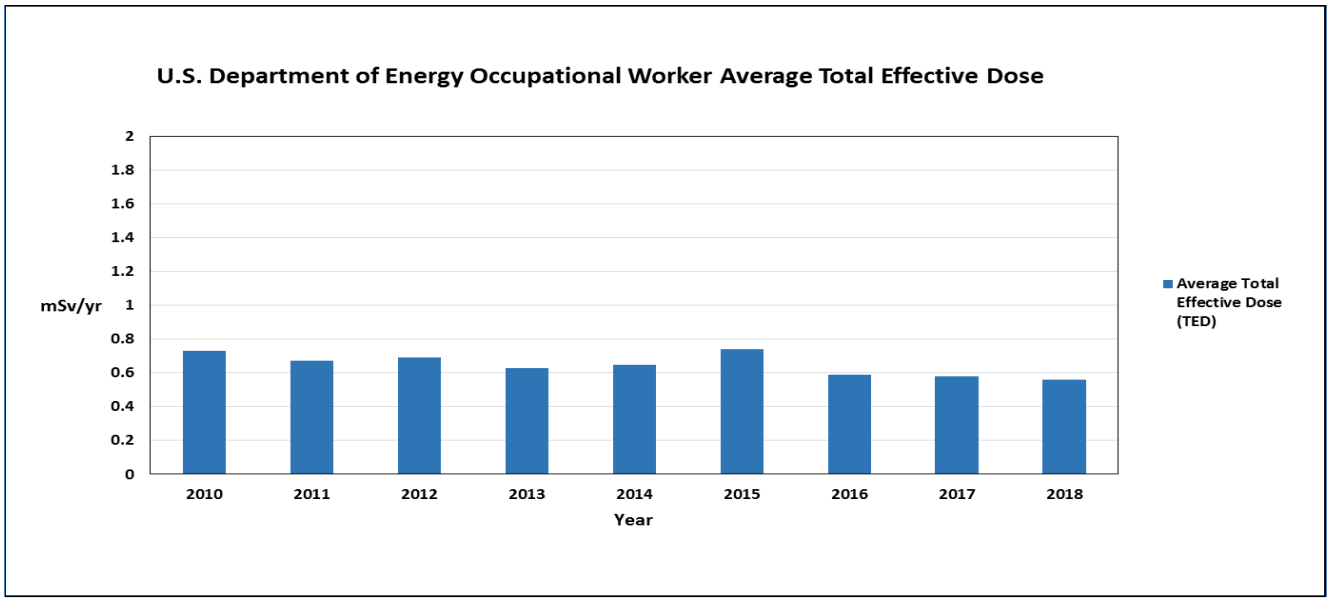

Figure F-4. U.S. Department of Energy Occupational Worker Yearly Average Total Effective Dose.

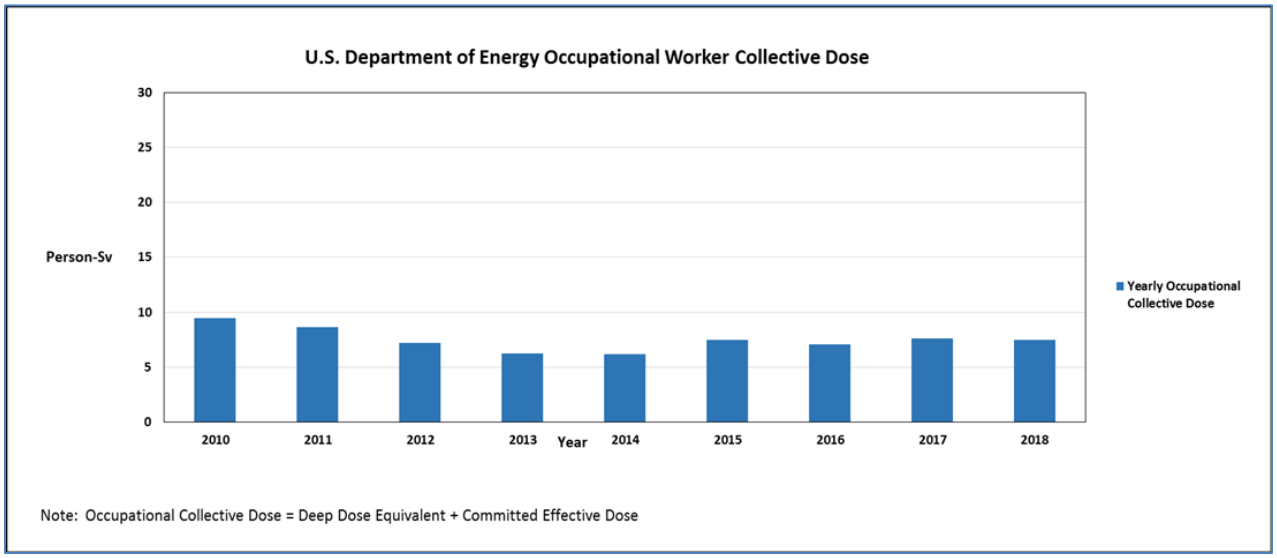

Figure F-5. Occupational Collective Dose and Average Measurable Dose at DOE.

Figure F-5 provides the collective doses to DOE workers with the largest collective dose of 9.47 person-Sv (9.5E2 person-rem) in 2010 and the lowest worker collective dose of 6.21 person-Sv (6.2E2 person-rem) in 2014. For 2018 the occupational collective dose was 7.49 person-Sv (7.5E2 person-rem). The values provided in Figure F-5, in comparison to the collective background dose from exposure to U.S. occupational worker population within the industry and commerce (110 person-Sv [1.1E4 person-rem])[121], is at least two orders of magnitude greater than the collective doses resulting from DOE site emissions.

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 DOL OSHA has regulations dealing with worker protection from ionizing radiation found in 29 CFR.
- The Mine Safety and Health Administration of 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.

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).[136]

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.[137]

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[138] (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 events 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

[136] ASERs are available at: https://www.energy.gov/ehss/policy-guidance-reports/environment-policy-guidance-reports/annual-site-environmental-reports.
[137] See https://www.epa.gov/compliance/national-emission-standards-hazardous-air-pollutants-compliance-monitoring.
[138] See https://www.fema.gov/national-response-framework.

those of the other mission areas. The NRF is always in effect, and elements can be implemented at any time. Selective implementation of NRF structures and procedures 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 NRF 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 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.[139]

As part of the NRF, the Federal Radiological Monitoring and Assessment Center (FRMAC) is a Federal asset available to respond to a nuclear or radiological incident upon the request of Department of Homeland Security (DHS) and state and local agencies. The FRMAC is an interagency organization with representatives from DOE/NNSA, EPA, NRC, DOD, Department of Health and Human Services (HHS), Federal Bureau of Investigation (FBI), and other Federal agencies. DOE/NNSA has the responsibility to maintain the operational readiness and will 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; (early, intermediate, and late[140]) of any nuclear or radiological incident or accident, within the U.S. in support of state, local, and tribal governments, and DHS or any other Federal coordinating agency. For the management of an event, related to the early 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.

[139] See https://www.fema.gov/media-library/assets/documents/25554.
[140] See https://www.epa.gov/radiation/protective-action-guides-pags.

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:[141] 100 mrem/year	TEDE: 1 mSv/yr Ambient Air 1 mSv/yr[142]
Uranium mill tailings sites (UMTRCA Title II facilities) (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 Bq/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/m^2-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 Bq/m^2-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.
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

[141] 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 TED, which is equivalent to TEDE in other Federal agencies.

[142] 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**
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 $pCi/m^2/s$ 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/yr 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/yr, 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/yr (1 mSv/yr for radionuclides limited by submersion dose).
Drinking water (40 CFR Part 141)	DOE & EPA	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/yr Uranium: 30 µg/L
Uranium fuel cycle (40 CFR Part 190)	DOE, 40 CFR Part 190 applies to the uranium fuel cycle in electricity production], 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

Table F-3. Major Radiation Protection Standards			
Summary Table Regulation	**Agency**	**U.S. Standard Limit**	**SI Equivalent**
Air emissions (NESHAPs) (40 CFR Part 61, H)	DOE & EPA	10 mrem/year to nearest off-site receptor	0.1 mSv/yr to nearest off-site receptor
Superfund cleanup (40 CFR Part 300)	DOE & EPA	Protective of human health & environment (lifetime risk), Complies with Applicable or Relevant and Appropriate Requirements	Not Applicable
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/yr TEDE plus ALARA Restricted Use: If institutional controls fail, not to exceed 1 mSv/yr or 5 mSv/yr (the 5mSv/yr dose limit is dependent on specific criteria in 10 CFR Part 20.1403, e.g., clean-up is not technically feasible at 1mSv/yr). 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[143] 29 CFR 1910.1096 NRC 10 CFR 20.1201)	DOE, OSHA, & NRC	5 rem/year & TEDE (TED) 15 rem/year eye (lens) dose equivalent[144] 50 rem/year Deep Dose + any other organ (other than lens of the eye)	50 mSv/yr TEDE (TED) 150 mSv/yr eye (lens) dose equivalent 500 mSv/yr Deep Dose + any organ (other than lens of the eye)

[143] OSHA = Occupational Safety and Health Administration.

[144] 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 waste management and disposal (40 CFR Part 191 & 10 CFR Part 60 [HLW Disposal])	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 critical organ DOE disposal sites (non-NRC licensed) 25 mrem whole body 75 mrem any critical organ Disposal Standards Applicable for 10000 Years After Disposal (all sites): 15 mrem/yr 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 critical organ DOE disposal sites (non-NRC licensed) 0.25 mSv whole body 0.75 mSv any critical organ Disposal Standards Applicable for 10000 Years After Disposal (all sites): 0.15 mSv/yr 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, and NRC	15 mrem/year to 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 up to 1 million years after disposal for undisturbed performance and from human intrusion; Ground-water concentrations not to exceed levels consistent with the drinking water limits for 10000 years after disposal.	0.15 mSv/yr to any member of the public from management and storage; 0.15 mSv/yr to the Reasonably Maximally Exposed Individual (RMEI) for 10000 years after disposal for undisturbed performance and from human intrusion; 1 mSv/yr to the RMEI between 10000 years and the period of geologic stability up to 1 million years after disposal for undisturbed performance and from human intrusion; Ground-water concentrations not to exceed drinking water limits for 10000 years after disposal.
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: Off-site transportation is excluded from the scope of the Joint Convention, and therefore applicable U.S. standards are not listed.

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, Revision 2,[145] 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, Revision 2, 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 350.5(a), 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. Licensees of spent fuel storage facilities at an NPP or at a nuclear fuel cycle facility may request an exemption or license amendment to the emergency preparedness program when the facility enters into the decommissioning phase. Historically, the provisions for emergency preparedness and response have been modified commensurate with the hazard of the materials remaining onsite.

Although the potential 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 an NPP, many of the elements for emergency response are still applicable. See the U.S. Fifth National Report[146] for a full discussion of the emergency response infrastructure, 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.[147] 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[148] 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

[145] https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0654/r2/
[146] See https://energy.gov/sites/prod/files/2014/10/f18/5th_US__National%20Report_9-18-14.pdf.
[147] See https://www.directives.doe.gov/directives-documents/100-series/0151.1-BOrder-c.

approach (including a graded approach) for effectively integrating these activities under a comprehensive, all-emergency concept.

Additional emergency management details are found in DOE G 151.1-1A.[149] 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.[150]

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).[151] 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, 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 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.[152] EPA issued revisions to the 1992 PAG Manual in January 2017, incorporating for the first time protective actions for drinking water, as well as planning guidance for cleanup and waste disposal after a radiological emergency. EPA also conducts training[153] for first responders and participates in a wide variety of exercises.

[149] See https://www.directives.doe.gov/directives-documents/0151.1-EGuide-1a.
[150] See https://energy.gov/em/downloads/third-national-report-joint-convention-safety-spent-fuel-management-and-safety.
[151] See https://www.epa.gov/radiation/radiological-emergency-response.
[152] See https://www.epa.gov/radiation/protective-action-guides-pags.
[153] See https://www.epa.gov/radiation/radiation-protection-document-library.

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[154] 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 of the U.S. Sixth National Report. 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.[155] Information is provided on specific provisions such as timing, the review process, financial assurance, public participation and other programmatic considerations.[156]

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 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 regional offices. Remediation of these sites is now managed more effectively as part of this larger program.

Additional information on decommissioning nuclear reactor facilities, material facilities and activities, and decommissioning license termination criteria can be found in the U.S. Sixth National Report at Section F.6.1.

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[154] 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/.

[155] Sites Undergoing Decommissioning (by location or name) is available at https://www.nrc.gov/info-finder/decommissioning/.

[156] *Status of Decommissioning Program 2019 Annual Report* is available at NRC's ADAMS, under ML19282A393.

F.6.2 Department of Energy Decommissioning Approach

DOE's management approach for disposing excess facilities is described in DOE O 413.3B[157] with the technical approaches described in DOE O 430.1C.[158] Further guidance is provided in DOE G 430.1-4.[159] Additional Orders and Guides for decommissioning and cleanup related activities are found in DOE's Directives system.[160]

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.[161]

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.[162]

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 Nuclear Materials Outside Reactor Cores*.[163]

[157] See https://www.directives.doe.gov/directives-documents/0413.3-BOrder-b.
[158] See https://www.directives.doe.gov/directives-documents/0430.1-BOrder-bc2.
[159] See https://www.directives.doe.gov/directives-documents/400-series/0430.1-EGuide-4.
[160] See https://www.directives.doe.gov/.
[161] See https://energy.gov/em/downloads/third-national-report-joint-convention-safety-spent-fuel-management-and-safety.
[162] 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.
[163] See https://www.nrc.gov/reading-rm/doc-collections/reg-guides/fuels-materials/rg/.

NRC has published guidance[164] on the safety of spent fuel management, including criticality safety. Specifically:

- NUREG-2215, *Standard Review Plan for Spent Fuel Dry Storage Systems and Facilities*, Chapter 7 on Criticality Evaluation; and
- NUREG-2216, *Standard Review Plan for Spent Fuel Transportation*, Chapter 6 on Criticality Evaluation.

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, Subpart F. The regulation in 10 CFR 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 cask storage 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.[165] The Pollution Prevention Act of 1990[166] 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.[167] 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.

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[164] See https://www.nrc.gov/waste/spent-fuel-storage/regs-guides-comm.html, https://www.nrc.gov/materials/transportation/regs-guides-comm.html, https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2215/, and https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2216/.

[165] 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.

[166] 42 U.S.C. 13101 and 13102.

[167] See https://www.epa.gov/p2.

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.

NRC issued a Policy Statement to emphasize the desirability of reducing waste volume to conserve disposal capacity and reduce the overall disposal costs.[168] 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.[169] 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.

[168] The document is available at NRC's ADAMS, under ML15023A098.

[169] The document is available at NRC's ADAMS, under ML080500187.

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 WAC, 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 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 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. Differences in the application of the IAEA safety standards and regulations largely stem from the fact that NRC regulatory infrastructure predates most IAEA safety standards. Furthermore, NRC requirements are written with a greater level of detail than the IAEA's safety standards.

Despite these differences, 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 for additional information on the 2010 and 2014 IRRS Missions. NRC's policy guidance 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 when appropriate. From 2018 to 2020, NRC has published 16 new or revised RGs that harmonize with or reference IAEA safety standards and the completion of an additional 9 RGs is anticipated by summer of 2020.

Several agencies now use or allow the use of the updated dose coefficients found in ICRP Publications 60, 68 and 72. 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 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).[170] 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 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. Permanent disposal remains the specified long-term strategy for spent fuel and radioactive waste. Until permanent disposal is achieved, the U.S. will continue to manage its inventory of spent fuel and radioactive waste in a safe and secure manner. The U.S. will also continue to make progress toward timely decommissioning of inactive nuclear facilities.

F.7.7 National Environmental Policy Act Process to Assess Potential Environmental Impacts

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 Section F.9.1 of the U.S. 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. NRC also has embraced social media as an important tool for reaching a wider public audience. As a result, much of the information about nuclear activities and the national policy about them is available to everyone. NRC's Facebook, Twitter, and

[170] 42 U.S.C. 9601, et seq.

YouTube platforms have been used effectively in real-life situations such as severe weather events to communicate timely and relevant information. Information is available to members of the public about different topics, including decommissioning, spent fuel, and radioactive waste.[171] See the U.S. Sixth National Report at Section F.7.8 for additional information on public and stakeholder involvement in the U.S. program activities.

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.[172] Therefore, additional reviews of existing facilities are not required to comply with the Joint Convention. 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 Final Safety Analysis Report (FSAR) to ensure the information included in the report contains the latest information developed.[173]

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 G.3 for siting of spent fuel facilities and Section H.2.2 for siting of waste management facilities.

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.

[171] See https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/.
[172] See 10 CFR Part 72.
[173] See https://www.nrc.gov/reading-rm/doc-collections/cfr/part072/part072-0070.html.

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 facilities against well-established design, construction, and operations 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. 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 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 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.[174] 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 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 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.[175]

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

[175] 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.[176]

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.[177] 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.[178]

NRC authority to issue orders is detailed in Section 161 of the 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.[179] Additional details on severity levels and recent enforcement actions for materials facilities are available at NRC's web site.[180]

In most cases orders, including those resulting from use of Alternative Dispute Resolutions[181] 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.[182]

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,[183] 10 CFR

[176] See https://www.nrc.gov/about-nrc/regulatory/enforcement/enforce-pol.html.
[177] The term *Order* within this context is distinguished from a DOE Order.
[178] See https://www.nrc.gov/about-nrc/regulatory/enforcement/program-overview.html.
[179] See https://www.nrc.gov/reading-rm/basic-ref/enf-man/process.pdf.
[180] See https://www.nrc.gov/reading-rm/doc-collections/enforcement/actions/materials/.
[181] See https://www.nrc.gov/about-nrc/regulatory/enforcement/adr.html.
[182] 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.
[183] See https://www.gpo.gov/fdsys/granule/CFR-2011-title10-vol4/CFR-2011-title10-vol4-part820.

Part 830,[184] 10 CFR 835,[185] and 10 CFR Part 851,[186] 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, DOE O 458.1,[187] and DOE O 435.1.

Other requirements for implementing 10 CFR Part 830 are found in DOE O 422.1-2A.[188] Implementation guidance is found in DOE G 421.1-2A[189] and DOE G 423.1-1B.[190] 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 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.

Under the Office of Enterprise Assessment,[191] 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 policies 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

[184] See https://www.gpo.gov/fdsys/granule/CFR-2011-title10-vol4/CFR-2011-title10-vol4-part830.
[185] See https://www.gpo.gov/fdsys/granule/CFR-2011-title10-vol4/CFR-2011-title10-vol4-part835.
[186] See https://www.gpo.gov/fdsys/granule/CFR-2011-title10-vol4/CFR-2011-title10-vol4-part851.
[187] See https://www.directives.doe.gov/directives-documents/0458.1-BOrder.
[188] See https://www.directives.doe.gov/directives-documents/0422.1-BOrder.
[189] See https://www.directives.doe.gov/directives-documents/0421.1-EGuide-2.
[190] See https://www.directives.doe.gov/directives-documents/0423.1-EGuide-1a.
[191] Detailed information about the enforcement mission and functions may be found at https://energy.gov/ea/services/enforcement.

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. Furthermore 10 CFR Part 851 establishes 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 as authorized by the AEA. Part 820 of 10 CFR 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.

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 AEA, as amended and the Nuclear Waste Policy Act, as amended. The licensing requirements for storage of spent fuel, HLW, and reactor related GTCC LLW at an ISFSI are contained in 10 CFR Part 72. Additional applicable regulations include 10 CFR Parts 71, 73, and 75. Table E-1 lists key 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 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: specific and general licenses. To obtain a 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; 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 that covers both the site and the storage system.

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 NPP licensee that has a license under 10 CFR Part 50 or 10 CFR Part 52. The prospective general licensee must 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. The general licensee must use dry cask storage systems that have been approved by NRC and issued a CoC. The term of a general license is tied to the term of the CoC being used and is valid 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.

NRC has approved and issued CoCs for 15 dry cask storage system designs, which general licensees may consider for use at their sites. 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 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.

NRC completed a rulemaking in 2011 to extend the specific license and CoC terms from 20-years to 40-years. The specific license or CoC may be renewed at the end of the initial term.[192] The current 40-year term applies to both initial and renewal terms for specific licenses and CoCs, and there is no restriction on the number of renewals.

G.2 Existing Facilities (Article 5)

ISFSIs in the U.S. use different dry cask 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 specific license or CoC evaluate aging of components through corrosion, chemical attack, and other mechanisms that may cause a reduction in the efficacy of important to safety storage cask components. Current guidance on renewing 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*.[193] Additionally, NUREG-2214, *Managing Aging Processes in Storage (MAPS) Report*, provides technical guidance on aging mechanisms and aging management programs that are considered generically acceptable to address aging effects so that the design bases of ISFSIs and dry cask storage systems will be maintained.[194]

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, addresses factors such as the radiological criteria, design basis events, geologic considerations, and controlled areas.[195] NRC decisions on the siting of ISFSIs are made available to the public.

[192] 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.
[193] NUREG-1927 is available at https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1927/r1.
[194] NUREG-2214 is available at https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2214/.
[195] For more detailed information on spent fuel storage, refer to https://www.nrc.gov/waste/spent-fuel-storage.html.

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 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 in 10 CFR Part 72, Subpart G.

NRC reviews safety analysis reports using guidance to the staff in NUREG-2215, *Standard Review Plan for Spent Fuel Dry Storage Systems and Facilities*.[196] This guidance ensures 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-2215.

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.

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 regulatory requirements, licensing and CoC requirements, and QA program commitments. NRC inspections at ISFSIs are conducted during ISFSI facility construction, during ISFSI pre-operational testing, and during routine loading and storage operations, to determine if the vendor and licensee are in full compliance. NRC performs

[196] NUREG-2215 is available at https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2215/.

inspections at vendors and fabricator facilities during design and fabrication activities of dry cask storage systems to determine if the vendor is in compliance with applicable NRC 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*.[197] The ISFSI inspection program focuses on those aspects of the program that are most important to safety. Safety focus areas (risk significant areas) in the ISFSI inspection oversight program are Occupational Exposure, Public Exposure, Fuel Management, Confinement/Canister Integrity, and Impact to Plant Operation.

For an ISFSI that has routine operations with loaded dry cask storage systems, an inspection is performed triennially. Inspections may occur more frequently, depending upon prior inspection history, licensee performance, lessons learned, emergent issues, scheduling issues, or continuous ISFSI loading to completely offload the spent fuel pool to dry cask storage. Continuous ISFSI loadings are inspected quarterly until the spent fuel pool has been completely offloaded. In addition, cask unloading occurrences should be inspected. After renewal of an ISFSI license or CoC, NRC inspectors evaluate whether licensees are adequately performing all activities associated with the licensee's aging management program.

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 cask storage system canisters and their contents, which show no degradation that would warrant changing the storage systems' design bases. The results of these studies are located in NUREG/CR-6831, *Examination of Spent PWR Fuel Rods after 15 Years in Dry Storage*.[198]

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*.[199] NRC also endorsed the "Graded Approach Criteria" for retaining important parameters in the Cask CoCs.[200] This set of criteria maintains safety and reduces licensing burden by removing or relocating details from the COC or Technical Specifications that are not risk significant to safety, thereby providing additional flexibility for licensees. The important parameters are those with a large influence on criticality safety and radiation levels. The ultimate determination of parameters is based on those the applicant uses in its criticality and shielding analyses that are used to demonstrate safety of the storage cask and facility design.

[197] The document is available at NRC's ADAMS, under ML120390415.
[198] The document is available at NRC's ADAMS, under ML032731021.
[199] These documents are available at NRC's ADAMS, under ML011940387 and ML010820352, respectively.
[200] The document is available at NRC's ADAMS, under ML19353D337.

Requirements for incident reporting are 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)

Currently, the U.S. has no spent fuel disposal capability (see Section A.3.1.1.). However, DOE has developed and is executing an 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 of 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 to better understand the potential degradation mechanisms involved in long-term dry cask storage. For example, existing storage systems are being evaluated as spent fuel will be stored in dry cask storage systems longer than anticipated when they were loaded. It is currently believed that storing spent fuel longer than originally anticipated will not present a risk to safety. However, DOE continues to conduct research to improve understanding of potential concerns (e.g., performance of long-term behavior of hydride re-orientation of the cladding, stress corrosion cracking, and thermal performance of the casks) to ensure sufficient time is available to address any safety concerns should they arise. A continuous evaluation of research priorities is performed by DOE, and research results are shared with international groups at ESCP that is sponsored by EPRI. See Section A.3.1 for current information on U.S. spent fuel and HLW storage and disposal.

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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 NRC's safety requirements for 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 HLW, LLW, and uranium mill tailings. NRC's regulatory framework for disposing and managing commercial spent fuel is described in Sections F and G.

DOE's waste management practices are described in DOE O 435.1. 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, 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 LLWPAA 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 LLWPAA 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 LLWPAA 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 LLWPAA, and part of the United States by the AEA. 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 an LLW disposal site. LLW disposal occurs at commercially operated LLW disposal facilities and could be licensed by either NRC pursuant to 10 CFR Part 61, or Agreement States pursuant to

their regulations, which are compatible with 10 CFR Part 61.[201] All currently operating sites are licensed by Agreement States. Facilities must 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 that 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 an 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.1.2.1 for additional information on the rulemaking.

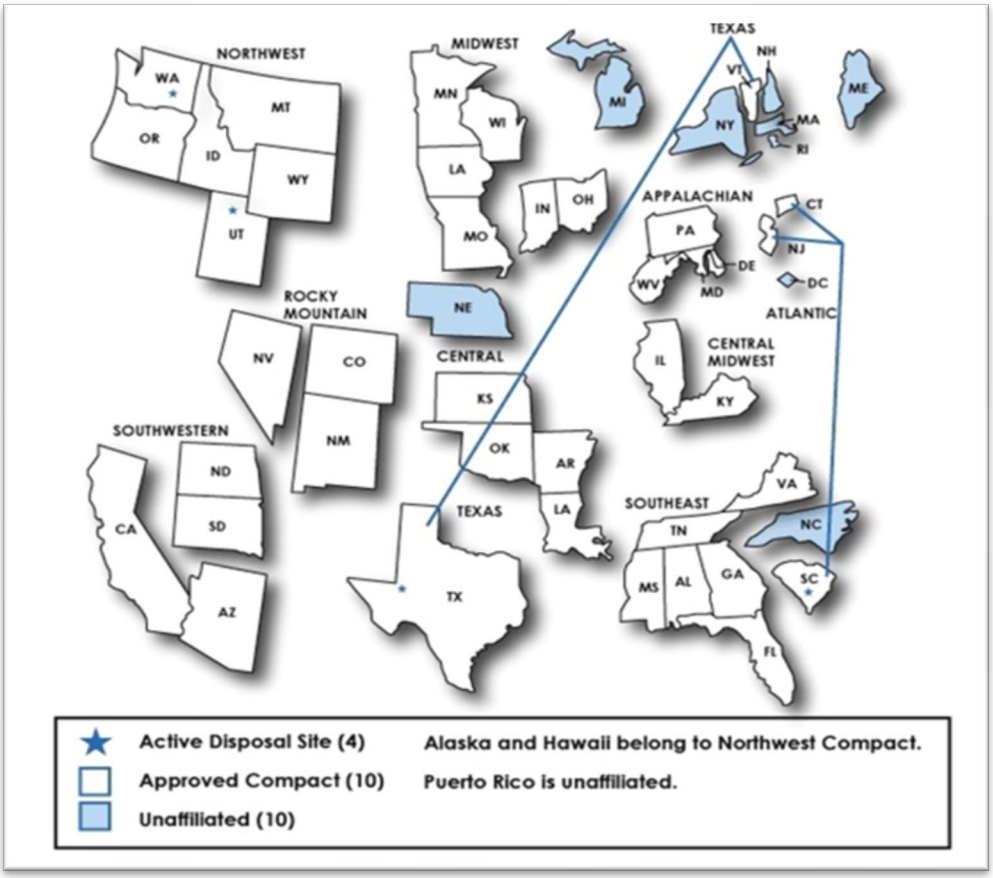

Figure H-1. U.S. Low-Level Waste Compacts.[202]

[201] There are no disposal facilities currently licensed by NRC for disposal of GTCC LLW. GTCC LLW is stored until a disposal facility is established in accordance with the LLWPAA.

[202] 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.

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 CERCLA or RCRA regulations (for the disposal of mixed waste). See Section E.2.2.3 on mixed waste regulation.

CERCLA authorizes EPA to respond to releases, or threatened releases, of hazardous substances that may endanger public health, welfare, or the environment. CERCLA 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. See also Section D.3.4.

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 420.1C[203] and DOE O 430.1C.[204] 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.
- Ability to control radionuclide migration pathways, surface erosion and run-off.

H.2.3 Design and Construction (Article 14)

Design and construction were 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, DOE O 420.1C, DOE O 414.1D, DOE Policy (P) 450.4A,[205] 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 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, WAC, and waste certification programs 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.[206] Site-specific radiological PAs are prepared and maintained for DOE LLW disposal facilities. In July 2017, DOE issued a Technical Standard, “Disposal Authorization Statement and Tank Closure Documentation DOE-STD-5002-2017” which outlines a consistent approach for preparing a PA in compliance with

[203] See https://www.directives.doe.gov/directives-documents/0420.1-BOrder-a.
[204] See https://www.directives.doe.gov/directives-documents/0430.1-BOrder-bc2.
[205] See https://www.directives.doe.gov/directives-documents/0450.4-APolicy.
[206] The date of issuance of DOE O 5820.2A the first detailed, prescriptive DOE LLW management order. LLW disposed of before (and after) that date is subject to the requirements of DOE O 458.1 and DOE O 435.1.

requirements.[207] By using the technical standard, the sites develop PAs that are complete, logical, technically correct, and result in valid conclusions.

In addition to PAs, site-specific radiological CAs are prepared and maintained for LLW disposal facilities receiving waste after September 26, 1988. The CA 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 CA results are used for planning, 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 technical standard for DOE O 435.1 (DOE-STD-5002-2017, Disposal Authorization Statement and Tank Closure Documentation).[208] The PA and CA are maintained to evaluate changes affecting the performance, design, and operating bases for the facility. Additional iterations of the PA and CA are conducted as necessary during the post-closure period.

A Disposal Authorization Statement (DAS) 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 DAS is issued based on a review of the facility's PA, CA, a 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.

Disposal Facility Closure Plans are developed for DOE LLW disposal sites. A preliminary closure plan is developed and reviewed with the PA and CA. The closure plan is updated to incorporate conditions specified in the DAS. 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.

More details on PAs, CA, and compliance demonstration are discussed in the U.S. Fourth National Report (see Section K.1.5).

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. 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,*[209] requires the maintenance of active and passive controls for as long as the hazard exists. The active control period is determined by public risk,

[207] See https://www.standards.doe.gov/standards-documents/5000/5002-astd-2017.
[208] See https://www.directives.doe.gov/directives-documents/400-series/0435.1-EGuide-1.
[209] See https://www.directives.doe.gov/directives/0454.1-APolicy/view.

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 WIPP 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

LAW does not have a statutory or regulatory definition, but generally means wastes that contain some residual radioactivity, including naturally occurring radionuclides, which can be safely disposed of in hazardous or municipal solid waste landfills. LAW is equivalent in concept to VLLW in the IAEA 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 an LLW disposal facility licensed under 10 CFR Part 61, if a licensee so chooses, procedures for 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 ALARA 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 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 NRC regulatory control with regard to the waste's radioactive content. Most Agreement States have regulations similar to 10 CFR 20.2002 covering the alternative 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

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. [210] 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 low 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.

Similarly, controlling solid materials disposition of real or personal property with the potential to contain residual radioactive material may be conducted by DOE in accordance with specific dose constraints and requirements established in DOE O 458.1. DOE sites may utilize a graded approach to demonstrate compliance with requirements, to include use of pre-approved authorized limits, or development of site-specific authorized limits.

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.[211] 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

[210] In the international context, "controlling solid materials disposition" is referred to as clearance.

[211] 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.

regulatory requirements of 10 CFR Part 20 (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.[212] 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.

In the past, NRC used the criteria in RG 1.86, *Termination of Operating Licenses for Nuclear Reactors*,[213] to guide the release of solid material at both reactor and materials facilities. The criteria were incorporated in licenses through specific license conditions. Since the previous U.S. National Report, NRC has rescinded RG 1.86 because it contains outdated regulatory processes. Now, for materials licensees and those in the fuel cycle, the 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*.[214] 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.

H.3.2.2 Volumetrically Contaminated Radioactive Material Release

NRC guidance on release levels is summarized in 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 volumetrically contaminated radioactive material release has not changed since the previous U.S. National Report and is also available from NRC website.[215] 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*

[212] 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.

[213] See https://www.federalregister.gov/documents/2016/08/12/2016-19195/termination-of-operating-licenses-for-nuclear-reactors.

[214] The document is available at NRC's ADAMS, under ML030650166.

[215] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1757/v1/.

Nuclear Power Stations.[216] 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. 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 UMTRCA 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 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. 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

[216] See https://www.nrc.gov/reading-rm/doc-collections/gen-comm/info-notices/1988/in88022.html.

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 EA under the provisions of NEPA (see Section F.7.7). If the EA identifies potential significant environmental impacts, NRC will prepare an EIS.

H.4.5 Institutional Measures after Closure (Article 17)

NRC 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.[217] 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 (LTSP) implemented by the custodial agency in the U.S. Fourth National Report.

H.5 Monitoring Releases to the Environment

RadNet 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.[218]

RadNet includes:

- 140 fixed air monitors that can deliver real-time data using various telemetry methods (67 have additional dose rate monitoring);
- 40 portable (or "deployable") real-time air monitors;
- 28 precipitation sampling locations; and
- 62 drinking water sampling locations.

[217] See https://www.nrc.gov/waste/decommissioning/reg-guides-comm.html.

[218] RadNet data and instructions for viewing reports are available through the RadNet home page at https://www.epa.gov/radnet.

For more information on RadNet see Section H.5. of the Sixth National Report. See the same section for information on RadMap, which is an interactive desktop tool to provide government at all levels with information about long-term radiation monitoring stations across the country.[219]

[219] See https://www.epa.gov/radiation/radmap.

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I. TRANSBOUNDARY MOVEMENT

I.1 United States of America Legal and Policy Framework for Transboundary Movement

The AEA grants regulatory oversight and licensing responsibility to NRC for commercial imports and exports of source, special nuclear and byproduct materials to and from the U.S.[220] NRC regulations governing commercial imports/exports are set forth in 10 CFR Part 110. See additional historical information in the U.S. Fourth National Report.

DOE imports are not subject to NRC import licensing authority under the AEA. For example, NRC's regulatory authority does not apply to DOE import of disused sealed sources. Some DOE exports are subject to NRC licensing authority under the AEA, including DOE exports of more than 500 grams of special nuclear material per year per recipient and DOE exports of more than three MT of source material per year per recipient. DOE exports of byproduct material are not required to be licensed by NRC.

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.[221]

Exports of irradiated or spent fuel are addressed separately in provisions governing exports of special nuclear material. A specific NRC license for imports of spent fuel is required if the shipment exceeds 100 kilograms.

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 forwards the application to DoS to coordinate reviews by interested U.S. Federal Government agencies for the proposed import or export, including contacting the involved foreign governments (country of material origin, intermediate, and/or ultimate consignee) to obtain assurances/consent for the proposed export or providing notice of the proposed import.

Upon receipt from DoS of an executive branch letter that the appropriate authorities of the country of origin have consented (for proposed exports) and the proposed export or import appears to be consistent with the provisions of the Joint Convention, 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

[220] 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.

[221] 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.

satisfied. A brief description of the export and import review process for each is provided below since the reviews involve different considerations.

I.2.1 Exports

Upon receipt of an application for export of radioactive waste, NRC requests DoS to notify the government of the recipient nation and obtain comments consistent with the Joint Convention. DoS also solicits recommendations from interested U.S. Federal agencies. NRC's criteria for export of radioactive waste under 10 CFR 110.42 include whether the appropriate authorities of the receiving country have consented to receipt of the radioactive waste, and whether the receiving country finds that it has the administrative and technical capacity and regulatory structure to manage and dispose of the waste.

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/NNSA, 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

Imports of radioactive waste into the U.S. require a specific import license. For proposed imports of radioactive waste, NRC receives the application and forwards it to DoS. DoS thereafter contacts the government of the exporting nation seeking acknowledgement that the exporting nation is aware of the proposed transaction and soliciting comments. NRC has exclusive jurisdiction within the U.S. (the states and U.S. territories) to grant or deny a license 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 LLW 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).

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.[222]

[222] 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.

Waste containing radioactive material requires a specific import license if it meets the threshold definition of radioactive waste in 10 CFR 110.2 and also does not fall within one of the six categories excluded from the definition. The threshold definition provides that material is radioactive waste if it is being imported (or exported) for the purpose of disposal in either a land disposal facility as defined in 10 CFR Part 61 or a disposal area, as defined in Appendix A to 10 CFR Part 40. If the proposed imported material does not qualify as radioactive waste for import purposes under 10 CFR 110.2, a specific license to import is not required and accordingly, would not be issued by NRC.

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 under 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 ^{226}Radium.

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 ordinarily be required.

Table I-1. Completed Export/Import Nuclear Regulatory Commission Licensing Actions for January 2000–June 2020																						
Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Total**
Byproducts	1	0	0	2	6	7	2	3	1	1	7	3	6	5	4	2	1	3	14	25	0	93
Components	13	19	5	7	15	10	11	16	5	9	13	16	14	25	16	14	15	5	5	13	6	252
Moderator Material	4	2	3	3	6	3	1	2	1	2	1	4	16	7	6	5	4	7	10	15	4	106
Reactor & Major Reactor Components	4	5	2	0	1	3	1	4	1	3	0	0	2	1	2	2	1	0	1	1	0	34
Special Nuclear Material	50	86	68	53	56	51	64	52	43	69	41	37	38	29	14	12	9	19	19	12	5	827
Source Material	10	17	2	14	11	4	5	8	12	5	5	8	8	3	7	7	4	6	8	7	4	155
Waste Exports	2	3	1	4	1	5	2	5	3	0	6	4	1	6	0	0	3	2	2	1	0	51
Waste Imports	3	4	0	2	2	3	3	9	2	1	5	4	2	5	0	1	3	1	1	0	0	51
Total	87	136	81	85	98	86	89	99	68	90	78	76	87	81	49	43	40	43	60	74	19	1569

Source: NRC, Office of International Programs.

Table I-2. Appendix P Licenses Issued December 2005–June 2020				
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
2017	0	13	0	13
2018	0	14	0	14
2019	0	20	0	20
2020	0	7	0	7
Total	191	227	42	460

Source: NRC, Office of International Programs.

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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 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.

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 to perform a safety evaluation of the sealed source or device. 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. Information on NRC's safety evaluation and registration criteria is contained in 10 CFR 32.210.

Registrations are maintained by NRC in the National Sealed Source and Device Registry. The public can download reports on current and former vendors and products from the National Registry from NRC's public web site. Information on the regulatory process for evaluating and licensing sealed sources and devices is available on NRC's public web site.[223] Agreement States also provide information from their radiation safety evaluations to NRC for the registry. NRC estimates there are approximately two million of these devices and sources in the U.S.

NRC regulations allow for use of certain equipment such as gas chromatograph units, fixed gauging devices, static eliminators, luminous exit signs, and calibration or reference standards under a general license. NRC evaluates the adequacy of these generally licensed products, ensuring that distributors meet the specific requirements in 10 CFR Part 32 Subpart B and that users meet the requirements in 10 CFR Part 31.[224] Other types of sources and devices that are used by the general public are exempt from both registration and licensing when certain requirements are met. The initial manufacturer or distributor must apply for and receive a specific license that allows the distribution of these products to individual users. Examples of these products include silicon chips, electron tubes, check sources, gunsights, and smoke detectors.[225]

Licensees possessing, using, packaging, handling, transferring, and disposing of licensed material are required to comply with the general occupational and public radiation protection regulations listed in Table E-1.

[223] See https://www.nrc.gov/materials/miau/sealed-source.html.
[224] See https://www.nrc.gov/materials/miau/general-use.html
[225] See https://www.nrc.gov/materials/miau/consumer-pdts.html

NRC is responsible for licensing and regulating the import and export of nuclear equipment and material as set forth in 10 CFR Part 110. Under these regulations (specifically, 10 CFR 110.2, 110.27, and 110.43), disused sealed sources of U.S. origin may be imported to the U.S. under a general license for return to a manufacturer, distributor or other entity authorized to receive and possess the source. In 2013, NRC published the *Branch Technical Position on the Import of Non-U.S. Origin Radioactive Sources*,[226] to provide additional guidance to applicants and licensees on the import of disused sealed sources, in an effort to prevent disused sealed sources being orphaned overseas and facilitating the return of disused sources to the supplier.

J.2 Management of Disused Sealed Sources

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. Disposal access for many sealed sources classified as Class A, B, and C LLW is available to licensees in all 50 states. However, significant disposal challenges remain, including the high cost of transportation and disposal for some sources, and development of disposal capability for sources classified as GTCC LLW and certain higher-activity Class B and C sealed sources (e.g., ^{137}Cs and ^{60}Co sources).

Commercial disposal sites in the U.S. limit the radioactive inventory, isotopic content, and geographic origin of waste they will accept. Even though disposal capacity has increased, and NRC updated the guidance for disposal of certain high-activity sources, many commercial actinide sources (such as ^{241}Am) as well as sources classified as GTCC LLW still have no disposal pathway. In addition, the availability of large volume containers capable of transporting high-activity sources is limited and packages are expensive to design, test, certify and fabricate. DOE/ NNSA has designed two Type B containers for the transportation of high-activity sources. See Section A.3.4 for additional information. These container designs will periodically undergo revisions to improve container operations and inclusion of additional content.

Licensees possessing disused sealed sources are responsible for properly storing the sources in accordance with NRC or Agreement state requirements until disposal. This includes sources that have no disposition path. The regulations in 10 CFR Part 20 require licensees to provide secure storage of the material to prevent radiation exposure to the public and to prevent unauthorized removal or access. All licensed facilities that use, store, or dispose of radioactive materials are inspected on a regular basis to ensure adequate safety and physical protection.

In February 2015, NRC published the revised CA BTP.[227] The CA BTP provides guidance for determining the classification of commercial LLW, including sealed sources, including an increased generic disposal limit for ^{137}Cs sources. The CA BTP also discusses “alternative approaches for averaging” that could be used to facilitate the disposal of higher-activity sealed sources. As a pilot implementation of the CA BTP, DOE/NNSA conducted a demonstration project to use the alternative approaches for averaging to dispose of sources at the U.S.

[226] See https://www.nrc.gov/docs/ML1317/ML13177A163.pdf
[227] See https://www.nrc.gov/waste/llw-disposal/llw-pa/llw-btp.html.

Ecology commercial LLW disposal facility in Washington State. The device selected for the pilot was an irradiator containing two ^{137}Cs source capsules with a combined activity of 563 Ci (20.8 TBq). The disposal was approved by the facility regulator and successfully completed in September 2017, demonstrating the feasibility of utilizing the methods described in the CA BTP.

DOE/NNSA manages two programs to facilitate disposal of disused sources. Under the OSRP, 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. Recoveries of registered sources are prioritized based on threat reduction criteria developed in coordination with NRC. See Section A.3.4 for additional information. In addition, DOE/NNSA administers the Source Collection and Threat Reduction program, working with the Conference of Radiation Control Program Directors (CRCPD) and NRC, to facilitate the collection and disposal of disused radioactive sealed sources at commercial LLW disposal facilities. In addition, EPA 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.

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K. GENERAL EFFORTS TO IMPROVE SAFETY

This section provides a summary of ongoing U.S. activities (some of which were addressed in Section A.2) 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 United States of America Program

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

- Cleanup of non-military radium contamination.
- Ongoing improvement of the regulatory framework, including guidance development and updating policies and procedures.
- Public engagement in decisions related to SF and RW management.
- Domestic and international disused sealed source collection efforts.
- International cooperation on decommissioning and other nuclear safety and security topics.

While some of these are continuing strengths, other features are new and have evolved since the Sixth Review Meeting. The following strong features of the current US program are discussed in this section.

K.1.1 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 provide a forum for exchanging strategies, evolving practices, and technologies with other nations. Through international cooperation, countries can coordinate 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. The U.S. actively participates in the full scope of programs of the two major international nuclear organizations, IAEA and Nuclear Energy Agency (NEA).

In addition to participating in more than 200 IAEA and NEA meetings each year, the U.S. participates in a number of peer review missions. On average, the U.S. supports between five to ten IAEA-sponsored peer review missions each year. Some experts on these teams come

from the U.S. Government while others come from industry. Examples of missions supported in recent years include Emergency Preparedness Review, IRRS, International Physical Protection Advisory Service, Operational Safety Assessment Review Team, and the Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation. The U.S. also actively participates in the IAEA Commission on Safety Standards, all of the IAEA Safety Standards Committees, the IAEA Nuclear Security Guidance Committee, NEA Committees, and many of the NEA committee-chartered working groups. These activities provide diverse forums for participants to share information and work together to leverage resources for mutual benefit. For example, the U.S. participated in the NEA's Expert Group on Legacy Management which developed a technical report issued in 2019 related to the regulation of nuclear and radiological legacy sites and installations. NRC developed portions of this report which included case studies detailing challenges, lessons learned, and recommendations related to the management of legacy sites in the U.S.

NRC continues to work both with IAEA and on a bilateral basis in support of countries seeking to enhance their nuclear regulatory programs. NRC has actively participated in guidance document development, as well as workshops and training activities to provide other countries with information and experience on building a robust, independent regulatory infrastructure. NRC has arrangements to exchange technical information with nuclear safety agencies in 45 countries and the European Atomic Energy Community. These arrangements establish the framework for NRC's communications with foreign regulatory authorities regarding pertinent information with direct applicability to ensuring the safety and security of civilian uses of nuclear and radioactive materials globally. These arrangements also enable NRC to provide training and health and safety assistance to countries as they work to develop their respective regulatory capabilities and nuclear safety infrastructure for oversight of a new nuclear power or radioactive materials program. In addition, NRC engages with many countries either bilaterally or regionally on a limited basis where there is not yet a formal bilateral arrangement in place.

The U.S. continues to provide international leadership and promote information exchange regarding U.S. experience in the decommissioning area. The U.S. participated in the review and development of IAEA Safety Standards related to decommissioning; participated in international projects, conferences, peer reviews, and workshops on decommissioning and waste disposal; and advised on the development of other countries' decommissioning regulatory programs. For example, the U.S. participated in the NEA Committee on Decommissioning of Nuclear Installations and Legacy Management and its predecessor, the Working Party on Decommissioning and Dismantling; the IAEA Project on the Decommissioning and Remediation of Damaged Nuclear Facilities; the annual meeting of the IAEA Waste Technology Committee; a technical meeting and consultancy working group on the completion of decommissioning; a consultancy working group on the decommissioning of small facilities; a technical meeting on institutional controls and the release of sites from regulatory control; and the 2018 NEA Workshop on Regulation of Decommissioning where NRC provided a presentation on U.S. experience with stakeholder involvement in the decommissioning process.

The U.S. also sponsored numerous workshops, discussion panels, and training activities on the decommissioning regulatory framework through bilateral and multilateral international counterparts. NRC has participated in bilateral cooperation meetings on decommissioning and spent fuel management, which included discussions on the U.S. reactor decommissioning process, reactor transition lessons learned, radiological characterization lessons learned, and decommissioning ALARA. NRC has supported visits by foreign delegations to the San Onofre, Oyster Creek, Vermont Yankee, Pilgrim, and Three Mile Island reactor decommissioning sites and has hosted foreign assignees to learn about the U.S. regulatory approach to decommissioning. In addition, NRC assigned a staff member to the French Nuclear Safety Authority for one year to share NRC's decommissioning experience.

The U.S. participates in the International Working Forum for the Regulatory Supervision of Legacy Sites, which is focused on efforts to better regulate existing sites and facilities and to avoid the creation of new legacy sites. The U.S. has provided insights and information on the decommissioning and long-term management of legacy uranium recovery sites in the U.S. and presented a case study on the Navajo Nation regarding a holistic approach to addressing uranium contamination.

The U.S. has bilateral agreements in place with several countries and continues to host numerous international visitors at U.S. sites and facilities. For example, the U.S. has continued interactions with the International Association for Environmentally Safe Disposal of Radioactive Materials, ESCP, International Framework for Nuclear Energy Cooperation (IFNEC), IAEA multi-lateral initiatives and bilateral agreements, and MOU. The IFNEC Reliable Nuclear Fuel Services Working Group (RNFSWG) collaborates on establishing an international supply framework to enhance reliable and cost-effective fuel services and supplies to the world market. The focus of its work, in recent years, has been international cooperation on the back end of the fuel cycle. The RNFSWG is currently exploring the feasibility of developing a multinational repository. A full version of the report can be found online. The RNFSWG has been encouraged to continue its important work on issues associated with fuel storage and disposal.

The U.S. assisted in conducting international reviews. In 2020, DOE issued "International Review Panel Report For the Atomic Energy of Canada Limited Canadian Nuclear Laboratories Near Surface Disposal Facility Safety Case and Assessment Documents" after the Atomic Energy of Canada Limited requested DOE to independently review safety case and assessment documents. The appropriate Canadian regulator, the Canadian Nuclear Safety Commission, will determine whether the proposed disposal facility meets Canadian regulatory requirements and should be built in Chalk River, Ontario, Canada.

International research collaboration activities help to advance the understanding and modeling of technical processes for geologic disposal. Research teams from radioactive waste management organizations, national research institutes, regulatory agencies, and universities, as well as industry and consulting groups, have participated in these activities. By doing so, they have provided a wide range of perspectives and solutions to these complex problems.

The international projects related to spent fuel and HLW management 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. Sixth National Report. Of interest, the U.S. co-sponsors the annual U.S./German Workshop on Salt Repository Research, Design, and Operation to bring together key investigators in salt repository science and engineering to discuss the latest scientific and technical research, as well as operational and regulatory issues. The 10th workshop in this series was held in May 2019 in Rapid City, South Dakota.[228]

K.1.2 Continued Enhancement to the Regulatory Framework

The regulatory system for spent fuel and radioactive waste management in the U.S. continues to be improved. See E.2. for additional information on the U.S. Regulatory System. NRC has several rulemaking activities in progress that relate to the provisions in the Joint Convention including:

K.1.2.1 10 CFR Part 61 Rulemaking

NRC is proposing to amend its regulations in 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, e.g., DU, 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.

In addition, NRC has developed a draft guidance document, NUREG-2175, *Guidance for Conducting Technical Analyses for 10 CFR Part 61,*[229] to facilitate the development of information and analyses that will support licensees or license applicants in addressing the proposed regulatory requirements. See B.2.3.2 for additional information.

K.1.2.2 Potential Rulemaking on Regulatory Improvements for Power Reactors Transitioning to Decommissioning

As noted in the U.S. Fifth National Report, the 2010 IRRS mission identified reactor decommissioning as a potential rulemaking opportunity. Since that time, a number of U.S. 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

[228] See https://energyworkshops.sandia.gov/nuclear/2019-u-s-german-workshop-on-salt-repository-research-design-and-operation/.
[229] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2175/.

reactors transitioning to decommissioning. See Section A.3.7.1 for additional information on this rulemaking.

K.1.2.3 Greater-than-Class C Low-Level Waste and Transuranic Waste Possible Rulemaking

The Commission in SRM-SECY-15-0094[230] directed NRC staff to prepare a regulatory basis for the near-surface disposal of GTCC LLW; to conduct a public workshop during the development of the regulatory basis to receive input from stakeholders; and to address TRU waste in the definitions section of 10 CFR 61.2. The draft regulatory basis for GTCC was issued for public comment on July 22, 2019 (84 FR 35037).[231] During the public comment period, NRC conducted public workshops to receive input from stakeholders. See Section A.3.8 for more information related to GTCC LLW disposal.

K.1.2.4 Transfer of Very Low-Level Waste to Exempt Persons for Disposal

On March 6, 2020, NRC issued a proposed interpretation of its radioactive waste disposal regulations in 10 CFR 20.2001 that would permit licensees to dispose of waste by transfer to persons who hold specific exemptions for the purpose of disposal. [232] In the proposed interpretation, NRC would consider approval of requests for specific exemptions for the purpose of disposal if they are for the disposal of VLLW by land burial. [233] Therefore, NRC's intent is that this interpretive rule would allow licensees to transfer VLLW to exempt persons for the purpose of disposal by land burial. Currently, NRC is requesting comment on this proposed interpretive rule.

K.1.3 Licensing Activities

Through licensing activities, the U.S. continues to improve management of radioactive waste and spent fuel. NRC evaluates commercial disposition of radioactive waste for medical isotope facilities as part of its reviews of license applications. In addition, NRC is currently reviewing two applications for facilities proposed for the interim storage of spent fuel and reactor-related GTCC LLW prior to final disposal. These facilities would not be co-located with a power reactor. NRC anticipates completing its safety and environmental reviews for these two applications in 2021. See Section A.3.1.3 for additional information on interim storage facilities.

K.1.4 Nuclear Regulatory Commission Transformational Activities

NRC’s current regulations serve the U.S. well and ensure the protection of public health and safety in the civilian uses of radioactive materials. Nevertheless, technological evolution and economic trends affecting the nuclear energy sector, as well as the commercial and medical use of nuclear materials, are likely to influence the agency workload in coming years, in both type

[230] The document is available at NRC’s ADAMS, under ML15356A623.
[231] For more information go to: Go to https://www.regulations.gov and search for Docket ID NRC-2017-0081.
[232] See *Transfer of Very Low-Level Waste to Exempt Persons for Disposal,* 85 FR 13076 (March 6, 2020).
[233] See Section A.3.2.2 for the use of the term VLLW in the U.S.

and scale. In such a dynamic environment, NRC will be challenged to operate with efficiency and agility while continuing to meet its mission. In late 2018 through early 2019, NRC conducted a scenario planning exercise wherein it formally assessed how NRC's external operational environment might evolve through 2030 and beyond, the findings of which were documented in a report, *The Dynamic Futures for NRC Mission Areas*.[234] Global and domestic nuclear power demand and the dimensions of nuclear technology innovation are likely to be key drivers for NRC's mission portfolio, but a high degree of uncertainty still exists with respect to the likelihood of any given outcome.

Subsequent to the issuance of the Dynamic Futures report, agency leadership identified the need for additional outreach to staff to solicit ideas and insights on actions that NRC could take to prepare for the future. In seeking out new and modernized approaches to the way that NRC works, the agency used, for the first time, a social media platform called Yammer to facilitate an event called NRC Futures Jam, which was held in June 2019. Staff could make and respond to comments and participate in facilitated discussions with agency leaders. Staff participation in the Futures Jam substantially exceeded expectations and several thousand postings were generated.

Based on insights from the futures assessment exercise and themes that emerged from the Futures Jam, NRC leadership established a framework for transformation that encompasses a broad set of activities intended to advance the agency's vision of becoming a modern, risk-informed regulator. There are four key focus areas for transformation: (1) managing the workforce, (2) accepting risk in decision-making, (3) generating innovative ideas to improve the ways that NRC works, and (4) adopting new technologies and approaches to data analytics. The scope of transformation, as presently conceived, primarily concerns how the agency conducts its work, and does not envision substantive changes to existing regulatory policies.

Implementation of the transformation is organized within initiatives to support the four focus areas. To date, NRC has launched seven initiatives, being led by teams of staff from across the agency:

- Be riskSMART – Developing a common understanding of what it means to accept risk, how it connects to the vision, and how risk insights can be applied to NRC activities.
- Agency desired culture – Building into our culture a mindset that welcomes change while reinforcing the behaviors and outcomes described in the agency's Leadership Model.
- Career enhancement – Clarifying and communicating opportunities to ensure that all staff understand paths that will enable them to grow throughout their career.
- Innovation – Finalizing and implementing the new InnovateNRC process and technology platform—InnovateNRC 2.0—agencywide to create and sustain a culture of innovation.

[234] https://www.nrc.gov/docs/ML1902/ML19022A178.pdf

- Process simplification – Simplifying and reinforcing our processes to achieve greater efficiency.
- Signposts and markers – Enhancing awareness of external signposts and markers pertinent to anticipating future agency workloads and adapting decision-making process to incorporate these indicators.
- Technology adoption – Enabling all staff to easily and efficiently complete their work with available technology and increasing the use of new and existing technology across the agency.

Some of these initiatives leverage work that is already underway across NRC, while others will involve the launch of new activities or programs to implement focused solutions for specific challenges. Additional initiatives are also likely to be launched as the current set are completed. The timeline for the full scope of initiative-focused work is approximately two years, but with the understanding that NRC will establish a culture with openness to innovation as an institutional norm. Additional information regarding these activities is available on NRC's public web site.[235]

K.1.5 Sharing Lessons Learned, Repairing and Improving Aging Infrastructures, and Waste Disposition Planning at the Department of Energy

General efforts to improve safety across DOE Complex takes many forms. Three of these forms include sharing lessons learned, repairing and improving aging infrastructures, and ensuring sustainable disposal pathways to protect human health and the environment.

Operation histories across DOE Complex continue to provide for significant opportunities to reevaluate DOE work processes and apply lessons learned. Greater focus is being placed on ensuring appropriate controls are in place to protect our workers, the public and the environment. By sharing lessons learned, EM expects to significantly minimize the risk of recurrence of operational incidents and maximize worker protection across DOE enterprise.

To improve safety, DOE has been placing a greater emphasis on repairing and replacing aging infrastructures at EM waste management facilities. For example, at WIPP ongoing infrastructure improvements include: a new safety significant confinement ventilation system and utility shaft, electrical substation replacement, lightning array design upgrade, and repairs to the waste handling building safety significant fire suppression system, fire water loop, salt hoist, and continuous miner.

K.1.6 Safety Measures Implemented at the Waste Isolation Pilot Plant (Revised Waste Acceptance Criteria for WIPP)

Responsible waste disposition and planning to ensure the sustainability of disposal pathways are key contributors to overall risk reduction and improved safety across DOE legacy sites. As of January 2020, nearly 70000 m^3 Land Withdrawal Act TRU waste volume was disposed at

[235] See https://www.nrc.gov/about-nrc/plans-performance/transforming-nrc.html

WIPP, representing over 175000 containers of waste removed from DOE sites.[236] Safe disposal of the waste reduces risks associated with ongoing storage and allows environmental remediation to proceed. As described in other sections of the report, DOE is taking actions to develop additional LLW disposal facilities to support this need over the coming decades in completing the EM mission.

WIPP is authorized for the disposal of defense-related TRU waste that is transported to WIPP by a certified transportation program using NRC-certified packages. All TRU waste shipped to WIPP from DOE waste generator sites must be characterized and certified by a Carlsbad Field Office-approved waste certifying program in compliance with WIPP's disposal, packaging, and transportation requirements, as outlined in the WIPP's WAC. To demonstrate compliance with the transportation and disposal requirements, information about the physical, chemical and radiological properties, and packaging of the waste must be known and verified prior to shipment from a TRU waste generator site. The primary basis for waste characterization is a process known as Acceptable Knowledge. Acceptable Knowledge is the documentation of all known information on how a TRU waste stream was created and managed; that information is then compiled and documented. Since 2017, an enhanced Acceptable Knowledge process has been implemented to meet new WAC requirements and includes greater screening and review of generator sites' documentations (e.g. plans, procedures, reports), chemical compatibility evaluations and a basis of knowledge evaluation for oxidizing chemicals in TRU waste chemicals to ensure appropriate measures are taken to prevent emplacement of non-compliant wastes.

Approved methods of Acceptable Knowledge waste characterization may include: radiological characterization using non-destructive assay or dose-to-curie methods; visual confirmation of items using real-time radiography or visual examination methods; flammable gas analysis to meet transportation requirements; extensive tracking; and DOE approvals throughout the process to ensure that only waste that has been certified to meet the new WAC is shipped to WIPP. Additionally, waste stream profile forms are approved by DOE and the data supporting the certification of waste is uploaded into the Waste Data System. TRU waste is tracked in the Waste Data System from characterization to shipping and disposal. In order to ship TRU waste to the WIPP facility, a waste generator site's waste certifying program must be Carlsbad Field Office-approved with certification from the New Mexico Environment Department and an initial baseline approval from EPA. Additional DOE oversight has been enhanced through waste generator site technical reviews, which examine work activities performed in preparing waste prior to entering the site's certified program.

K.1.7 Expertise in Nuclear Waste Management and Safety Oversight

The U.S. has personnel with an abundance of technical expertise in nuclear waste management and safety oversight. Staff integrate and deploy waste management solutions and address the current and future inventory of civilian and defense-related spent fuel and HLW. It is essential to maintain this knowledge for the long-term sustainability of nuclear energy. DOE provides a

[236] See Section K.2.2.5 for more information.

key leadership role in defining and developing the science, technology, and infrastructure base for the management of legacy and future radiological materials through an integrated nuclear fuel cycle management approach. This base is instrumental in supporting knowledge and developing the next generation of experts. In this leadership role, the U.S. Government coordinates closely with other Federal Government agencies in executing the management and disposition of civilian and defense-related spent fuel and HLW.

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 HLW.
- Timely development of GTCC LLW disposal capability.
- Development of Hanford Waste Treatment and Immobilization Plant facility as key element of the strategy for defense HLW management.
- Disposition of spent fuel and radioactive waste arising from medical isotope production.
- Recovery of WIPP facility.
- Disposal of DU (addressed in Section A.3.2.3).

In addition, the following suggestions were identified for the U.S. at previous review meetings:

- Continue efforts to consolidate rulemaking and corresponding guidance in order to facilitate the orderly transition from operation to decommissioning (addressed above in Section K.1.2.2).
- Promote information exchange at the international level about U.S. experience related to decommissioning and decontamination and emergency response (addressed above in Section K.1.1).
- Continue efforts in cleanup of major U.S. legacy sites.
- Respond to changes in the external environment (addressed above in Section K.1.4).

The U.S. continues to address these challenges and identify measures to improve safety. The challenges of the current U.S. Program are discussed below.

K.2.1 Management and Disposal of Spent Fuel and High-Level Waste

The U.S. has taken steps forward to address the challenge of safely managing spent fuel and radioactive waste. However, development of a deep geologic repository requires extensive coordination especially with affected parties who reside in the area of storage and disposal facilities. As a result, continued storage of spent fuel at the reactor ISFSIs will be necessary for

longer time periods than originally expected, due to delays in the availability of a repository for permanent disposal.

To create momentum and ensure progress, the U.S. is initiating processes to develop alternative solutions and engaging stakeholders in developing an actionable path forward. For example, DOE will support planning for the near-term consolidation and storage of commercial spent fuel until a long-term solution is determined. DOE will conduct activities that would lay the groundwork necessary to ensure near-term deployment of interim storage to ensure safe and effective consolidation and temporary storage of commercial spent fuel.

Agencies must communicate with the public and program stakeholders to assure them that subject matter experts have the experience and knowledge to safely and securely handle the spent fuel and HLW. DOE must provide the public with background information to help familiarize them with the spent fuel program and the safe management of the nuclear material. This sort of outreach is critical to ensuring that affected citizens, including States, Tribes, and local communities, which may be impacted by the storage of radioactive material, have access to a platform where they can learn about and engage with DOE and other Federal Government agencies. This communication and coordination help to build relationships with affected parties who reside in the area of storage and disposal facilities. Such communication can also highlight for the public indirect impacts from the storage and/or disposal of spent fuel and radioactive waste management including tax benefits, creation of jobs, and social benefits of bringing work and economic incentives to the local area.

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

The U.S. has generated significant amounts of radioactive waste and spent fuel throughout the years in support of the Nation's priorities. Some of the streams generated have a defined disposition path that is safe for the public and environment; however, there are several types of radioactive waste and spent fuel that are considered problematic, as disposition pathways are not yet identified or available; quantities generated are larger than anticipated, necessitating a review of the technical basis and possible revision of regulations for LLW land disposal facilities; they are undergoing waste classification to determine appropriate disposition pathways; available disposal capacity is insufficient; or they do not meet the WAC for a repository.

K.2.2.1 Greater-than-Class C Low-Level Waste

DOE remains committed to developing and implementing GTCC LLW disposal. As required by the EPAct05, DOE submitted a report to the U.S. Congress in November 2017 and is awaiting Congressional action before making a final decision on disposal for GTCC LLW.[237] See Section

[237] See https://www.energy.gov/sites/prod/files/2018/09/f55/GTCC-2017-Report-to-Congress-on-Disposal-Alternatives.pdf

A.3.8 for additional information. In addition, NRC has developed a draft regulatory basis for GTCC LLW disposal at licensed facilities. See Section K.1.2.3 for additional information.

K.2.2.2 Spent Fuel and Radioactive Waste Arising from Medical Isotope Production

DOE is responsible for planning and carrying out programs for DOE-generated radioactive wastes, developing waste disposal technologies, and establishing a ULTB program associated with ^{99}Mo production. 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 commercial disposal path. NRC has issued construction permits to authorize construction of facilities for production of medical isotopes using LEU. Subsequently, an operating license application was accepted for review by NRC. See Section A.3.6 for additional information.

K.2.2.3 Sealed Radioactive Sources

As noted in the 2018 Radiation Source Protection and Security Task Force Report,[238] the U.S. has continued to make progress in increasing commercial disposal options for most Class A, B, and C sealed sources and in addressing a lack of transportation and disposal options for sealed sources with the highest activity. With respect to GTCC LLW, in July 2019, NRC staff issued a draft regulatory basis[239] that sought public comment on a potential rulemaking to establish requirements for the near-surface disposal of GTCC LLW. Currently, the default disposal path for GTCC LLW is a geologic repository unless the Commission, on a case-by-case basis, approves an alternative disposal path.[240]

The NRC issued certificates of compliance to DOE/NNSA for the Model 435-B container in 2014 and for the Model 380-B container in 2017. These containers will enable shipment of nearly all commercially used devices containing high-activity ^{60}Co and ^{137}Cs radioactive sealed sources. See Section A.3.4 for additional information.

As discussed in Section J.2, in 2015 NRC published the revised CA BTP[241] which provides more flexibility and increased disposal options for higher activity Class B and C sealed sources. The proposed 10 CFR Part 61 rulemaking, discussed in Section K.1.2.1, is another effort that could increase the availability of commercial disposal pathways for Class B and C sealed sources.

K.2.2.4 Calcine and Sodium Bearing Waste

DOE currently manages both calcine solids and sodium-bearing waste (SBW) at the Idaho National Laboratory. The 2002 Idaho High-Level Waste and Facilities Disposition Final EIS analyzed the environmental impacts of alternative treatment disposal options for these

[238] The document is available at NRC's ADAMS, under ML18276A155.
[239] A regulatory basis is a pre-rulemaking document used by NRC.
[240] 10 CFR 61.55(a)(2)(iv).
[241] See https://www.nrc.gov/waste/llw-disposal/llw-pa/llw-btp.html.

wastes.[242] In a December 2005 Record of Decision (ROD), DOE decided to treat SBW using steam reforming technology. The Department has constructed the Integrated Waste Treatment Unit to treat this waste. It has undergone several waste simulant runs in preparation for commencing "hot" operations.

In a January 2010 ROD, the Hot Isostatic Pressing (HIP) treatment process was selected to treat calcine and to support off-site disposal of SBW, if additional treatment is required. The calcine would be retrieved from storage and treated using the HIP process and packaged for shipment (by a later date) for disposal outside of the State of Idaho. The HIP process will convert the calcine to a monolithic, glass-ceramic waste form compliant with the Civilian Radioactive Waste Management System - Waste Acceptance System Requirements Document (WASRD) (DOE/RW-0351).

K.2.2.5 Defense Waste Disposal at WIPP

All TRU waste, generated from atomic energy defense activities, may be disposed of at WIIP if it meets the other WIPP requirements (e.g., WIPP WAC and the WIPP HWFP). Potential waste streams in the *Annual Transuranic Waste Inventory Report* - 2019 have meaningful uncertainties regarding their eligibility, due to technical or legal considerations as of December 31, 2018, the data cutoff date. In most cases, a waste stream is reported as "potential" because of technical considerations, such as the lack of characterization data; however, sites may also use this designation based on legal restrictions or at the direction of DOE. Five TRU waste generator sites currently report potential TRU waste inventories: West Valley Demonstration Project, Hanford Site – Office of River Protection, Idaho National Laboratory, Savannah River Site, and Babcock and Wilcox Nuclear Energy Services. In the current inventory report, DOE estimated over 14000 m^3 are categorized as potential because of regulatory restrictions, incomplete data, a need for a defense or TRU waste determination, or a legal consideration.

An existing subject of interest is the capacity of the WIPP facility for disposal of future TRU waste streams. DOE has had success and continues with efforts to ensure that adequate physical disposal capacity exists to support the DOE cleanup mission. On December 21, 2018, regulatory approval was received on modification to the WIPP facility permit on how TRU waste disposal volume is tracked and enables for a more accurate count against the statutory limit of 6.2 million cubic feet set in the WIPP LWA (Public Law 102-579). This new approach considers the volume of the inner-most container of a waste package. The new approach does not count as waste void spaces, dunnage, and packing material. DOE continues to monitor and track the TRU waste volume emplaced at the WIPP facility to ensure compliance with the WIPP LWA and takes appropriate action to ensure the needs of the DOE complex as related to TRU waste disposition are decided upon in a timely and appropriate manner. Also, DOE is undertaking initial planning for additional future waste panels, which will entail engineering design as well as meeting legal and regulatory requirements. These changes will provide a crucial waste

[242] See https://www.energy.gov/nepa/downloads/eis-0287-final-environmental-impact-statement.

disposition pathway to support completion of the cleanup mission at the largest and most complex legacy defense sites in the U.S.

K.2.3 Cleanup of Major United States of America Legacy Sites

DOE is responsible for 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 must accomplish in the next several decades. There remain technical uncertainties that also must be addressed in other cleanup activities, such as decommissioning DOE nuclear facilities, managing spent fuel and remediating contaminant plumes in deep subsurface vadose zones. 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.

The partial roof collapse of an excess facility at the Hanford site in Washington State provides an example of the remaining cleanup challenges. Between 1960 and 1965, eight railcars filled with contaminated materials were placed inside a 360-foot storage tunnel next to the Plutonium Uranium Extraction Plant. In 1964, another tunnel was constructed to store additional railcars. In the mid-1990s, the tunnels, which are next to the Plutonium Uranium Extraction Plant, were sealed. On May 9, 2017, the roof of a 20-foot section of one tunnel collapsed. Air and surface sampling detected no contamination following the collapse. DOE has taken measures to stabilize the tunnel and strengthen structural integrity by filling it with grout. The site provides the public with information documenting the near- and long-term actions taken to ensure the safety of the workforce and the public.[243]

K.2.4 Regulatory Body Challenges

NRC identified major challenges for the future in NUREG-1614, Volume 7, *Strategic Plan: Fiscal Years 2018-2022*, dated February 2018.[244] Many external factors influence the ability of NRC to achieve its strategic goals and the associated strategic objectives. These factors include: (1) industry operating experience; (2) national priorities; (3) a significant incident at a domestic or non-U.S. nuclear facility; (4) the security and threat environment; (5) Federal legislation; (6) Federal court litigation; (7) market forces; (8) new technologies; and (9) resource availability. NRC continues to strengthen its ability to anticipate and respond promptly to shifts in priorities necessitated by these factors. For example, NRC's *Statement of Regulatory*

[243] See https://www.hanford.gov/page.cfm/PUREXTunnelsInformation.
[244] See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1614/v7/.

Priorities for Fiscal Year 2020 provides some of the more important regulatory actions that NRC is considering issuing in proposed or final form during FY 2020.[245] See Section K.1.4 for additional information on NRC's transformational activities.

K.3 Peer Review

The U.S. Government strongly supports the IAEA's and the NEA's suite of peer review services. For example, NRC regularly provides technical experts to participate in IRRS missions around the world, often at a senior leadership level. NRC hosted an IRRS Mission in 2010[246] and a follow-up mission in February 2014.[247] NRC completed its work on all recommendations and suggestions identified by the IRRS team.

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.

The U.S. has made publicly available its National Reports on DOE web site[248] and the IAEA Joint Convention web site.[249] Past Review Meeting presentations from 2006,[250] 2009,[251] 2012,[252] 2015,[253] and 2018[254] are also publicly available. In addition, starting in 2015, redacted versions of the questions and comments received from other contracting parties during the Fifth[255] and Sixth[256] Review Meetings were made publicly available.

[245] The document is available at NRC's ADAMS, under ML19108A373.
[246] See http://www-ns.iaea.org/downloads/actionplan/IRRS%20Mission%20to%20the%20USA__Oct_2010_1.pdf.
[247] The document is available at NRC's ADAMS, under ML14265A068.
[248] See https://www.energy.gov/em/services/waste-management/waste-and-materials-disposition-information.
[249] See https://www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste/documents.
[250] The document is available at NRC's ADAMS, under ML061320554.
[251] The document is available at NRC's ADAMS, under ML16203A283.
[252] The document is available at NRC's ADAMS, under ML12164A397.
[253] The document is available at NRC's ADAMS, under ML16203A263.
[254] The document is available at NRC's ADAMS, under ML18121A393.
[255] The document is available at NRC's ADAMS, under ML19099A464.
[256] The document is available at NRC's ADAMS, under ML19098B237.

ANNEXES[257]

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

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Annex D-1A. Spent Fuel Management Facilities: Government Facilities[258]									
State	**Installation**	**Facility**	**Function**	**Licensee**	**Regulator**	**SF Source[259]**	**Inventory**	**Units**	**Estimated Activity (Bq)[260]**
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 Laboratory (INL)	Multiple INL Facilities	Wet Storage	DOE	DOE	1,2	2.16	MTHM	1.13E+17
			Dry Storage	DOE	DOE	1,2	186.90	MTHM	1.58E+18
		ISFSI[261]	Dry Storage	DOE	NRC	2	81.59	MTHM	9.25E+16
Maryland	National Institute of Standards and Technology (Gaithersburg)	Research/Test Reactor	Wet Storage	National Institute of Standards and Technology	NRC	2	0.01	MTHM	1.03E+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
New Mexico	Sandia National Laboratory (SNL)	Multiple SNL Facilities	Wet & Dry Storage	DOE	DOE	1,2	0.18	MTHM	7.89E+16

[258] Data Source: DOE National Spent Nuclear Program database (Spent Fuel Database Version 7.0.6, February 17, 2020). Navy Spent Fuel is excluded from this report.
[259] SF Sources: 1-Defense Applications; 2-Commercial NPPs and Test/Research Reactors.
[260] Nominal source term estimates calculated for 2020 based on methodology described in the report DOE/SNF/REP-078 Rev. 2, Source Term Estimates for DOE Spent Nuclear Fuels.
[261] In addition to this facility, NRC licensed a second DOE ISFSI at Idaho National Laboratory, which DOE subsequently decided not to construct.

Annex D-1A. Spent Fuel Management Facilities: Government Facilities[258]									
State	**Installation**	**Facility**	**Function**	**Licensee**	**Regulator**	**SF Source[259]**	**Inventory**	**Units**	**Estimated Activity (Bq)[260]**
Rhode Island	Rhode Island Atomic Energy Commission (Narragansett)	Research/Test Reactor	Wet Storage	Rhode Island Atomic Energy Commission	NRC	2	0.03	MTHM	1.98E+14
South Carolina	Savannah River Site (SRS)	SRS Storage	Wet Storage	DOE	DOE	1,2	26.99	MTHM	1.23E+18
			Dry Storage	DOE	DOE	2	0.01	MTHM	2.61E+15
Tennessee	Oak Ridge Reservation (ORR)	Multiple ORR Facilities	Wet Storage	DOE	DOE	2	0.55	MTHM	9.44E+16
Washington	Hanford Site	Multiple Hanford Facilities	Dry Storage	DOE	DOE	1,2	2129.31	MTHM	1.69E+18

Annex D-1B. Spent Fuel Management Facilities: University Research Facilities[262]								
State	**Installation**	**Facility**	**Function**	**Licensee**	**Regulator**	**Inventory**	**Units**	**Estimated Activity (Bq) for 2020[263]**
California	University of California (Irvine)	Research Reactor	Wet Storage	University of California	NRC	20.33	kg HM	9.33E+13
	University of California (Davis)[264]	Research Reactor	Wet Storage	University of California	NRC	80.33	kg HM	1.09E+15
Florida	University of Florida (Gainesville)	Research Reactor	Wet Storage	University of Florida	NRC	19.30	kg HM	1.18E+14
Indiana	Purdue University (West Lafayette)	Research Reactor	Wet Storage	Purdue University	NRC	12.03	kg HM	1.45E+14
Kansas	Kansas State University (Manhattan)	Research Reactor	Wet Storage	Kansas State University	NRC	21.44	kg HM	5.33E+14
Maryland	University of Maryland (College Park)	Research Reactor	Wet Storage	University of Maryland	NRC	19.84	kg HM	5.07E+14
Massachusetts	University of Massachussets-Lowell	Research Reactor	Wet Storage	University of Massachussets-Lowell	NRC	10.64	kg HM	1.29E+14
	Massachusetts Institute of Technology (Cambridge)	Research Reactor	Wet Storage	Massachusetts Institute of Technology	NRC	19.85	kg HM	5.78E+15

[262] Data Source: DOE National Spent Nuclear Program database (SFD Version 7.0.6, February 17, 2020).
[263] Source term estimates calculated for 2020 based on methodology described in the report DOE/SNF/REP-078 Rev. 2, *Source Term Estimates for DOE SNF*.
[264] Formerly McClellan Airforce Base (Sacramento).

Annex D-1B. Spent Fuel Management Facilities: University Research Facilities[262]								
State	**Installation**	**Facility**	**Function**	**Licensee**	**Regulator**	**Inventory**	**Units**	**Estimated Activity (Bq) for 2020[263]**
Missouri	University of Missouri (Columbia)	Research Reactor	Wet Storage	University of Missouri	NRC	36.19	kg HM	3.24E+15
	University of Missouri (Rolla)	Research Reactor	Wet Storage	University of Missouri	NRC	25.52	kg HM	3.17E+15
North Carolina	North Carolina State University (Raleigh)	Research Reactor	Wet Storage	North Carolina State University	NRC	484.05	kg HM	1.55E+15
Ohio	Ohio State University (Columbus)	Research Reactor	Wet Storage	Ohio State University	NRC	26.15	kg HM	3.16E+14
Oregon	Oregon State University (Corvallis)	Research Reactor	Wet Storage	Oregon State University	NRC	75.63	kg HM	8.65E+14
	Reed College (Portland)	Research Reactor	Wet Storage	Reed College	NRC	18.94	kg HM	3.92E+14
Pennsylvania	Pennsylvania State University (University Park)	Research Reactor	Wet Storage	Pennsylvania State University	NRC	37.94	kg HM	1.40E+15
Texas	Texas A&M University (College Station)	Research Reactor	Wet Storage	Texas A&M University	NRC	68.76	kg HM	1.26E+15
	University of Texas (Austin)	Research Reactor	Wet Storage	University of Texas	NRC	42.83	kg HM	3.17E+14
Utah	University of Utah (Salt Lake City)	Research Reactor	Wet Storage	University of Utah	NRC	25.77	kg HM	1.15E+15
Washington	Washington State University (Pullman)	Research Reactor	Wet Storage	Washington State University	NRC	57.53	kg HM	2.77E+15

Annex D-1B. Spent Fuel Management Facilities: University Research Facilities[262]								
State	**Installation**	**Facility**	**Function**	**Licensee**	**Regulator**	**Inventory**	**Units**	**Estimated Activity (Bq) for 2020[263]**
Wisconsin	University of Wisconsin (Madison)	Research Reactor	Wet Storage	University of Wisconsin	NRC	58.28	kg HM	3.73E+14

Annex D-1C. Spent Fuel Management Facilities: Other Research and Nuclear Fuel Cycle Facilities[265]								
State	**Installation**	**Facility**	**Function**	**Licensee**	**Regulator**	**Inventory**	**Units**	**Estimated Activity (Bq) for 2020[266]**
California	Aerotest Research (San Ramon)	Research/Test Reactor	Wet Storage	Aerotest Research	NRC	17.50	kg HM	3.54E+15
	General Electric (Pleasanton)	Research/Test Reactor	Wet Storage	General Electric	NRC	3.98	kg HM	5.11E+12
Michigan	Dow Chemical Co. (Midland)	Research/Test Reactor	Wet Storage	Dow Chemical Co.	NRC	14.81	kg HM	2.23E+14
Virginia	BWX Technology, Inc.	Fuel Cycle Facility	Dry Storage	BWX Technology	NRC	43.89	kg HM	2.15E+15

[265] Data Source: DOE National Spent Nuclear Program database (Spent Fuel Database Version 7.0.6, February 17, 2020).

[266] Source term estimates calculated for 2020 based on methodology described in the 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 Installations[267]

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	1347	MTHM
		ISFSI	Dry Storage	Tennessee Valley Authority	NRC	1082	MTHM
	Farley	Farley 1 & 2	Wet Storage	Southern Nuclear Operating Co.	NRC	839	MTHM
		ISFSI	Dry Storage	Southern Nuclear Operating Co.	NRC	715	MTHM
Arizona	Palo Verde	Palo Verde 1, 2, & 3	Wet Storage	Arizona Public Service Company	NRC	1097	MTHM
		ISFSI	Dry Storage	Arizona Public Service Company	NRC	1569	MTHM
Arkansas	Arkansas Nuclear One	Arkansas Nuclear One 1 & 2	Wet Storage	Entergy Nuclear Operations, Inc.	NRC	539	MTHM
		ISFSI	Dry Storage	Entergy Nuclear Operations, Inc.	NRC	1087	MTHM

[267] Based on the data from the *Spent Nuclear Fuel and Reprocessing Waste Inventory: FCRD-NFST-2013-000263*; Rev. 7; September 2020. The inventory values represent quantities estimated "as of" December 31, 2019. Excludes ISFSIs for Fort St. Vrain SNF and TMI-2 SNF which are included in Annex D-1A addressing Government Facilities.

Annex D-1D. Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Installations[267]

State	Site	Facility (Installation)	Spent Fuel Function	Licensee	Regulator	Inventory	Units
California	Diablo Canyon	Diablo Canyon 1 & 2	Wet Storage	Pacific Gas & Electric Co.	NRC	749	MTHM
		ISFSI	Dry Storage	Pacific Gas & Electric Co.	NRC	798	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	440	MTHM
		ISFSI	Dry Storage	Southern California Edison Co.	NRC	1169	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 Nuclear Connecticut, Inc.	NRC	1378	MTHM
		ISFSI	Dry Storage	Dominion Nuclear Connecticut, Inc.	NRC	557	MTHM

Annex D-1D. Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Installations[267]

State	Site	Facility (Installation)	Spent Fuel Function	Licensee	Regulator	Inventory	Units
Florida	Crystal River	ISFSI	Dry Storage	Duke Energy Florida, Inc.	NRC	582	MTHM
	Saint Lucie	Saint Lucie 1 & 2	Wet Storage	Florida Power & Light Co.	NRC	1024	MTHM
		ISFSI	Dry Storage	Florida Power & Light Co.	NRC	511	MTHM
	Turkey Point	Turkey Point 3 & 4	Wet Storage	Florida Power & Light Co.	NRC	1027	MTHM
		ISFSI	Dry Storage	Florida Power & Light Co.	NRC	409	MTHM
Georgia	Hatch	Hatch 1 & 2	Wet Storage	Southern Nuclear Operating Co.	NRC	697	MTHM
		ISFSI	Dry Storage	Southern Nuclear Operating Co.	NRC	1039	MTHM
	Vogtle	Vogtle 1 & 2	Wet Storage	Southern Nuclear Operating Co.	NRC	986	MTHM
		ISFSI	Dry Storage	Southern Nuclear Operating Co.	NRC	565	MTHM

Annex D-1D. Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Installations[267]

State	Site	Facility (Installation)	Spent Fuel Function	Licensee	Regulator	Inventory	Units
Illinois	Braidwood	Braidwood 1 & 2	Wet Storage	Exelon Generation Co., LLC	NRC	1110	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	390	MTHM
	Byron	Byron 1 & 2	Wet Storage	Exelon Generation Co., LLC	NRC	1074	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	498	MTHM
	Clinton	Clinton 1	Wet Storage	Exelon Generation Co., LLC	NRC	569	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	177	MTHM
	Dresden	Dresden 1 (shutdown) Dresden 2 & 3	Wet Storage	Exelon Generation Co., LLC	NRC	927	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	960	MTHM
	LaSalle	LaSalle County 1 & 2	Wet Storage	Exelon Generation Co., LLC	NRC	1175	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	499	MTHM

Annex D-1D. Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Installations[267]

State	Site	Facility (Installation)	Spent Fuel Function	Licensee	Regulator	Inventory	Units
Illinois (cont.)	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	1156	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	664	MTHM
	Zion	ISFSI	Dry Storage	Zion Solutions	NRC	1019	MTHM
Iowa	Duane Arnold	Duane Arnold	Wet Storage	NextEra Energy Duane Arnold, LLC	NRC	372	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	847	MTHM
Louisiana	River Bend	River Bend 1	Wet Storage	Entergy Operations, Inc.	NRC	403	MTHM
		ISFSI	Dry Storage	Entergy Operations, Inc.	NRC	374	MTHM
	Waterford	Waterford 3	Wet Storage	Entergy Operations, Inc.	NRC	557	MTHM
		ISFSI	Dry Storage	Entergy Operations, Inc.	NRC	310	MTHM

Annex D-1D. Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Installations[267]

State	Site	Facility (Installation)	Spent Fuel Function	Licensee	Regulator	Inventory	Units
Maine	Maine Yankee	ISFSI	Dry Storage	Maine Yankee Atomic Power Co.	NRC	542	MTHM
Maryland	Calvert Cliffs	Calvert Cliffs 1 & 2	Wet Storage	Calvert Cliffs Nuclear Power Plant Inc.	NRC	506	MTHM
		ISFSI	Dry Storage	Calvert Cliffs Nuclear Power Plant Inc.	NRC	1030	MTHM
Massachusetts	Pilgrim	Pilgrim 1	Wet Storage	Holtec Pilgrim, LLC (owner); Holtec Decommissioning International, LLC (decommissioning operator)	NRC	527	MTHM
		ISFSI	Dry Storage		NRC	204	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	1226	MTHM
		ISFSI	Dry Storage	Indiana Michigan Power Co.	NRC	617	MTHM
	Fermi	Enrico Fermi 2	Wet Storage	DTE Electric Co.	NRC	410	MTHM
		ISFSI	Dry Storage	DTE Electric Co.	NRC	275	MTHM

Annex D-1D. Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Installations[267]

State	Site	Facility (Installation)	Spent Fuel Function	Licensee	Regulator	Inventory	Units
Michigan (cont.)	Palisades	Palisades	Wet Storage	Entergy Nuclear Operations, Inc.	NRC	187	MTHM
		ISFSI	Dry Storage	Entergy Nuclear Operations, Inc.	NRC	559	MTHM
Minnesota	Monticello	Monticello	Wet Storage	Northern States Power Co.	NRC	150	MTHM
		ISFSI	Dry Storage	Northern States Power Co.	NRC	317	MTHM
	Prairie Island	Prairie Island 1 & 2	Wet Storage	Northern States Power Co.	NRC	381	MTHM
		ISFSI	Dry Storage	Northern States Power Co.	NRC	641	MTHM
Mississippi	Grand Gulf	Grand Gulf 1	Wet Storage	Entergy Operations, Inc.	NRC	553	MTHM
		ISFSI	Dry Storage	Entergy Operations, Inc.	NRC	432	MTHM
Missouri	Callaway	Callaway	Wet Storage	Union Electric Co.	NRC	606	MTHM
		ISFSI	Dry Storage	Union Electric Co.	NRC	282	MTHM

Annex D-1D. Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Installations[267]

State	Site	Facility (Installation)	Spent Fuel Function	Licensee	Regulator	Inventory	Units
Nebraska	Cooper	Cooper	Wet Storage	Nebraska Public Power District	NRC	205	MTHM
		ISFSI	Dry Storage	Nebraska Public Power District	NRC	330	MTHM
	Fort Calhoun	Forth Calhoun (shutdown)	Wet Storage	Omaha Public Power District	NRC	254	MTHM
		ISFSI	Dry Storage	Omaha Public Power District	NRC	212	MTHM
New Hampshire	Seabrook	Seabrook 1	Wet Storage	NextEra Energy Seabrook, LLC	NRC	381	MTHM
		ISFSI	Dry Storage	NextEra Energy Seabrook, LLC	NRC	322	MTHM
New Jersey	Hope Creek/ Salem[268]	Hope Creek/ Salem 1 & 2	Wet Storage	PSE&G Nuclear, LLC	NRC	1617	MTHM
		ISFSI	Dry Storage	PSE&G Nuclear, LLC	NRC	867	MTHM
	Oyster Creek	Oyster Creek	Wet Storage	Oyster Creek Environmental Protection, LLC (owner); Holtec Decommissioning International, LLC (decommissioning operator)	NRC	436	MTHM
		ISFSI	Dry Storage		NRC	367	MTHM

[268] Hope Creek and Salem are listed as a single site in this table due to proximity and shared ISFSI.

Annex D-1D. Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Installations[267]

State	Site	Facility (Installation)	Spent Fuel Function	Licensee	Regulator	Inventory	Units
New York	FitzPatrick	FitzPatrick	Wet Storage	Exelon Generation Co., LLC	NRC	378	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	393	MTHM
	Ginna	Ginna	Wet Storage	R.E. Ginna Nuclear Power Plant, LLC	NRC	423	MTHM
		ISFSI	Dry Storage	R.E. Ginna Nuclear Power Plant, LLC	NRC	118	MTHM
	Indian Point	Indian Point 1 (shutdown) Indian Point 2 & 3	Wet Storage	Entergy Nuclear Operations, Inc.	NRC	905	MTHM
		ISFSI	Dry Storage	Entergy Nuclear Operations, Inc.	NRC	699	MTHM
	Nine Mile Point	Nine Mile Point 1 & 2	Wet Storage	Exelon Generation Co., LLC	NRC	1020	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	430	MTHM

Annex D-1D. Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Installations[267]

State	Site	Facility (Installation)	Spent Fuel Function	Licensee	Regulator	Inventory	Units
North Carolina	Brunswick	Brunswick 1 & 2	Wet Storage	Duke Energy Progress, LLC	NRC	448	MTHM
		ISFSI	Dry Storage	Duke Energy Progress, LLC	NRC	480	MTHM
	McGuire	McGuire 1 & 2	Wet Storage	Duke Energy Carolinas, LLC	NRC	922	MTHM
		ISFSI	Dry Storage	Duke Energy Carolinas, LLC	NRC	881	MTHM
	Shearon Harris	Shearon Harris 1	Wet Storage	Duke Energy Progress, LLC	NRC	1638	MTHM
Ohio	Davis-Besse	Davis-Besse 1	Wet Storage	First Energy Nuclear Operating, Co.	NRC	400	MTHM
		ISFSI	Dry Storage	First Energy Nuclear Operating, Co.	NRC	235	MTHM
	Perry	Perry 1	Wet Storage	First Energy Nuclear Operating, Co.	NRC	589	MTHM
		ISFSI	Dry Storage	First Energy Nuclear Operating, Co.	NRC	245	MTHM
Oregon	Trojan	ISFSI	Dry Storage	Portland General Electric Corp.	NRC	359	MTHM

Annex D-1D. Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Installations[267]

State	Site	Facility (Installation)	Spent Fuel Function	Licensee	Regulator	Inventory	Units
Pennsylvania	Beaver Valley	Beaver Valley 1 & 2	Wet Storage	First Energy Nuclear Operating, Co.	NRC	1163	MTHM
		ISFSI	Dry Storage	First Energy Nuclear Operating, Co.	NRC	171	MTHM
	Limerick	Limerick 1 & 2	Wet Storage	Exelon Generation Co., LLC	NRC	1100	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	554	MTHM
	Peach Bottom	Peach Bottom 2 & 3	Wet Storage	Exelon Generation Co., LLC	NRC	956	MTHM
		ISFSI	Dry Storage	Exelon Generation Co., LLC	NRC	1123	MTHM
	Susquehanna	Susquehanna 1 & 2	Wet Storage	Susquehanna Nuclear, LLC	NRC	729	MTHM
		ISFSI	Dry Storage	Susquehanna Nuclear, LLC	NRC	1153	MTHM
	Three Mile Island	Three Mile Island 1 (shutdown)	Wet Storage	Exelon Generation Co., LLC	NRC	791	MTHM

Annex D-1D. Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Installations[267]							
State	**Site**	**Facility (Installation)**	**Spent Fuel Function**	**Licensee**	**Regulator**	**Inventory**	**Units**
South Carolina	Catawba	Catawba 1 & 2	Wet Storage	Duke Energy Carolinas, LLC	NRC	986	MTHM
		ISFSI	Dry Storage	Duke Energy Carolinas, LLC	NRC	589	MTHM
	Oconee	Oconee 1, 2, & 3	Wet Storage	Duke Energy Carolinas, LLC	NRC	603	MTHM
		ISFSI	Dry Storage	Duke Energy Carolinas, LLC	NRC	1778	MTHM
	Robinson	Robinson 2	Wet Storage	Duke Energy Carolinas, LLC	NRC	175	MTHM
		ISFSI	Dry Storage	Duke Energy Carolinas, LLC	NRC	263	MTHM
	Summer	Summer	Wet Storage	South Carolina Electric & Gas Co.	NRC	547	MTHM
		ISFSI	Dry Storage	South Carolina Electric & Gas Co.	NRC	126	MTHM

Annex D-1D. Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Installations[267]

State	Site	Facility (Installation)	Spent Fuel Function	Licensee	Regulator	Inventory	Units
Tennessee	Sequoyah	Sequoyah 1 & 2	Wet Storage	Tennessee Valley Authority	NRC	745	MTHM
		ISFSI	Dry Storage	Tennessee Valley Authority	NRC	898	MTHM
	Watts Bar	Watts Bar 1 & 2	Wet Storage	Tennessee Valley Authority	NRC	390	MTHM
		ISFSI	Dry Storage	Tennessee Valley Authority	NRC	255	MTHM
Texas	Comanche Peak	Comanche Peak 1 & 2	Wet Storage	Comanche Peak Power Co., LLC	NRC	813	MTHM
		ISFSI	Dry Storage	Comanche Peak Power Co., LLC	NRC	565	MTHM
	South Texas	South Texas 1 & 2	Wet Storage	STP Nuclear Operating Co.	NRC	1338	MTHM
		ISFSI	Dry Storage	STP Nuclear Operating Co.	NRC	238	MTHM
Vermont	Vermont Yankee	ISFSI	Dry Storage	NorthStar[269]	NRC	702	MTHM

[269] NorthStar Decommissioning Holdings, LLC and parent corporations have ownership interest. NorthStar Nuclear Decommissioning Company, LLC is the decommissioning operator.

Annex D-1D. Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Installations[267]

State	Site	Facility (Installation)	Spent Fuel Function	Licensee	Regulator	Inventory	Units
Virginia	North Anna	North Anna 1 & 2	Wet Storage	Dominion Generation	NRC	553	MTHM
		ISFSI	Dry Storage	Dominion Generation	NRC	1009	MTHM
	Surry	Surry 1 & 2	Wet Storage	Virginia Electric and Power Co.	NRC	329	MTHM
		ISFSI	Dry Storage	Virginia Electric and Power Co.	NRC	1233	MTHM
Washington	Columbia Generating Station	Columbia Generating Station	Wet Storage	Energy Northwest	NRC	270	MTHM
		ISFSI	Dry Storage	Energy Northwest	NRC	539	MTHM
Wisconsin	Kewaunee	ISFSI	Dry Storage	Dominion Energy Kewaunee, Inc.	NRC	519	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	428	MTHM
		ISFSI	Dry Storage	NextEra Energy Point Beach, LLC	NRC	565	MTHM

Annex D-1D. Spent Fuel Management Facilities: Commercial Nuclear Power Plants and Independent Spent Fuel Storage Installations[267]							
State	**Site**	**Facility (Installation)**	**Spent Fuel Function**	**Licensee**	**Regulator**	**Inventory**	**Units**
TOTALS[270]	Commercial NPPs and ISFSIs	All NPPs plus Morris ISFSI	Wet Storage	Various	NRC	45065	MTHM
		All other Commercial ISFSIs	Dry Storage	Various	NRC	39207	MTHM
		All Commercial NPPs and ISFSIs	Grand Total	Various	NRC	84272	MTHM

[270] Inventory values represent historical values collected from sites plus an additional amount generated using a forecasting tool to provide estimated values for each site through the end of 2019. Values for sites in the table were rounded to the nearest MTHM. Values for totals were rounded up to the next MTHM.

Annex D-2A. Radioactive Waste Management Facilities: Government Facilities[271]										
State	Installation	Licensee	Regulator[272]	Facility	Function	Waste Source	Waste/ Material Type	Inventory (m3)[273]	Estimated Activity (Bq)[274]	Rad Cat
California	Lawrence Berkeley National Laboratory	DOE	DOE/CA	Various Waste Facilities	Storage	2	LLW/MLLW	9.89E+02		6
	Lawrence Livermore National Laboratory	DOE	DOE/CA	Various Waste Facilities	Storage	1	LLW/MLLW	2.44E+03		1,2,3,4,5
						1	TRU/MTRU	3.33E+02	5.55E+14	3
	Stanford Linear Accelerator	DOE	DOE/CA	Various Waste Facilities	Storage	2	LLW/MLLW	2.06E+03		1

[271] See Key to Annex D-2 on last page of this table.

[272] CA = California; ID = Idaho; IL = Illinois; KY = Kentucky; NM = New Mexico; NV = Nevada; NY = New York; OH = Ohio; SC = South Carolina; TN = Tennessee; WA = Washington

[273] Stored inventories for LLW/MLLW are as September 30, 2019 per DOE's FY 2020 BLDD. Stored inventory volumes for TRU are as of December 31, 2018 per the Annual Transuranic Waste Inventory Report - 2019. Disposed inventory volume of TRU at WIPP is as of July 7, 2020 per a WIPP Status Report from the Waste Data System (WDS). Disposed inventories for LLW/MLLW in active facilities are as of September 30, 2019 per DOE's FY 2020 BLDD. Disposed inventory for LLW in Savannah River Saltstone Vaults based on the quarterly Saltstone Permit reports as of October 31, 2019. Stored inventory of Hanford HLW based on the Waste Tank Summary Report for Month Ending December 31, 2019 (HNF-EP-0182). Stored inventory volumes of Idaho, Savannah River, and West Valley HLW are based on site sources as of December 31, 2019. Stored inventory of Los Alamos and Hanford sealed sources are based on site sources as of December 31, 2019. Disposed inventory of submarine hulls at Hanford is based on site sources as of December 31, 2019.

[274] Reported activities for stored and disposed LLW/MLLW are parametric estimates. Reported activities for stored TRU are as of December 31, 2018 per the Annual Transuranic Waste Inventory Report – 2019. Activity for disposed TRU at WIPP is as of July 7, 2020 per a WIPP Status Report from the Waste Data System (WDS). Activity of Idaho, Savannah River and West Valley HLW based on site sources as of December 31, 2019. Activity of Hanford HLW based on the Best Basis Inventory data as of March 2019. Reported activities for sealed sources are based on site sources as of December 31, 2019.

Annex D-2A. Radioactive Waste Management Facilities: Government Facilities[271]										
State	Installation	Licensee	Regulator[272]	Facility	Function	Waste Source	Waste/ Material Type	Inventory (m3)[273]	Estimated Activity (Bq)[274]	Rad Cat
Idaho	Idaho National Laboratory	DOE	DOE/ID	Calcined Solids Storage Facility	Storage in underground tanks/bins	1	HLW	4.40E+03	1.20E+18	2,3
			DOE/ID	HLW Tank Farm	Liquid Storage in underground tanks	1	HLW	3.41E+03	1.37E+18	2,3
			DOE/ID/EPA	Idaho CERCLA Disposal Facility	Disposal in engineered surface disposal cell for D&D wastes	1	LLW/MLLW	3.39E+05		1,2,3,4,5
			DOE	RWMC (Includes RH waste vaults)	Disposal in shallow land disposal facility	1	LLW	6.65E+04	2.73E+17	1,2,3,4,5
			DOE/ID	TRU Waste Storage Facilities	Storage	1	TRU/MTRU	1.28E+04	6.22E+15	2,3
			DOE/ID	Various Waste Facilities	Storage, characterization, treatment, packaging	1	LLW/MLLW	3.88E+03	9.77E+10	1,2,3,4,5

Annex D-2A. Radioactive Waste Management Facilities: Government Facilities[271]										
State	**Installation**	**Licensee**	**Regulator[272]**	**Facility**	**Function**	**Waste Source**	**Waste/ Material Type**	**Inventory (m3)[273]**	**Estimated Activity (Bq)[274]**	**Rad Cat**
Illinois	Argonne National Laboratory	DOE	DOE/IL	TRU Waste Storage	Storage	1	TRU/MTRU	7.82E+01	3.34E+14	2,3
				Various Waste Facilities	Storage	2	LLW/MLLW	8.86E+01		1,2,3,4,5
	Fermi Laboratory	DOE	DOE/IL	Various Waste Facilities	Storage	2	LLW/MLLW	5.61E+01		1
Kentucky	Paducah Gaseous Diffusion Plant	DOE	DOE/KY	Various Waste Facilities	Storage, characterization, treatment, packaging	1	LLW/MLLW	5.12E+04		3,4
Missouri	Weldon Springs	DOE	DOE	On-Site Disposal Cell (Closed)	Disposal in engineered, surface disposal cell (Closed)	1	11e(2)	1.12E+06		4
Multiple States[275]	Other DOE	DOE	DOE/Various states	Various Waste Facilities	Storage, characterization, treatment, packaging	1	LLW/MLLW	5.41E+02		6
	Other DOE TRU Waste Small Quantity Sites	DOE	DOE/Various states	TRU Waste Facilities (small)	Storage	1	TRU/MTRU	1.13E+01	3.24E+12	3

[275] Multiple includes LLW/MLLW stored inventories at Ames Laboratory, Brookhaven Laboratory, Kansas City Plant, Pacific Northwest National Laboratory, Pantex Plant, Princeton Laboratory, Thomas Jefferson National Accelerator Facility, and WIPP. Multiple includes TRU stored inventories at the Nuclear Radiation Development Site, Lawrence Berkeley National Laboratory, and the Separation Process Research Unit.

Annex D-2A. Radioactive Waste Management Facilities: Government Facilities[271]										
State	Installation	Licensee	Regulator[272]	Facility	Function	Waste Source	Waste/ Material Type	Inventory (m3)[273]	Estimated Activity (Bq)[274]	Rad Cat
Nevada	Nevada National Security Site	DOE	DOE	Area 3/Area 5 RWMS	Disposal in trenches and subsidence craters	1	LLW	1.34E+06	6.33E+17	1,2,3,4,5
			DOE	Greater Confinement Disposal	Disposal in boreholes	1	TRU	2.00E+02	2.11E+15	1,2,3,4,5
			DOE/NV	LLW/MLLW Storage Facility	Storage	1	LLW/MLLW	2.60E+02		1,2,3,4,5
			DOE/NV	MW Disposal Unit	Disposal in shallow trenches	1	MLLW	3.13E+04	1.44E+14	1,2,3,4,5
			DOE	TRU Waste Facilities	Storage, characterization, packaging	1	TRU	6.94E+01	2.07E+13	3

Annex D-2A. Radioactive Waste Management Facilities: Government Facilities[271]										
State	Installation	Licensee	Regulator[272]	Facility	Function	Waste Source	Waste/ Material Type	Inventory (m3)[273]	Estimated Activity (Bq)[274]	Rad Cat
New Mexico	Los Alamos National Laboratory	DOE	DOE	Sealed Source Facilities	Disused Sealed Source Storage	1	Sealed Source	4.90E+01		6
			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/NM	TRU Waste Facilities	Storage, characterization, packaging	1	TRU/MTRU	3.99E+03	2.46E+16	2,3
			DOE/NM	Various Waste Facilities	Storage	1	LLW/MLLW	4.26E+03		1,2,3,4,5
	Sandia National Laboratory - NM	DOE	DOE/NM	TRU Waste Facilities	Storage, characterization, packaging	1	TRU/MTRU	2.20E+01	6.81E+13	3
			DOE/NM	Various Waste Facilities	Storage, characterization, treatment, packaging	1	LLW/MLLW	1.17E+02	8.46E+11	2,3,5
	Waste Isolation Pilot Plant	DOE	DOE/NM/EPA	WIPP Disposal	Disposal in deep salt formation	1	TRU/MTRU	9.81E+04	8.85E+16	1,2,3,4,5

Annex D-2A. Radioactive Waste Management Facilities: Government Facilities[271]										
State	**Installation**	**Licensee**	**Regulator[272]**	**Facility**	**Function**	**Waste Source**	**Waste/ Material Type**	**Inventory (m3)[273]**	**Estimated Activity (Bq)[274]**	**Rad Cat**
New York	Niagara Falls Storage Site (FUSRAP)	USACE	NY	Niagara Falls Storage Facility	Restoration Waste Storage	1	11e(2)	1.99E+05		4
	Separations Process Research Unit	DOE	DOE/NY	Various Waste Facilities	Storage	1	LLW/MLLW	4.13E+02		2,3
	West Valley Demonstration Plant	DOE	DOE/NY	HLW Dry Storage Pad	Interim storage of Vitrified HLW	3	HLW	2.08E+02	5.74E+17	2,3
			DOE/NY	TRU Waste Facilities	Storage	3	TRU/MTRU	4.89E+03	9.48E+14	2,3
			DOE/NY	Various Waste Facilities	Storage, characterization, treatment, packaging	3	LLW/MLLW	1.76E+03		1,2,3
Ohio	Fernald Environmental Management Project	DOE	DOE	On-Site 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	4.75E+04		4

Annex D-2A. Radioactive Waste Management Facilities: Government Facilities[271]										
State	Installation	Licensee	Regulator[272]	Facility	Function	Waste Source	Waste/ Material Type	Inventory (m3)[273]	Estimated Activity (Bq)[274]	Rad Cat
South Carolina	Savannah River Site	DOE	DOE	E-Area Disposal	Disposal in underground vaults and trenches	1	LLW	4.28E+05	6.42E+16	1,2,3,4,5
			DOE/SC	Glass Waste Storage Building	Interim Storage of Vitrified HLW[5]	1	HLW	3.37E+03	2.29E+18	1,2,3,4,5
			DOE/SC	HLW Tank Farm	Liquid Storage in underground double-shell, stainless steel tanks	1	HLW	1.33E+05	9.15E+18	1,2,3,4,5
			DOE	Old Burial Ground	Historical disposal (Closed)	1	LLW	6.77E+05		1,2,3,4,5
			DOE	Saltstone Vaults	Disposal of low-level waste in engineered cells	1	LLW	1.16E+05		1,2,3,4,5
			DOE/SC	TRU Waste Facilities	Storage, characterization, packaging	1	TRU/MTRU	7.45E+02	6.59E+16	2,3
			DOE/SC	Various Waste Facilities	Storage, characterization, treatment, packaging	1	LLW/MLLW	0.00E+00		1,2,3,4,5

Annex D-2A. Radioactive Waste Management Facilities: Government Facilities[271]										
State	**Installation**	**Licensee**	**Regulator[272]**	**Facility**	**Function**	**Waste Source**	**Waste/ Material Type**	**Inventory (m3)[273]**	**Estimated Activity (Bq)[274]**	**Rad Cat**
Tennessee	Oak Ridge Reservation	DOE	DOE/TN/EPA	EMWMF	Disposal in engineered surface disposal cell for D&D wastes	1	LLW/MLLW	1.78E+06		1,2,3,4,5
			DOE	Hydrofracture	Historical disposal (Closed)	1	LLW	1.73E+04		1,2,3,4,5
			DOE	Interim Waste Management Facility	Disposal in engineered aboveground facility (Closed)	1	LLW	3.70E+03	1.18E+13	1,2,3,4,5
			DOE	Old Burial Ground	Historical disposal (Closed)	1	LLW	4.41E+05		1,2,3,4,5
			DOE/TN	TRU Waste Facilities	Storage, characterization, packaging, treatment	1	TRU/MTRU	1.00E+03	2.37E+15	2,3
			DOE/TN	Various Waste Facilities	Storage (in building and on concrete pad), characterization, treatment, packaging	1	LLW/MLLW	1.93E+03		1,2,3,4,5
Utah	Monticello Remedial Action Project	DOE	DOE	Monticello Disposal Cell	Disposal in engineered, surface disposal cell (Closed)	1	11e(2)	1.91E+06		4

Annex D-2A. Radioactive Waste Management Facilities: Government Facilities[271]										
State	Installation	Licensee	Regulator[272]	Facility	Function	Waste Source	Waste/ Material Type	Inventory (m3)[273]	Estimated Activity (Bq)[274]	Rad Cat
Washington	Hanford Site	DOE	DOE	200 Area Burial Grounds	Disposal in trenches	1	LLW	3.11E+05	1.69E+17	1,2,3,4,5
			DOE	Decommissioned Submarine Hulls Disposal Area	Navy submarine hulls disposal in trenches	1	LLW	1.35E+02		1
			DOE/WA/EPA	ERDF	Disposal (from D&D) in engineered surface disposal unit	1	LLW/MLLW	9.53E+06		1,2,3,4,5
			DOE/WA	HLW Tank Farm	Liquid Storage in underground single- and double-shell tanks	1	HLW	2.06E+05	4.84E+18	1,2,3,4,5
			DOE/WA	IDF	Disposal	1	LLW/MLLW	0.00E+00		1,2,3,4,5
			DOE/WA	RMW Trenches	Disposal in lined trenches	1	MLLW	1.22E+05	6.54E+16	1,2,3,4,5
			DOE/WA	TRU Waste Facilities	Storage, characterization, packaging	1	TRU/MTRU	1.45E+04	2.89E+17	2,3
			DOE/WA	Various Waste Facilities	Storage, characterization, treatment, packaging	1	LLW/MLLW	2.09E+03		1,2,3,4,5
			DOE	WESF	Cs-Sr Storage in hot cells and storage pool	1	Sealed Source	1.94E+03	3.14E+18	2

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, ^{68}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, Np, and their respective decay products.
		4	Naturally-Occurring Isotopes	^{238}U, ^{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, ^{225}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}Ti, ^{208}Ti, and ^{210}Ti) ^{14}C, ^{40}K, ^{40}V, ^{87}Rb, ^{115}In, ^{123}Te, ^{138}La, ^{142}Ce, ^{144}Nd, ^{147}Sm, ^{148}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[276]									
State	**Installation**	**Licensee**	**Regulator**	**Type**	**Function**	**Waste Source**	**Inventory (m3)[277]**	**Estimated Activity (Bq)[278]**	**Rad Cat**
Arizona	SLT Secured Land Transport	SLT Secured Land Transport	AZ	Commercial	Broker/Transporter	3	N/A		
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 Environmental, Inc.	New World Environmental, Inc.	CA	Commercial	Broker	3	N/A		
	NEWEX	NEWEX	XA	Commercial	Broker	3	N/A		
	PWN Environmental	PWN Environmental	CA	Commercial	Broker/Processor/ Transporter	3	N/A		

[276] See Key to Annex D-2

[277] Commercial disposal of inventories are as of December 31, 2016 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.

[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[276]									
State	**Installation**	**Licensee**	**Regulator**	**Type**	**Function**	**Waste Source**	**Inventory (m3)[277]**	**Estimated Activity (Bq)[278]**	**Rad Cat**
California (cont.)	Thomas Grey Associates	Thomas Grey Associates	CA	Commercial	Broker/Processor (liquids and radium)/Transporter	3	N/A		
Colorado	CAST Transportation	CAST Transportation	CO	Commercial	Transporter	3	N/A		
	MACTEC, Inc.	MACTEC, Inc.	NRC	Commercial	Broker/Processor/ Transporter	3	N/A		
	Next Generation Solutions	Next Generation Solutions	CO	Commercial	Broker	3	N/A		
Connecticut	Cabrera Services, Inc.	Cabrera Services, Inc.	NRC	Commercial	Broker	3	N/A		
	Radiation Safety Associates	Radiation Safety Associates	NRC	Commercial	Broker/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.	NRC/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

Annex D-2B. Radioactive Waste Management Facilities: Commercial/Other Facilities[276]									
State	**Installation**	**Licensee**	**Regulator**	**Type**	**Function**	**Waste Source**	**Inventory (m3)[277]**	**Estimated Activity (Bq)[278]**	**Rad Cat**
Kentucky	Maxey Flats	State of Kentucky	KY	Commercial	LLW – All Classes (closed)	3	1.35E+05	8.88E+16	1,2,3,4,5
Maryland	Advanced Technologies & Laboratories, Int'l	Advanced Technologies & Laboratories, Int'l	MD	Commercial	Broker/Processor	3	N/A		
	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/Transporter	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	Broker/Transporter	3	N/A		
	RSO, Inc.	RSO, Inc.	MD	Commercial	Broker/Processor/ Transporter	3	N/A		
Michigan	Pharmacia and Upjohn Co.	Pharmacia and Upjohn Co.	NRC	Private	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		

Annex D-2B. Radioactive Waste Management Facilities: Commercial/Other Facilities[276]									
State	**Installation**	**Licensee**	**Regulator**	**Type**	**Function**	**Waste Source**	**Inventory (m3)[277]**	**Estimated Activity (Bq)[278]**	**Rad Cat**
Missouri	Pangea Group	Pangea Group	NRC	Commercial	Broker	3	N/A		
	R.M. Wester	R. M. Wester	NRC	Commercial	Broker/Transporter	3	N/A		
	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 States	Multiple ISFSIs	Various Utilities and Commercial Sites	NRC	Other Government	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

Annex D-2B. Radioactive Waste Management Facilities: Commercial/Other Facilities[276]									
State	**Installation**	**Licensee**	**Regulator**	**Type**	**Function**	**Waste Source**	**Inventory (m3)[277]**	**Estimated Activity (Bq)[278]**	**Rad Cat**
New Jersey	Disposal Consultant Services, Inc.	Disposal Consultant Services, Inc.	NJ	Commercial	Broker/Transporter	3	N/A		
	Radiac Research Corp.	Radiac Research Corp.	NJ	Commercial	Processor – Waste Disposal Service Prepackaged only	3	N/A		
	Radiation Science, Inc.	Radiation Science, Inc.	NRC/NJ	Commercial	Broker/Transporter	3	N/A		
	Veolia ES Technical Solutions, L.L.C.	Veolia ES Technical Solutions, L.L.C.	NRC	Commercial	Broker/Transporter	3	N/A		
New Mexico	Curie Environmental Services	Curie Environmental Services	NM	Commercial	Broker/Processor/ Transporter	3	N/A		
New York	Radiac Research Corp.	Radiac Research Corp.	NRC & NY	Commercial	Broker/Transporter	3	N/A		
	WMG Inc.	WMG Inc.	NRC	Commercial	Transporter	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	3.09E+16	1,2,3,4,5

Annex D-2B. Radioactive Waste Management Facilities: Commercial/Other Facilities[276]									
State	**Installation**	**Licensee**	**Regulator**	**Type**	**Function**	**Waste Source**	**Inventory (m3)[277]**	**Estimated Activity (Bq)[278]**	**Rad Cat**
North Carolina	HHS, Dept. of Public Health Service	Dept. of Health & Human Services	NRC	Other Government	Processor – Research and Development Type A Broad	3	N/A		
	V.A. Medical Center	Dept. of Veterans Affairs	NRC	Other Government	Processor – Medical Institution Broad	3	N/A		
Ohio	Earthline Technologies, Inc.	Earthline Technologies, Inc.	OH	Commercial	Broker	3	N/A		
	Ohmart/VEGA Corporation	Ohmart/VEGA Corporation	NRC/OH	Commercial	Broker	3	N/A		
	Qual-X, Inc.	Qual-X, Inc.	OH	Commercial	Processor	3	N/A		
	Solutient Technologies	Solutient Technologies	OH	Commercial	Broker/Processor/ Transporter	3	N/A		
	Tritium Disposal	Tritium Disposal	NRC	Commercial	Transporter	3	N/A		

Annex D-2B. Radioactive Waste Management Facilities: Commercial/Other Facilities[276]									
State	**Installation**	**Licensee**	**Regulator**	**Type**	**Function**	**Waste Source**	**Inventory (m3)[277]**	**Estimated Activity (Bq)[278]**	**Rad Cat**
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	Broker/Transporter	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	Private	Processor – Medical Institution Broad	3	N/A		
	I.C.E. Service Group, Inc.	I.C.E. Service Group, Inc.	PA	Commercial	Broker/Transporter	3	N/A		
	MHF Services	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	7.20E+05	7.90E+17	1,2,3,4,5
					LLW Disposal Class B	3	5.34+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		

Annex D-2B. Radioactive Waste Management Facilities: Commercial/Other Facilities[276]									
State	**Installation**	**Licensee**	**Regulator**	**Type**	**Function**	**Waste Source**	**Inventory (m3)[277]**	**Estimated Activity (Bq)[278]**	**Rad Cat**
Tennessee	Ameriphysics, LLC	Ameriphysics, LLC	TN	Commercial	Broker	3	N/A		
	Bionomics	Bionomics	TN	Commercial	Broker/Transporter	3	N/A		
	Chase Environmental	Chase Environmental Group, Inc.	TN	Commercial	Broker/Processor/ Transporter	3	N/A		
	Energy*Solutions*	Energy*Solutions* Bear Creek	TN	Commercial	Broker/Processor/ Transporter	3	N/A		
		Energy*Solutions* Gallagher Road	TN	Commercial	Processor	3	N/A		
	Erwin ResinSolutions	Energy*Solutions*	TN	Commercial	Processor (IX Resins)	3	N/A		
	Hittman Transport Services	Energy*Solutions*	TN	Commercial	Transporter	3	N/A		
	Integrated Environmental Management, Inc.	Integrated Environmental Management, Inc.	TN	Commercial	Broker/Transporter	3	N/A		
	Perma-Fix Diversified Scientific Services	Perma-Fix	TN	Commercial	Processing of resins, sludges, and liquids	3	N/A		

Annex D-2B. Radioactive Waste Management Facilities: Commercial/Other Facilities[276]									
State	**Installation**	**Licensee**	**Regulator**	**Type**	**Function**	**Waste Source**	**Inventory (m3)[277]**	**Estimated Activity (Bq)[278]**	**Rad Cat**
Tennessee (cont.)	Perma-Fix Environmental Waste Operations Center	Perma-Fix	TN	Commercial	Processing/ Treatment of mixed waste	3	N/A		
	Philotechnics	Philotechnics, Ltd.	TN	Commercial	Broker/Processor/ Transporter	3	N/A		
	Studsvik Processing Facility	Studsvik Processing Facility	TN	Commercial	Processor	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 Afterloader	3	N/A		
	Visionary Solutions	Visionary Solutions	TN	Commercial	Mixed waste, encapsulation, transport	3	N/A		

Annex D-2B. Radioactive Waste Management Facilities: Commercial/Other Facilities[276]									
State	**Installation**	**Licensee**	**Regulator**	**Type**	**Function**	**Waste Source**	**Inventory (m3)[277]**	**Estimated Activity (Bq)[278]**	**Rad Cat**
Texas	NNSI	NNSI	TX	Commercial	MLLW processing	3	N/A		
			TX	Commercial	Sealed Source Facility	3	2.04E+01		
	Qal-Tek Associates	Qal-Tek Associates	TX	Commercial	Packaging/Broker (Sealed Sources)	3	N/A		
	USA Environment	USA Environment	TX	Commercial	Broker/Processor/ Transporter	3	N/A		
	Waste Control Specialists (WCS)	WCS	TX	Commercial	TRU Storage (DOE Temporary)	1	5.90E+01	1.61E+14	3
					MLLW Treatment	3	N/A		
					11e.(2) Storage and Disposal	1	2.12E+04		4
			TX	Commercial	Commercial LLW Disposal	3	4.61E+03	2.69E+16	
			TX	Commercial	Federal LLW Disposal	1,2	1.05E+04		
Utah	Energy*Solutions*	Energy*Solutions*	UT	Commercial	MLLW Treatment and Disposal	3	1.93E+05		1,2,3,4,5
					LLW – Class A Disposal	3	3.87E+06	4.81E+15	1,2,3,4,5

Annex D-2B. Radioactive Waste Management Facilities: Commercial/Other Facilities[276]									
State	**Installation**	**Licensee**	**Regulator**	**Type**	**Function**	**Waste Source**	**Inventory (m3)[277]**	**Estimated Activity (Bq)[278]**	**Rad Cat**
Utah (cont.)	Energy*Solutions*	Energy*Solutions*	UT	Commercial	11e.(2) Disposal	3	1.51E+06		1,2,3,4,5
	RWM – Utah, Inc.	RWM – Utah, Inc.	UT	Commercial	Broker/Processor	3	N/A		
Virginia	B&W Energy Services	B&W Energy Services	NRC	Commercial	TRU Storage (DOE)	1	1.03E+01	7.81E+13	3
Washington	PermaFix Northwest	PermaFix Northwest	WA	Commercial	MLLW treatment and processing	3	N/A		
	U.S. Ecology – Richland	U.S. Ecology	WA	Commercial	LLW – Class A Disposal	3	3.96E+05		
					LLW – Class B Disposal	3	3.74E+03		
					LLW – Class C Disposal	3	2.82E+03		
					Sealed sources, leak testing	3	N/A		
Past Practices									
Ocean Disposal	Atlantic			Past Practice	LLW	1,2,3	8.60+03	2.94E+15	
Ocean Disposal	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, ^{68}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, Np, and their respective decay products.
		4	Naturally-Occurring Isotopes	^{238}U, ^{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, ^{225}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}Ti, ^{208}Ti, and ^{210}Ti) ^{14}C, ^{40}K, ^{40}V, ^{87}Rb, ^{115}In, ^{123}Te, ^{138}La, ^{142}Ce, ^{144}Nd, ^{147}Sm, ^{148}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 provides oversight.	NRC	UMTRCA Title I	3421465	m3	TBD
	Cotter	Cotter Corp.	Conventional 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

[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 (cont.)	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
	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 program.	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

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 (cont.)	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.	Conventional mill	No activity; site under State Order.	Colorado	UMTRCA Title II	N/A		N/A
	UMETCO/ Uravan	EPA Superfund	Conventional mill	Reclamation and decommissioning are completed; Completion Review Report is being prepared.	Colorado	UMTRCA Title II	9500000	Dry Tonnes	N/A
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

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)**
Nebraska	Crow Butte	Crow Butte Resources, Inc.	In-situ site	Operating, but focusing on groundwater restoration	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
		Rio Algom Mining LLC	Conventional mill	Completing reclamation; site closure is expected in 2025.	NRC	UMTRCA Title II	33000000	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 ground-water remain issues for EPA, NRC, New Mexico and the Navajo Nation. License amendment request review in progress.	NRC	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)
New Mexico (cont.)	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	Expected closure to be determined.	NRC	UMTRCA Title II	22000000	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

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)
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
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.	Conventional 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

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 (cont.)	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.	Conventional 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 material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	7143000	Dry Tonnes	47
	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

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 (cont.)	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	Conventional 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

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 (cont.)	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. Rosita: Wells plugged in wellfields 1-6, wellfield 7 in restoration and wellfield 8 is in standby.	Texas	UMTRCA Title II	N/A		N/A
	Goliad	UEC	In-situ site	Licensed but not constructed.	Texas	UMTRCA Title II	N/A		N/A
	Brevard & Brown (locations)	Signal Equities, LLC	In-situ site	Licensed but not constructed. NRC has concurred on the Completion Review Report.	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)**
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 60% complete.	NRC	UMTRCA Title I	10743163	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.	Conventional mill	Structures have been removed and radioactive material has been disposed in the two tailings embankments that have final cover.	Utah	UMTRCA Title II	3500000	Dry Tonnes	N/A
	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

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 (cont.)	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	5281081	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.	Conventional 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
	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

[280] The White Mesa facility also accepts material from other uranium recovery sites.

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)
Washington	Dawn Mining	Dawn Mining Co.	Conventional uranium mill	Final radon barriers on the four tailings disposal areas and building demolition were completed in 2018. Final status survey for soil cleanup and review of the application for alternate concentration limits is ongoing	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	Site has been ceded to the U.S. Government.	Wyoming	UMTRCA Title II	4700000	Dry Tonnes	N/A

[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 (cont.)	Gas Hills West	American Nuclear Corp.	11e.(2) byproduct material disposal site	Reclamation incomplete due to insolvency. Site stabilized, but funds to complete reclamation are lacking. Closure to be determined.	NRC	UMTRCA Title II	N/A	N/A	N/A
	Gas Hills North	Pathfinder Mines Corp -- Lucky MC	11e.(2) byproduct material disposal site	Estimated date for closure to be determined.	Wyoming	UMTRCA Title II	N/A	N/A	N/A
	Gas Hills East	Umetco Minerals Corp.	11e.(2) byproduct material disposal site	Estimated date for closure to be determined.	Wyoming	UMTRCA Title II	15169698	Dry Tonnes	3699
	Highlands	Exxon Mobil Corp.	11e.(2) byproduct material disposal site	Estimated date for closure to be determined.	Wyoming	UMTRCA Title II	N/A	N/A	N/A
	Willow Creek Project (formerly Christensen Ranch)	Uranium One	In-situ site	Operating, but not producing	Wyoming	UMTRCA Title II	N/A	N/A	N/A
	Moore Ranch	Uranium One	In-situ site	Licensed but not constructed.	Wyoming	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 (cont.)	Nichols Ranch	Uranerz Energy	In-situ site	Operating	Wyoming	UMTRCA Title II	N/A	N/A	N/A
	Lost Creek	Lost Creek	In-situ site	Operating	Wyoming	UMTRCA Title II	N/A	N/A	N/A
	Ross	Strata Energy, Inc.	In-situ site	Operating	Wyoming	UMTRCA Title II	N/A	N/A	N/A
	Shirley Basin–North	Pathfinder Mines Corp.	11e.(2) byproduct material disposal site; ISR application submitted to Wyoming	Operating	Wyoming	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	Wyoming	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 (cont.)	Split Rock	Western Nuclear Inc.	11e.(2) byproduct material disposal site	Completion Review Report and draft LTSP under review.	Wyoming	UMTRCA Title II	7700000	Dry Tonnes	2750
	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.	Conventional uranium mill	On standby status.	Wyoming	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, Transferred to DOE for long-term monitoring in FY19
Indiana	Joslyn Manufacturing and Supply Company (Fort Wayne)	Remedial Investigation Contract Awarded with work anticipated to start in FY20
Iowa	Iowa Army Ammunition Plant (Middletown)	Ongoing Remediation
Maryland	W.R. Grace Site (Baltimore)	Remediation Pending; demolition design underway
Massachusetts	Shpack Landfill (Norton/Attleboro)	Remediation Complete, Transferred to DOE for long-term monitoring in FY19
Missouri	Latty Avenue Properties (Hazelwood)	Ongoing Remediation; majority of remedial activities completed in 2013
	St. Louis Airport Site	Remediation Complete; Groundwater Monitoring and Long-term Management Activities Continue since 2007
	St. Louis Airport Site Vicinity Properties	Ongoing Remediation
	St. Louis Downtown Site	Ongoing Remediation; Issued a ROD for No Further Action for inaccessible soils at Group 1 properties. Remedial Investigation for Inaccessible Soils in Group 2 in FY20
New Jersey	Maywood Chemical Superfund Site	Ongoing Remediation
	Middlesex Sampling Plant	Groundwater Proposed Plan; Initiate ROD in FY20
	Middlesex Municipal Landfill	Completed Feasibility Study; initiating proposed plan in FY20
	DuPont Chamber Works (Deepwater)	Ongoing Remediation

[282] Source: U.S. Army Corps of Engineers, *Formerly Utilized Sites Remedial Action Program Update 2018, EP 360-1-36, 2020*.
[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	Niagara Falls Storage Site (Lewiston)	Phytoremediation Underway
	Guterl Specialty Steel (Lockport)	Remedial Investigation; Groundwater Monitoring
	Seaway Industrial Park (Towanda)	In 2009, signed a ROD; awaiting funding
	Colonie Site	Remedial Investigation Complete; Transferred to DOE in FY19
	Sylvania Corning Plant (Hicksville)	Remedial Investigation
	Tonawanda Landfill	Started remedial action in FY19
Ohio	Luckey Site	Ongoing Remediation; Contract pending for remaining activities
	Harshaw Chemical Company	Remediation Decision Pending
Pennsylvania	Shallow Land Disposal Area (Parks Township)	Remediation Pending in FY22
	Superior Steel (Carnegie)	Remedial Investigation; Report expected in FY21

Annex D-5. Decommissioning of Complex Licensed Materials Sites[284]			
State	**Installation**	**Location**	**Decommissioning Status[285]**
NRC Regulated Site			
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 (Dept. of the Army)	Madison	Estimated closure to be determined.
Missouri	Sigma-Aldrich	Maryland Heights	Estimated closure in 2020 under unrestricted release.
New Jersey	Dept. 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.

[284] Status of the Decommissioning Program 2018 Annual Report is available at NRC's ADAMS, under ML18257A301.

[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.

Annex D-5. Decommissioning of Complex Licensed Materials Sites[284]			
State	**Installation**	**Location**	**Decommissioning Status[285]**
Oklahoma	FMRI (Fansteel), Inc.	Muskogee	Estimated closure to be determined.
	Kerr-McGee – Cimarron	Cimarron	Estimated closure to be determined.
Pennsylvania	BWX Technologies, Inc. Shallow Land Disposal Area[288]	Parks Township	Estimated closure to be determined.
Agreement State Regulated Sites			
California	Halaco	Oxnard	EPA Superfund Site - Estimated closure to be determined.
	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.
Florida	Iluka Resources, Inc.	Green Cove Springs	All physical work and clean-up to Resident Farmer criteria was completed this past year. They currently have three storage facilities that are classified as Recreationist areas. They are currently working with Florida's Department of Environmental Protection to get their Conservation Easement. Expected completion is end of summer 2020.

[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]**
Illinois	Weston Solutions (Formerly Kerr-McGee)	West Chicago	In 2018 and 2019, Weston continued to perform groundwater and hydrological investigations in order to formulate a groundwater remedy. These investigations included the evaluation of in-situ leaching of uranium as a remediation methodology, supporting treatability studies (bench-scale and pilot-scale), pumping and infiltration testing, and stabilization studies. Weston continues to use the data from these investigations to refine the sites flow and transport model. A groundwater remedy is expected to be selected by mid-2020
Kansas	Beta Chem	Lenexa	Estimated closure to be determined.
Massachusetts	Shpack Landfill	Norton	Estimated closure to be determined - complicated by multiple jurisdictions.
	BASF (Formerly Engelhard Corp.)	Plainville	Remediation in progress. Estimated closure to be determined.
	Starmet Corp. (Formerly Nuclear Metals)	Concord	Estimated closure to be determined.
	Wyman Gordon Co.	North Grafton	Estimated closure to be determined.
	Texas Instruments	Attleboro	Estimated closure to be determined.
	Norton/St. Gobain	Worcester	Estimated closure to be determined - Environmental remediation ongoing.
New Jersey	Shieldalloy Metallurgical Corp[289]	Newfield	NRC reinstated New Jersey's authority to regulate Shieldalloy Metallurgical Corp. New Jersey maintains jurisdiction of this licensed site. The site is currently undergoing remediation under a Department approved remedial action work plan.

[289] Transfer of regulatory authority of Shieldalloy site was set aside by federal appellate decision in Shieldalloy Metallurgical Corp v. NRC, 768 f,3d 1205 (2014).

Annex D-5. Decommissioning of Complex Licensed Materials Sites[284]			
State	**Installation**	**Location**	**Decommissioning Status[285]**
Ohio	Ineos USA, LLC (Formerly BP Chemical)	Lima	Estimated closure to be determined. D&D resumption delayed until 2019 due to state prohibitions.
	Advanced Medical Systems, Inc.	Cleveland	Estimated closure to be determined.
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	Estimated closure to be determined.
	Keystone Metals Reduction	Cheswick	Estimated closure to be determined. Being monitored long term by state Hazardous Site Cleanup Program.
	Karnish Instruments	Lock Haven	Estimated closure to be determined.
	Global Tungsten & Powders Corp.	Towanda	Estimated closure to be determined.
	Remacor	West Pittsburg	Building demolition and disposal complete in 2019. Undergoing assessment for possible remediation action by EPA on soils.
	Superbolt (Formerly Superior Steel)	Carnegie	Estimated closure to be determined. USACE waiting funding to proceed with site cleanup activities.
	Safety Light Corp.	Bloomsburg	Estimated closure to be determined. Transferred to EPA - completed cleanups and disposal of wastes in most contaminated areas. Assessments for future site use and any additional cleanup being evaluated by EPA.

Annex D-5. Decommissioning of Complex Licensed Materials Sites[284]			
State	**Installation**	**Location**	**Decommissioning Status[285]**
Pennsylvania (cont.)	Shallow Land Disposal Area	Parks Township	NRC licensed site, but Pennsylvania involved in cleanup. Site Preparations expected to start in 2020, and remediation work expected to start in 2022. Duration of cleanup unknown currently.
	Westinghouse Electric Corp.	Madison	Estimated closure to be determined.
	Whittaker Corp.	Greenville	Ongoing.
Texas	ASARCO	Houston	Investigation and cleanup ongoing (In post-closure. Remedial action is enhanced monitored natural attenuation. No radiological concerns).
	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 2019 Annual Report, 2020

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	DECON
	San Onofre - Unit 2	Pressurized Light-Water Reactor	1069 MWe	DECON
	San Onofre - Unit 3	Pressurized Light-Water Reactor	1070 MWe	DECON
Connecticut	Millstone - Unit 1	Boiling Light-Water Reactor	660 MWe	SAFSTOR
Florida	Crystal River	Pressurized Light-Water Reactor	825 MWe	DECON
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	DECON
Massachusetts	Pilgrim	Boiling Light-Water Reactor	690 MWe	DECON
Michigan	Fermi - Unit 1	Liquid Metal Fast Breeder Reactor	60 MWe	SAFSTOR
Nebraska	Fort Calhoun	Pressurized Light-Water Reactor	484 MWe	DECON
New Jersey	Oyster Creek	Boiling Light-Water Reactor	636 MWe	DECON
New York	Indian Point - Unit 1	Pressurized Light-Water Reactor	265 MWe	DECON Pending
	Indian Point - Unit 2	Pressurized Light-Water Reactor	998 MWe	DECON Pending

Annex D-6. Nuclear Regulatory Commission - Licensed Power and Demonstration Reactors Under Decommissioning				
State	**Facility**	**Reactor Type**	**Power**	**D&D Status**
Pennsylvania	Peach Bottom - Unit 1	High Temperature Gas Reactor	40 MWe	SAFSTOR
	Three Mile Island - Unit 1	Pressurized Light-Water Reactor	819 MWe	SAFSTOR
	Three Mile Island - Unit 2	Pressurized Light-Water Reactor	906 MWe	Monitored SAFSTOR
Vermont	Vermont Yankee	Boiling Light-Water Reactor	514 MWe	DECON
Wisconsin	La Crosse	Boiling Light-Water Reactor	50 MWe	DECON
	Kewaunee	Pressurized Light-Water Reactor	535 MWe	SAFSTOR
Research and Test Reactors				
California	General Atomics	TRIGA Mark F	1500 kW	DECON
	General Atomics	TRIGA Mark I	250 kW	DECON
	General Electric Co.	GETR (Tank)	5000 kW	SAFSTOR Possession Only

LIST OF ACRONYMS AND ABBREVIATIONS

Acronym/ Abbreviation	Name
Acceptance Program	Foreign Research Reactor Spent Nuclear Fuel Acceptance Program
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
CA	Composite Analyses
CAA	Clean Air Act
CA BTP	Concentration Averaging and Encapsulation Branch Technical Position
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)
CFR	Code of Federal Regulations
CISF	Consolidated Interim Storage Facilities
CoC	Certificate of Compliance
CSD	Considered Sites Database
D&D	Decontamination & Decommissioning
DECON	Prompt Decommissioning
DHS	Department of Homeland Security
DNFSB	Defense Nuclear Facilities Safety Board
DOE	Department of Energy
DOE G	DOE Guide
DOE O	DOE Order
DOL	Department of Labor
DoD	Department of Defense
DoS	Department of State
DU	Depleted Uranium
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPAct05	Energy Policy Act of 2005
EPAct92	Energy Policy Act of 1992
EPRI	Electric Power Research Institute

Acronym/ Abbreviation	Name
ESCP	Extended Storage Collaboration Program
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
FFA	Federal Facility Agreements
FRMAC	Federal Radiological Monitoring and Assessment Center
FR	*Federal Register*
FSAR	Final Safety Analysis Report
FTE	Full-Time Equivalent
FWDF	Federal Waste Disposal Facility
FUSRAP	Formerly Utilized Sites Remedial Action Program
FY	Fiscal Year
GTCC	Greater-than-Class C
HEU	Highly-Enriched Uranium
HHS	Department of Health and Human Services
HIP	Hot Isostatic Pressing
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
kgU	Kilogram of Uranium
LAW	Low-Activity Waste
LEU	Low-Enriched Uranium
LFRG	Low-Level Waste Disposal Facility Federal Review Group
LLWPAA	Low-Level Radioactive Waste Policy Amendments Act of 1985
LLW	Low-Level Waste
LTP	License Termination Plan
LTSP	Long-Term Surveillance Plan
m^3	Cubic Meters
MLLW	Mixed Low-Level Waste
MOU	Memorandum of Understanding
MRB	Management Review Board
mSv	MilliSievert
MT	Metric Tons

Acronym/ Abbreviation	Name
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
NEA	Nuclear Energy Agency
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NNSA	National Nuclear Security Administration
NORM	Naturally Occurring Radioactive Materials
NorthStar	NorthStar Medical Radioisotopes
NOV	Notices of Violations
NPDES	National Pollutant 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
NWF	Nuclear Waste Fund
NWPA	Nuclear Waste Policy Act of 1982, as amended
NWTRB	Nuclear Waste Technical Review Board
ORR	Oak Ridge Reservation
OSHA	Occupational Safety and Health Administration
OSRP	Off-Site Source Recovery Program
PA	Performance Assessment
PAGs	Protective Action Guides
PSDAR	Post-Shutdown Decommissioning Activities Report
QA	Quality Assurance
RCRA	Resource Conservation and Recovery Act of 1976
REIRS	Radiation Exposure Information and Reporting System
RG	Regulatory Guide
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. Delayed Decommissioning.
SDWA	Safe Drinking Water Act
SHINE	SHINE Medical Technologies, LLC
SRS	Savannah River Site
Sv	Sievert
SWPF	Salt Waste Processing Facility

Acronym/ Abbreviation	Name
TED	Total Effective Dose
TEDE	Total Effective Dose Equivalent
TENORM	Technologically Enhanced NORM
TRU	Transuranic
ULTB	Uranium Lease and Take-Back
UMTRCA	Uranium Mill Tailings Radiation Control Act
URL	Uniform Resource Locator
U.S.	United States of America
USACE	U.S. Army Corps of Engineers
VLLW	Very Low-Level Waste
WAC	Waste Acceptance Criteria
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:

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