DOE/EM-0654, Rev. 1
October 2005

United States of America

Second National Report

for the

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

United States Department of Energy

In Cooperation with the
United States Nuclear Regulatory Commission
United States Environmental Protection Agency
United States Department of State

ABSTRACT AND ACKNOWLEDGEMENT

The United States of America 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 nuclear activities into compliance with general safety standards and practices. The first U.S. National Report was presented at the first Review Meeting of the Contracting Parties under the Joint Convention in November 2003 in Vienna, Austria. This second U.S. National Report updates the first report, which documented spent fuel and radioactive waste management safety in the United States under the terms of the Joint Convention. It also incorporates additional information and responses to questions raised at the November 2003 meeting of the Contracting parties. This report does not reflect developments in the U.S. status after August 17, 2005, e.g., subsequent to the passage of the Energy Policy Act of 2005 and publication of proposed revisions to certain radiation standards for Yucca Mountain.

The U.S. is in compliance 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. The report describes radioactive waste management in the U.S. in both commercial and government sectors, providing annexes with information on spent fuel and waste management facilities, inventories, and ongoing decommissioning projects. Detailed information is provided on spent fuel and radioactive waste management safety, as well as imports/exports (transboundary movements) and disused sealed sources, as required by the Joint Convention.

The U.S. Department of Energy acknowledges the support and cooperation of the U.S. Environmental Protection Agency, U.S. Nuclear Regulatory Commission, and U.S. 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. Additional information is available on the internet web sites listed in Section A.

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A. INTRODUCTION

This second National Report updates the first National Report published on May 3, 2003, 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).

A.1 Purpose and Structure of this Report

This report satisfies the requirements of the Joint Convention for reporting on the status of safety at spent fuel (SF) and radioactive waste management facilities within the United States of America (U.S.). The Joint Convention was ratified by the U.S. on April 9, 2003, and entered into force on July 10, 2003. The U.S. participated in the first review meeting held in Vienna, Austria, from November 3 through November 14, 2003. The Joint Convention is an important part of a global effort to raise the level of nuclear safety at nuclear facilities in the aftermath of the 1986 accident at the Chernobyl nuclear power plant in Ukraine, and other events. The Joint Convention provides incentives for nations to bring their nuclear activities into compliance with internationally endorsed public health and safety standards or their equivalent. A copy of the Joint Convention is available electronically from the International Atomic Energy Agency (IAEA).[2]

The Joint Convention is a companion to and is structured similar to the Convention on Nuclear Safety (CNS), which entered into force for the United States on July 10, 1999. The CNS is successfully increasing safety at civilian nuclear power plants throughout the world. The U.S. Nuclear Regulatory Commission (NRC) published the *National Report for the Convention on Nuclear Safety*, in September 2004.[3] The Joint Convention provides a series of broad commitments on the safe management of spent fuel and radioactive waste without prescribing specific or mandatory standards on contracting nations. The Joint Convention extends the review process in the CNS to spent fuel and radioactive waste management activities.[4] Each member state having ratified the Joint Convention (Contracting Party) is obligated to prepare a National Report covering the scope of the Joint Convention and subject it to review by other Contracting Parties. The second review meeting will occur at the IAEA in Vienna, Austria, in May 2006.

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[1] International Atomic Energy Agency, Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, INFCIRC/516, December 24, 1997.
[2] International Atomic Energy Agency, http://www.iaea.org/Publications/Documents/Conventions/jointconv.html,
[3] U.S. Nuclear Regulatory Commission, United States of America, National Report for the Convention on Nuclear Safety, NUREG-1650, Revision 1, Washington DC, USA, September 2004.
[4] Disused sealed sources are also within the scope of the Joint Convention, as specified in the preamble of the Convention on Nuclear Safety.

This Department of Energy (DOE) report was prepared by a working group composed of staff from DOE and other agencies of U.S. Government involved in international and domestic nuclear activities, including the Department of State, U.S. Environmental Protection Agency (EPA), and NRC.

This report describes how the U.S. meets the objectives described in Article 1 of the Joint Convention:

1. *Achieve and maintain a high-level of safety worldwide in spent fuel and radioactive waste management through the enhancement of national measures and international cooperation, including where appropriate, safety-related technical cooperation;*
2. *Ensure that during all stages of spent fuel and radioactive waste management there are effective defenses against potential hazards so that individuals, society, and the environment are protected from harmful effects of ionizing radiation, now and in the future in such a way that needs and aspirations of the present generation are met without compromising the ability of future generations to meet their needs and aspirations; and*
3. *Prevent accidents with radiological consequences, and mitigate such consequences should they occur during any stage of spent fuel or radioactive waste management.*

The report format and content follow guidelines agreed to at the preparatory meeting of Contracting Parties to the Joint Convention in December 2001, as amended.[5] Chapters and annexes (or appendices) in this report have the same titles as prescribed in these guidelines, facilitating review by other Contracting Parties. Table A-1 provides a cross-reference between the chapters in this report and the specific reporting requirements in the Joint Convention.

Table A-1. Joint Convention Reporting Requirements

National Report Section	Joint Convention Section
A. Introduction	
B. Policies and Practices	Article 32, Paragraph 1
22*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. General Safety Provisions	Articles 21-26; Articles 4-9 ; Articles 11-16
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. Planned Activities to Improve Safety	Multiple Articles
L. Annexes	Multiple Articles

Information in this report is derived from publicly available information sources. More detailed information can be found at the internet web sites listed in Table A-2.

[5]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, Vienna, Austria, December 13, 2002. http://www.iaea.org/Publications/Documents/Conventions/jointconv.html

Table A-2. Key Sources of Information Available on the Internet
Code of Federal Regulations
Access to all regulations: http://www.access.gpo.gov/cgi-bin/cfrassemble.cgi?title=2006
Energy, Title 10: (Includes DOE and NRC regulations): http://www.access.gpo.gov/cgi-bin/cfrassemble.cgi?title=200510
Protection of the Environment, Title 40: http://www.access.gpo.gov/cgi-bin/cfrassemble.cgi?title=200540
U.S. Department of Energy
Homepage: http://www.energy.gov
Office of Environment, Safety, and Health: http://tis.eh.doe.gov/portal/home.htm
Office of Environmental Management: http://www.em.doe.gov/index4.html
Office of Civilian Radioactive Waste Management: http://www.ocrwm.doe.gov/
Office of Independent Assessment and Performance Assurance: http://www.oa.doe.gov/
Energy Information Administration: http://www.eia.doe.gov/fuelnuclear.html
Integrated Safety Management: http://www.eh.doe.gov/ism/
Orders and directives: http://www.directives.doe.gov/
Technical standards: http://tis.eh.doe.gov/techstds/
Waste Isolation Pilot Plant: http://www.wipp.ws/
U.S. Nuclear Regulatory Commission
Homepage: http://www.nrc.gov/
Regulations: http://www.nrc.gov/reading-rm/doc-collections/cfr/
Regulatory guides: http://www.nrc.gov/reading-rm/doc-collections/reg-guides/
Statutes and legislation: http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0980/
Advisory Committee on Nuclear Waste: http://www.nrc.gov/what-we-do/regulatory/advisory/acnw.html
Radioactive waste: http://www.nrc.gov/waste.html
Nuclear materials: http://www.nrc.gov/materials.html
Nuclear Materials Decommissioning: http://www.nrc.gov/what-we-do/regulatory/decommissioning.html
Nuclear Reactor Decommissioning: http://www.nrc.gov/what-we-do/regulatory/decommissioning.html
U.S. Environmental Protection Agency
Homepage: http://www.epa.gov/
Regulations: http://www.epa.gov/epahome/cfr40.htm
Major environmental laws: http://www.epa.gov/epahome/laws.htm
Office of Air and Radiation: http://www.epa.gov/oar
Office of Solid Waste: http://www.epa.gov/osw/
Radiation Program: http://www.epa.gov/radiation/
Waste Isolation Pilot Plant Oversight: http://www.epa.gov/radiation/wipp/index.html
Yucca Mountain Standards: http://www.epa.gov/radiation/yucca/index.html
Other
U.S. Department of State, Bureau of Nonproliferation: http://www.state.gov/t/np/
U.S. Defense Nuclear Facilities Safety Board: http://www.dnfsb.gov/
National Academy of Sciences: http://www4.nationalacademies.org/nas/nashome.nsf
National Council on Radiation Protection and Measurements: http://www.ncrp.com/
U.S. Nuclear Waste Technical Review Board (NWTRB): http://www.nwtrb.gov/
Conference of Radiation Control Directors, Inc.: http://www.crcpd.org/
U.S. Customs and Border Protection: http://www.customs.ustreas.gov/
Department of Homeland Security: http://www.dhs.gov
U.S. Army Corps of Engineers Formerly Utilized Sites Remedial Action Program: http://hq.environmental.usace.army.mil/programs/fusrap/fusrap.html

The internet references provided in this report were available to the public and accurate as of the publication date. In some cases some of these URLs may change over time or no longer be active.

A.2 Summary Results from the Previous Review

The *Guidelines Regarding the Form and Structure of a National Report* specify each National Report should contain conclusions from the discussion of the National Report at the previous Review Meeting and to what extent the discussion and comparisons with the practices of other Contracting Parties have made evident strong features in its current practices; and areas for improvement and major challenges for the future. The U.S. has six decades of experience in the operations of spent fuel and radioactive waste management facilities. The U.S. found the first review process under the Joint Convention confirmed the existence of a high quality and successful program to safely manage and dispose of spent fuel and radioactive waste – the U.S. national policy is safe permanent disposal of spent fuel and radioactive waste to ensure long-term containment and isolation from the environment.

Information to meet the Joint Convention reporting requirements was compiled into an integrated, National Report comprehensively documenting the safety of radioactive waste management in the U.S. The U.S. National Report was published in May 2003 and distributed to 32 other contracting parties for review prior to the First Review Meeting of the Parties in November 2003. The U.S. received 167 written questions or comments from 17 Contracting Parties. Written responses to these questions or comments were provided prior to the review meeting. These questions and comments were considered during the preparation of this report. The U.S. review session was held on November 4, 2003. A summary presentation was given by members of the U.S. delegation followed by a question and answer period. Feedback from Contracting Parties on the U.S. report and presentation session was very positive. There was unanimous consent from those present the report and presentation were informative, comprehensive, transparent, and fulfilled the requirements of the Joint Convention.

The first review urged nations to commit to a reliable waste disposal capability for all their waste, and must not assume other nations or future generations will solve their disposal issues. Many Contracting Parties hoped for the possibility of an international or regional repository to meet their disposal needs, highlighting the progress the U.S. has made toward geologic disposal of spent fuel and high-level waste at the planned Yucca Mountain repository. The review also noted the operation of the world's only deep geological repository for disposal of transuranic (long-lived) radioactive waste at the Waste Isolation Pilot Plant (WIPP). WIPP set a standard for successful disposal operation. The review highlighted the difficulties most nations are facing about geologic disposal. Many of the questions asked during the U.S. review session focused on topics related to Yucca Mountain, reflecting international interest in this project. The U.S. is also focusing on maintaining capacity for low-level radioactive waste disposal facilities and developing disposal capacity for greater-than-class C low-level waste.

There was feedback during the November 2003 review from a group of Contracting Parties recommending an extension to the U.S. deadline for return of foreign research reactor spent fuel. The U.S. policy has now been changed and is discussed later in this report. This is a key part of a broader U.S. global initiative to increase security of radioactive material.

The U.S. review highlighted extensive experience gained through the decommissioning of a variety of nuclear facilities. The U.S. noted all Contracting Parties would benefit from a strategy to decommission nuclear facilities, preferably at the onset of the project and before licensing, to ensure future waste legacies are avoided. Such a strategy is heavily dependent upon the availability of radioactive waste disposal capability.

The review also pointed out areas in the National Report where additional information was needed. This report includes inventories of stored spent fuel at nuclear power plants and research reactors and an estimate of waste arising from mining of resource ore. Several thematic areas were singled out for additional information, such as regulatory staffing, emergency preparedness, discharges and releases to the environment, inspection and enforcement experience, and dose measurement history. This report includes information on these topics.

B. POLICIES AND PRACTICES

This section summarizes the U.S. national policy for spent fuel and radioactive waste management, and related nuclear activities. The section also describes:

- The different roles and responsibilities of Federal Government agencies and commercial or private sector entities in the use of nuclear energy in the U.S.;
- The classification of spent fuel and types of radioactive waste; and
- The practices for spent fuel and radioactive waste management, including background information.

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

The U.S. Congress engaged in a vigorous and contentious debate over civilian versus military control of the atom following World War II. The Atomic Energy Act of 1946 resolved the debate by creating the Atomic Energy Commission (AEC) to assume authority over the sprawling scientific and industrial complex built by the military during the War. The AEC was the predecessor of current U.S. Government agencies governing nuclear activities.

The Atomic Energy Act of 1954 assigned AEC the functions of both encouraging the use of nuclear power and regulating its safety. AEC regulatory programs sought to ensure public health and safety from the hazards of nuclear power without imposing excessive requirements inhibiting the growth of the industry. The Atomic Energy Act of 1954 made development of commercial nuclear power in the private sector possible. The U.S. Government has actively promoted the development of commercial nuclear power and ensured its safe use ever since.

The U.S. Congress passed the Energy Reorganization Act of 1974 and redistributed the functions performed by the AEC to two new agencies. It created NRC as an independent agency to regulate private sector and non-military governmental nuclear power, and the Energy Research and Development Administration (ERDA) to promote energy and nuclear power development. ERDA was also responsible for defense nuclear activities. NRC was established as an independent authority governed by a five-member Commission to regulate the possession and use of nuclear materials as well as siting, construction, and operation of nuclear facilities. ERDA was established to ensure development of all energy sources, increase efficiency and reliability of energy resource use. It was also responsible for AEC military and production activities and general basic research activities. Supporters and critics of nuclear power agreed promotional and regulatory duties of AEC for commercial activities should be assigned to different agencies.

NRC began regulatory operations on January 19, 1975. It 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, commercial sealed sources, including disused sealed sources. NRC is also responsible for licensing commercial nuclear waste management facilities, independent spent fuel management facilities, and the planned Yucca Mountain repository for disposal of high-level waste (HLW) and spent fuel. NRC also oversees certain state programs where NRC has relinquished limited regulatory authority to the individual states.

The Department of Energy Organization Act brought a number of the Federal government's agencies and programs, including ERDA, into a single agency, DOE, which was made responsible for nuclear energy technology and nuclear weapons programs. DOE has added new nuclear-related activities for environmental clean up of contaminated sites and surplus facilities. DOE retains authority under the Atomic Energy Act of 1954 for regulation of its nuclear activities other than certain specifically designated facilities, such as the repository at Yucca Mountain. DOE is responsible for developing the planned Yucca Mountain site as a repository.

EPA was created in 1970 to address a growing public demand in the U.S. for cleaner water, air, and land. EPA was assigned the daunting task of repairing the damage already done to the environment and established new criteria for a cleaner environment. Under its general authority, EPA establishes generally applicable environmental standards for the protection of the general environment from radioactive material. This authority establishes standards for cleanup of active and inactive uranium mill tailing sites, environmental standards for the uranium fuel cycle, and environmental radiation protection standards for management and disposal of spent fuel (SF), HLW, and transuranic (TRU) waste. EPA standards are implemented and enforced by other government agencies. EPA also regulates disposition of hazardous chemical wastes. EPA promulgates standards for and certifies compliance at the Waste Isolation Pilot Plant (WIPP) repository for the disposal of defense-related TRU waste. EPA standards limit airborne emissions of radionuclides from DOE sites managing defense-related spent fuel and radioactive waste under the Clean Air Act. The regulatory roles of the U.S. Government agencies for nuclear activities are described in detail in Section E.

B.2 Government and Commercial Entities

B.2.1 Government Sector

DOE is responsible for and performs most of the spent fuel and radioactive waste management activities for government-owned and generated waste and materials located, for the most part, on government-owned sites. These activities include management of spent fuel remaining from decades of defense reactor operations, primarily at the Hanford Site, Washington, and Savannah River Site, South Carolina. These operations ceased in the early 1990s. Reprocessing of spent fuel from defense reactors ceased in 1992. DOE has safely stored the remaining defense spent fuel and spent fuel generated in a number of research and test reactors since then. DOE also provides safe storage for the core of the decommissioned Fort St. Vrain gas-cooled reactor and the core of the Three-Mile-Island Unit 2 reactor damaged in an accident in 1979**.**

The U.S. has an aggressive program for the return of “foreign” research reactor fuel originally enriched or supplied by the U.S. This spent fuel is being returned by other nations for safe keeping in the U.S. The U.S. Secretary of Energy announced a new Global Threat Reduction Initiative on May 26, 2004, to remove or secure high-risk nuclear and radiological materials around the world posing a threat. Part of this initiative is continuing the program of accepting

U.S.-origin foreign research reactor spent fuel back into the U.S. Other parts of this initiative include worldwide efforts to:

- Convert research reactors and medical isotope production process to low enriched uranium fuel and targets;
- Assist countries with Russian-origin highly-enriched uranium research reactors in converting to low-enriched uranium fuel; and
- Identify, recover, and store certain domestic radioactive sealed sources and other radiological materials posing a security risk.

The initiative also includes a global materials recovery team to pre-position equipment and assign personnel for urgent nuclear materials recovery operations.

DOE has a complete waste management system for government spent fuel and waste. This includes numerous storage facilities and processing facilities (treatment and conditioning). Disposal facilities for low-level waste (LLW) and the Waste Isolation Pilot Plant for TRU waste are described in other sections of this report. Other waste management treatment and disposal systems support cleanup and closure of facilities no longer serving a DOE mission. More information is provided in Section D on spent fuel and radioactive waste facilities in the government sector.

DOE Order 435.1, *Radioactive Waste Management*, addresses protection of the worker, public health and safety, and the environment for all DOE radioactive waste management. Numerous references are made throughout this report to DOE Order 435.1 and its technical manual and guidance documents. Section H-2 provides additional detail about DOE Order 435.1.

DOE is pursuing licensing and construction of a geologic repository for spent fuel and HLW at Yucca Mountain, Nevada. The planned geologic repository will provide permanent disposal of spent fuel and HLW from commercial and government facilities. More information on the planned geologic repository is provided in Section D.1.2.

Decommissioning activities generate radioactive waste in both the commercial and government sectors. Decommissioning activities are described in Section D.3.

B.2.2 Commercial Sector

Owners and operators of nuclear power plants and other types of facilities generating radioactive waste manage the spent fuel and radioactive waste generated by their facilities prior to disposal. Waste disposal sites, however, will ultimately be administered by U.S. Federal or state governments. Government custody may occur at different stages of the waste management scheme depending on the type of radioactive waste and generating activity. Additional information on commercial spent fuel and radioactive waste management is provided in Section D.

B.2.3 Classification of Spent Fuel and Radioactive Waste

B.2.3.1 Spent Fuel

In the U.S., spent fuel is fuel withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been chemically separated by reprocessing. DOE allows test specimens of fissionable material irradiated for research and development only, and not production of power or plutonium, to be classified as waste, and managed in accordance with DOE Order 435.1, when it is technically infeasible, cost prohibitive, or would increase worker exposure to separate the remaining test specimens from contaminated material.

B.2.3.2 Radioactive Waste

The U.S. radioactive waste classification system has two separate subsystems. One classification subsystem applies to commercial waste and is defined in NRC regulations. The other classification subsystem applies to DOE waste.

Radioactive waste from DOE nuclear operations is classified as HLW, TRU waste, LLW, or mill tailings.[6] Waste may also contain hazardous waste constituents. Waste with both radioactive and hazardous constituents in the U.S. is called “mixed” waste, e.g., mixed LLW or mixed TRU waste.

LLW is classified in the commercial sector as Class A, Class B, Class C and Greater-than-Class C (GTCC) LLW. These classes are defined in NRC regulations (Title 10, Code of Federal Regulations [CFR], Part 61), based on potential LLW hazards and disposal and waste form requirements. Class A LLW contains lower concentrations of radioactive material than Class B LLW, which has lower concentrations than Class C LLW. Table B-1 compares the commercial waste classification structure to IAEA proposed waste classes.

DOE manages waste from its operations using procedures and requirements comparable to those used by NRC for commercial waste. Both NRC and DOE approaches apply similar performance objectives. DOE does not use the NRC LLW classification system for its near surface disposal systems, however. DOE requires each LLW facility operator to conduct a performance analysis considering waste forms and characteristics, site conditions, and facility design. This analysis leads to specific waste acceptance criteria tailored to each of its LLW facilities. Table B-2 compares DOE disposal classification to IAEA proposed waste classes. DOE uses the TRU waste class for long-lived, alpha emitting waste (see Table B-2 for complete definition). Similar NRC regulated commercial waste falls in the GTCC LLW category.

Crosswalk to the IAEA waste classification scheme is approximate based on available waste management data. The data provide a reasonable translation with some uncertainty of the U.S. waste classes into the IAEA proposed classification system. Many nations, like the U.S., have their own reporting categories. It is useful then to compare national classification schemes to a common classification scheme to gain a common understanding for reviews under the Joint Convention. The U.S. provided information to the Net-Enabled Waste Management Data Base program at the IAEA in 2004 to define the U.S. waste classification scheme and compare it to waste classes with proposed waste classes in IAEA Safety Guide 111-G-1.1, *Classification of Radioactive Waste*.

The proposed IAEA waste classes include HLW and low and intermediate level waste (LILW). The LILW class is further subdivided into short-lived (LILW-SL) and long-lived (LILW-LL) subclasses. The IAEA system for classification of radioactive waste does not recognize waste such as those from mining and milling uranium ore. Despite having fairly long half-lives, the IAEA notes that mining and milling wastes may have concentrations low enough to allow either exemption or disposal in the same fashion as short-lived wastes, depending on safety

[6] Referred to in Section 11e.(2) of the Atomic Energy Act as byproduct material.

analyses.[7] Table B-1 and Table B-2 show no correlation with the IAEA system for 11e.(2) byproduct material.

B.2.3.3 Materials Considered Radioactive Waste

U.S. radioactive waste has many designations for its hazards and the circumstances and processes in which it is created. Uranium mill tailings, the final byproduct of the uranium ore extraction process, are considered radioactive wastes. The day-to-day rubbish generated in medical laboratories and hospitals, contaminated by medical radioisotopes, is also designated radioactive waste. Tailings from industrial extraction of metals and minerals of value (such as molybdenum or vanadium) are not routinely considered radioactive waste, but the processor of tailings having elevated levels of natural radionuclides may be licensed by NRC. The laws also specify which chemical and physical forms are regulated and controlled, and also by which Federal or state entity.

NRC regulates most, but not all, sources of radioactivity, including LLW and HLW disposal, and source material (uranium and thorium), special nuclear material (enriched uranium and plutonium), and byproduct material (material made radioactive in a reactor and residues from the milling of uranium and thorium. Regulations addressing various aspects of the generation and control of radioactive wastes and other nuclear activities are codified in the U.S. Code of Federal Regulations (CFR). These regulations, found in Title 10 (“Energy”) of the CFR, address the storage, treatment, and possession of radioactive waste. Section E provides discussion about the various regulations.

Currently the individual states[8] in the U.S. usually regulate the sources of radiation that NRC does not regulate. For example, naturally occurring radioactive materials (NORM) such as radium and radon, and radioactive materials produced in particle accelerators, such as cobalt-57, are regulated by the states rather than NRC. Radiation producing machines, such as particle accelerators and x-ray machines (both medical and industrial) are also regulated by the states. However, the Energy Policy Act of 2005 (EPACT05) signed into law in August 2005 authorizes NRC to regulate accelerator-produced material and radium-226 among other changes. NRC is developing regulations and procedures to address its new EPACT05 responsibilities.

The Office of Surface Mining of the U.S. Department of Interior and the individual states regulate mining of uranium ore. Other extraction mining and refinement operations for metals, phosphates, etc. may concentrate naturally occurring radionuclides in these tailings materials. Some mineral extraction processes (not for nuclear content) are specifically licensed by NRC, because they incidentally result from the use, or concentration, of material above 0.05 percent by weight source material. Identified processors are required to obtain a NRC license. See Section C-2 for more information on these materials.

B.3 Spent Fuel Management Practices

This subsection provides information on spent fuel storage and disposal practices in the U.S. Past reprocessing activities are also described.

[7] Classification of Radioactive Waste, A Safety Guide, Safety Series No 111-G-1.1, IAEA1994.
[8] In this context, “states” within the United States of America are similar to provinces or departments indicating the next level of government below the federal level.

Table B-1. U.S. Commercial Radioactive Waste Classification Compared with the IAEA Proposed Classification for Disposal				
Waste Class	**1. U.S. Definition**	**IAEA[9] HLW**	**IAEA LILW-LL**	**IAEA LILW-SL**
HLW	The highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste containing fission products in sufficient concentrations and other highly radioactive material that the Commission, consistent with existing law, determines by rule requires permanent isolation. [10]	100%	0%	0%
Greater Than Class C (GTCC) LLW	Waste not generally acceptable for near-surface disposal is waste from which form and disposal methods must be different, and in general more stringent, than those specified in Class C waste. In the absence of specific requirements in this part, such waste must be disposed of in a geologic repository as defined in 10CFR Part 60 or 63 unless proposals for disposal of such waste in a 10CFR Part 60 licensed disposal site are approved by NRC. Radionuclide concentration (individual or combinations of isotopes) exceeds 10CFR61.55 limits in Table 1 (long-lived) or Table 2, Column 3 (short lived).	0%	100%	0%
Class C LLW	Waste that not only must meet more rigorous requirements on waste form to ensure stability but also requires additional measures at the disposal facility to protect against inadvertent intrusion. Must meet both the minimum and stability requirements in the 10CFR61.55. Radionuclide concentration per 10CFR61.55 falls between 10% and 100% of values on Table 1 (long-lived radionuclides) or between the values in Column 2 and Column 3 of Table 2 (short lived radionuclides) with application of sum of fractions rule for isotope mixtures.	0%	25%[11]	75%
Class B LLW	Waste that must meet more rigorous requirements on waste form to ensure stability. The physical form and characteristics must meet both the minimum and stability requirements in the 10CFR61.56. Concentration limits of certain short-lived radionuclides are higher than Class A limits as defined in 10CFR61.55 Column 2 of Table 2 (short-lived radionuclides).	0%	0%	100%
Class A LLW	The physical form and characteristics must meet the minimum requirements in 10CFR61.56. Concentration is limited in 10CFR61.55, e.g. to concentration limits in Column 1 of Table 2 (short-lived radionuclides) or 10% of limits in Table 1 (long-lived radionuclides) or combinations thereof by sum of fractions rule.	0%	0%	100%
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.[12]	0%	0%	0%

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[9] IAEA, Classification of Radioactive Waste; A Safety Guide, Safety Series No. 111-G-1.1.
[10] From the Nuclear Waste Policy Act, as amended.
[11] A reasonable estimate of the split of Class C waste into the IAEA categories is by the fraction of waste classified as Class C by long-lived radionuclides per 10CFR61.55 Table 1 to compare with IAEA LILW-LL. Percentages determined based on commercial disposal data for 1998–2000.
[12] Title 10 CFR Part 40, Domestic Licensing of Source Material (Section 40.4)

Table B-2. DOE Radioactive Waste Classification Compared with the IAEA Proposed Classification for Disposal[13]				
Waste Class	**U.S. Definition**	**IAEA[i] HLW**	**IAEA LILW-LL**	**IAEA LILW-SL**
HLW	High-level waste is the highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste containing fission products in sufficient concentrations; and other highly radioactive material that is determined, consistent with existing law, to require permanent isolation. (Reference: DOE Manual 435.1, *Radioactive Waste Management*, adapted from: Nuclear Waste Policy Act of 1982 (NWPA), as amended.)	100%	0%	0%
TRU	Radioactive waste containing more than 3,700 becquerels (100 nanocuries) of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20-years, except for: (1) HLW, (2) waste that the Secretary of Energy has determined, with the concurrence of the Administrator of EPA, does not need the degree of isolation required by the 40 CFR Part 191 disposal regulations; or (3) waste NRC has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61. (Reference: DOE Manual 435.1, *Radioactive Waste Management* citing the Waste Isolation Pilot Plant Land Withdrawal Act of 1992 (WIPP LWA), as amended)	0%	100%	0%
LLW	Radioactive waste that is not HLW, spent fuel, TRU waste, byproduct material (as defined in section 11(e)2 of the Atomic Energy Act of 1954, as amended), or naturally occurring radioactive material. Reference: DOE Manual 435.1, *Radioactive Waste Management* citing the Nuclear Waste Policy Act of 1982, as amended)	0%	0.5%	99.5%
11e.(2) Byproduct Material	The tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content. (Reference: DOE Manual 435.1, *Radioactive Waste Management* citing Atomic Energy Act of 1954, as amended.)	0%	0%	0%

B.3.1 Spent Fuel Storage

U.S. spent fuel has been produced in commercial nuclear power plants, research reactors, and defense reactors. Currently 104 licensed nuclear power reactors provide about 20 percent of the electricity generated in the U.S. Information on U.S. nuclear power reactors is provided in the U.S. National Report for the Convention on Nuclear Safety (Ref NUREG-1650 Rev. 1). All operating nuclear power reactors are storing spent fuel in NRC licensed on-site spent fuel pools (SFPs) or independent spent fuel storage installations (ISFSIs). Nuclear power plants being decommissioned may have spent fuel stored on site. Spent fuel is typically stored on site pending disposal when a nuclear power plant is decommissioned. NRC amended its regulations in 1990 allowing licensees to store spent fuel in NRC-certified dry storage casks, at approved reactor sites. Section D.1.1 provides additional information on spent fuel storage.

Spent fuel from both domestic and foreign research reactors, in addition to limited quantities of commercial spent fuel, is stored at DOE and other research reactor facilities throughout the country. DOE also stores spent fuel from former defense production reactors. Storage of

[13]IAEA, Classification of Radioactive Waste; A Safety Guide, Safety Series No. 111-G-1.1

radioactive waste at DOE sites is managed consistent with regulatory guidelines used at commercial nuclear facilities.

B.3.2 Spent Fuel Disposal

The Nuclear Waste Policy Act (NWPA) of 1982 provides for siting, construction, and operation of a deep geologic repository for the disposal of spent fuel and HLW. NWPA also 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 public health and safety standards; and
- NRC for developing regulations to implement EPA standards, deciding whether or not to license construction, operation, decommissioning and closure of the repository, and certifying packages used to transport spent fuel and HLW to the repository, if it is licensed.

The NWPA, as amended in 1987, directed DOE to characterize a site at Yucca Mountain, Nevada, for its potential use as a geologic repository. Section D.1.2 provides additional information on the planned repository at Yucca Mountain.

B.3.3 Waste Confidence Determination

In 1990, NRC updated an earlier generic determination, finding spent fuel generated in any reactor can be stored safely and without significant environmental impacts for at least 30 years beyond its licensed life. Sufficient repository capacity will be available within 30 years beyond its licensed life for operation of any reactor to dispose of the commercial high-level waste and spent fuel generated by commercial reactors up to that time. Spent fuel from a reactor can either be stored in an SFP or ISFSI, either on site or off site until a permanent disposal facility is licensed. NRC expects sufficient capacity for such storage to be available for at least 30 years beyond the licensed operating life of existing U.S. reactors.

B.3.4 Reprocessing in the United States

Reprocessing, where plutonium, uranium, or both are recovered from spent fuel to be used again in a reactor, was abandoned in the 1970s in the United States because of concerns about nuclear proliferation. Several reprocessing ventures had been contemplated in the 1960s and early 1970s. General Electric Company planned construction of a commercial reprocessing facility near Morris, Illinois, in the late 1960s, but only the storage facility was completed and remains in operation today. Another facility at West Valley, New York, was operated by Nuclear Fuel Services from 1966 to 1972. This facility processed 640 metric tons heavy metal (MTHM) from government and commercial nuclear power plants, resulting in 2.3 million liters of liquid HLW. This was the only commercial reprocessing plant operated in the U.S. The U.S. Government declared a moratorium on domestic reprocessing of commercial spent fuel in 1977. The moratorium was rescinded in 1981, but commercial reprocessing never resumed.

The West Valley Demonstration Project, a research and development project funded by DOE, completed vitrification of the HLW stored at West Valley in 2002. The New York State Energy Research and Development Authority now owns the site. There are 270 canisters filled with vitrified HLW stored at West Valley.

The May 2001 *National Energy Policy* recommended the United States "…develop reprocessing and final treatment technologies that are cleaner, more efficient, less waste-intensive, and more proliferation resistant." These technologies are key components needed for next-generation nuclear energy systems. They form the basis for ongoing DOE research and development programs on advanced nuclear reactors and spent fuel treatment and transmutation technologies.

B.4 Radioactive Waste Management Practices

Radioactive waste in the U.S. results from a number of activities. Each of these will be discussed in the following sections of this report.

B.4.1 Low-Level Waste

Low-level waste typically consists of contaminated protective shoe covers and clothing, wiping rags, mops, filters, reactor water treatment residues, equipment and tools, soil, debris, luminous dials, medical tubes, swabs, injection needles, syringes, and laboratory animal carcasses and tissues. Radioactivity can range from just above background to very high levels, such as parts from inside the reactor vessel in a nuclear power plant. The U.S. has a comprehensive management system for most LLW. Commercial and government facilities exist for LLW processing, including treatment, conditioning, and disposal. Generators prepare LLW for shipment to licensed disposal. Section D.2.2.2 provides additional information on the facilities and inventories of LLW.

LLW disposal volumes and radioactivity vary from year to year based on the types and quantities generated. The volume of operational commercial LLW has been decreasing over the years due to significant advances in volume reduction techniques to offset the high cost of disposal. Large volumes of LLW have been generated in recent years from facility decommissioning and site remediation. LLW specific activity has thus increased.

Commercial LLW disposal facilities are designed, constructed, and operated under licenses issued by either NRC or an Agreement State (see Section H.3) based on NRC health and safety requirements. NRC regulations restrict the waste disposal quantities, forms, and activity levels in commercial LLW facilities.

DOE operates disposal facilities for LLW generated in the government sector under authority of the Atomic Energy Act. DOE also uses commercial LLW disposal sites in certain circumstances. These practices are described further in Section F and Section H.

LLW (Class A, B and C) is currently disposed in near surface facilities. A key factor in the LLW disposal requirements and waste classification system is protecting people during operations and later from their inadvertent intrusion. The design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls are removed. GTCC LLW is stored until an adequate method of disposal is established. GTCC LLW is discussed further in Section D.2.1.2.

B.4.2 Transuranic Waste

Classification as "TRU waste" exists only within DOE government (non-commercial) sector. TRU waste generally consists of protective clothing, tools, glassware, equipment, soils, and sludge contaminated with manmade radioisotopes heavier than uranium. TRU elements are beyond or "heavier" than uranium on the periodic table of the elements. See Table B-2 for the definition of TRU waste. These elements include plutonium, neptunium, americium, curium, and californium. TRU waste is produced during nuclear fuel research and development; during nuclear weapons research, production, and cleanup; and from reprocessing spent fuel. TRU waste is itself divided into two categories, contact-handled and remote-handled, based on its surface dose rate. The maximum radiation dose at the surface of a contact-handled TRU waste container is 2 mSv per hour (200 mrem per hour). Remote-handled TRU waste emits more radiation than contact-handled TRU waste and must be both handled and transported in shielded casks. Surface radiation levels of unshielded containers of remote-handled TRU waste exceed 2 mSv per hour (200 mrem per hour).   Section D.2.2.1 provides information on disposal of TRU waste.

B.4.3   High-Level Waste

The planned Yucca Mountain repository, if licensed, will be used for the disposal of HLW in addition to spent fuel disposal. HLW resulting from commercial reprocessing activities was vitrified and is stored at the former reprocessing plant in West Valley, New York. Defense HLW is stored, managed and treated at three DOE sites. More information on HLW management is provided in Section D.

B.4.4   Uranium Recovery

Uranium recovery is the extraction or concentration of uranium from any ore processed primarily for its source material content.[14] This results in waste from uranium solution extraction processes. These wastes usually have relatively low concentrations of radioactive materials with long half-lives.

Four types of uranium recovery operations are regulated by NRC:

1. Milling of uranium or thorium ore involving conventional processes of excavation and extraction,
2. Solution or “in situ” leach mining involving chemical removal of uranium from subsurface layers by pumping fluids through the formation by a series of injection and recovery wells and is subsequently sent to a processing facility to selectively concentrate the uranium,
3. Heap leach recovery, similar to (2), but generally performed at the earth’s surface by placing dissolution fluids on ore or tailings material piles and collecting the uranium bearing liquid infiltrating through the tailings, and
4. Processing of radioactive waste as an “alternate feed material” through conventional mills to extract the uranium from the waste.

A uranium mill is a chemical plant designed to extract uranium from mined ore. A conventional mill uses uranium ore from either open pit or deep mining. The mined ore is brought to the milling facility by truck where the ore is crushed and leached. The leaching agent not only extracts uranium from the ore, but also other constituents like molybdenum, vanadium, selenium, iron, lead, and arsenic.   Sulfuric acid is usually the leaching agent, but alkaline leaching can also be used. The extraction processes concentrates the uranium into a uranium-oxygen compound (U_3O_8) called yellow cake because of its yellowish color. The remainder of the crushed rock, in processing fluid slurry, is called “tailings”.

In-situ leach (ISL) facilities are another means of extracting uranium from underground. ISLs recover uranium from low-grade ores not economically recoverable by other methods. A leaching agent such as oxygen with sodium carbonate is injected through wells into the ore

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

body to dissolve the uranium. The leach solution is pumped from the formation, and an ion exchange process is used to separate the uranium from the solution.

Solution or ISL mining of uranium became an important component of the U.S. uranium recovery industry in the 1970s. Most NRC-regulated solution mines are in New Mexico, Wyoming, and Nebraska. This method of mining is most effective in permeable geologic formations at shallow to moderate depths where uranium ore bodies are formed in narrow zones by flow of uranium-bearing ground water from oxidizing to reducing conditions.

Uranium recovery facilities are located principally in the Western U.S., where deposits of uranium ore are located. NRC requires licensees to meet regulations compatible with EPA standards for cleanup of uranium and thorium milling sites after processing operations have permanently closed. This includes requirements for long-term stability of byproduct material disposal piles, radon emissions control, water quality protection and cleanup, and cleanup of lands and buildings.

Uranium mills shut down or scaled back operations in the early 1980s, when the price of uranium fell. The only U.S. thorium mill was remediated under the direction of the State of Illinois, an Agreement State. The price of uranium is still depressed and many previously operated mills have cleaned or are cleaning up (decommissioning) waste resulting from extracting uranium from ore based on NRC or Agreement State requirements. This waste, primarily mill tailings (sandy ore residue), poses a potential hazard to public health and safety. The U.S. Congress enacted the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) and established two programs to protect the public and the environment from uranium mill tailings.

UMTRCA Title I established a joint Federal/State-funded program for remedial action at inactive uranium milling sites and “vicinity properties” contaminated from the production of uranium for sale to the Federal government, with ultimate Federal ownership of the tailings disposal sites under general license from NRC. DOE is responsible under Title I for cleanup and remediation of these sites. NRC is required to evaluate DOE designs and implementation activities and, after remediation, concur the site meets EPA standards.

UMTRCA Title II applies to uranium milling licensed by NRC or Agreement States after 1977. Title II of the Act gives authority to NRC to control radiological and non-radiological hazards and EPA to set generally applicable standards (40 CFR Part 192) for both radiological and non-radiological hazards. This Act provides for eventual state or Federal government ownership of the disposal sites under general license from NRC.

B.4.5 Waste from Enrichment and Fuel Fabrication Facilities

The product from uranium recovery facilities is processed to enrich the fissile content. Tailings containing depleted uranium are a byproduct of the gaseous diffusion enrichment process. Fuel manufacturing facilities fabricate enriched nuclear fuel assemblies for light water reactors. This activity includes receipt, possession, storage, and transfer of special nuclear material. The manufacturing process produces pellets, which are sintered and then loaded into fuel rods. Fuel rods are placed in storage and are withdrawn as needed and fabricated into fuel assemblies. Other licensed activities supporting fuel manufacturing include uranium storage, scrap recovery, waste disposal, and laboratory services. Radioactive waste from these processes, which vary in type and amount, is managed within the classes described in Table B-1; e.g., Class A LLW.

DOE is planning to dispose of its inventory of surplus weapons-grade plutonium to address nonproliferation goals with Russia, as well as facilitate closure of former weapons complex sites. A disposition path for surplus weapons-grade plutonium will be fabricating the plutonium into Mixed Oxide (MOX) fuel and then irradiating it in commercial reactors. The irradiated plutonium remaining in the spent fuel cannot be easily re-used in nuclear weapons. Spent MOX fuel would be disposed in the planned geologic repository. Other radioactive waste generated during fabrication will be disposed of in DOE facilities.

B.4.6 Ocean Disposal

The U.S. disposed of some LLW in the ocean in the 1950s and 1960s. This activity, while not specifically regulated, was an accepted method for managing low-level radioactive waste.[15] Authority for such disposals was derived later from the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA), authorizing EPA to issue permits and promulgate regulations for disposing of materials into the territorial waters of the United States. Such disposal could not degrade or endanger human health, welfare, ecological systems, the marine environment, or the economy. It specifically prohibited ocean disposal of HLW. Any request for ocean disposal of LLW requires a permit that must be approved by both houses of U.S. Congress.[16]

B.4.6.1 EPA Actions Relating to Ocean Disposal of LLW

EPA undertook a series of studies to determine the impact of ocean dumping on the marine environment. EPA issued a proposal in 1973 based on these studies, specifying conditions for permits for ocean disposal of LLW. The final rule for such permits was issued on January 11, 1977.[17] No applications for this type of permit have yet been submitted to EPA. Severe national and international restrictions were placed on ocean disposal. Commercial generators and EPA then accelerated the search for acceptable radioactive waste disposal alternatives. Ocean disposal of LLW was discontinued in conformity with U.S. environmental laws and regulations and international agreements designed to prevent marine pollution, such as the London Convention.

B.4.6.2 Status of Ocean Disposal

The U.S. disposed of some radioactive waste at sea before such practices were discontinued. Records of the volume and type of waste disposed in the ocean by the U.S. are incomplete, but EPA records indicate between 1946 and 1970, more than 55,000 containers of radioactive waste were disposed of at sites in the Pacific Ocean. About 34,000 containers of radioactive waste were also disposed of at sites off the East Coast of the United States from 1951 to 1962. The U.S. no longer disposes of radioactive waste in this manner.

A protocol was developed in 1996 to amend the London Convention to ban ocean disposal of radioactive wastes and incineration at sea. Article II of the 1996 Protocol defines the objectives of this amendment as:

> *Contracting Parties shall individually and collectively protect and preserve the marine environment from all sources of pollution and take effective*

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[15] Radiation Protection at EPA: The First 30 Years. EPA 402-B-00-001. August 2000 at URL: http://www.epa.gov/radiation/docs/402-b-00-001.pdf

[16] Marine Protection, Research, and Sanctuaries Act, 33 USC 1801 et seq., 1972.

[17] U.S. Environmental Protection Agency, *40 CFR 220, Ocean Dumping, Final Revision of Regulations and Criteria*, in the *Federal Register* 42 *FR* 2462, January 11, 1977.

measures, according to their scientific, technical and economic capabilities, to prevent, reduce and where practicable eliminate pollution caused by dumping or incineration at sea of wastes or other matter. Where appropriate, they shall harmonize their policies in this regard.

EPA works very closely with other U.S. Federal agencies, including the Department of State, the Coast Guard, the U.S. Army Corps of Engineers (COE), and the National Oceanic and Atmospheric Administration to coordinate the U.S. Government's policies on the London Convention and discussions about ratification of the 1996 Protocol. EPA also works with the same Federal agencies to develop consistent national policies to implement Title I of MPRSA, which governs ocean disposal of material in waters of the U.S. from the baseline to the boundary of the 200-mile Exclusive Economic Zone.

B.5 Decommissioning

Decommissioning is an activity generally taking place at the end of operation of commercial and governmental nuclear facilities. NRC and other governmental agencies' recommendations, and in some cases requirements, include provision for decommissioning planning in the pre-operational design and strategy. Waste from decommissioning is managed within the waste classes in Table B-1 and Table B-2. Additional information is found in Section F.6.

C. SCOPE OF APPLICATION

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

C.1 Application to Reprocessing of Spent Fuel

The U.S. does not have any commercial reprocessing facilities. No declaration is, therefore, needed under Article 3.1.

C.2 Application to Naturally Occurring Radioactive Materials

The Joint Convention does not apply to naturally occurring radioactive materials (NORM) originating outside the nuclear fuel cycle, except when a disused sealed source containing naturally occurring radioactive material is declared radioactive waste by the Contracting Party (Article 3.2).

The U.S. has not declared any byproduct material containing only NORM and originating outside the nuclear fuel cycle as radioactive waste under the Joint Convention. The U.S also considers technologically enhanced NORM (TENORM) materials in the same category as NORM for Joint Convention purposes.

C.3 Application to Defense Activities

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

U.S. military programs are primarily in the United States Department of Defense and the National Nuclear Security Administration. The National Nuclear Security Administration is a separate agency within DOE overseeing the military application of nuclear energy; maintenance and enhancement of the safety, reliability, and performance of the U.S. nuclear weapons stockpile; and development of 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 or other governmental programs. Spent fuel and waste in military programs are managed, however, in accordance with the objectives stated in Article 1 of the Joint Convention.

When waste and spent fuel are permanently transferred to an exclusively civilian program, the Joint Convention applies to their safe management. The Joint Convention will apply to naval reactor spent fuel when accepted for disposal in the planned geologic repository at Yucca Mountain along with commercial spent fuel. The safety case for disposal of spent fuel and HLW from Federal government programs will be addressed in DOE's Yucca Mountain license application, since these will be co-disposed with commercial waste.

C.4 Application to Radioactive Waste and Spent Fuel Management Facilities

The Joint Convention defines radioactive waste management as all activities, including decommissioning activities, relating to handling, pretreatment, treatment, conditioning, storage, or disposal of radioactive waste, excluding off-site transportation. For purposes of the Joint Convention the U.S. has both commercial and government radioactive waste management facilities.

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

The Joint Convention allows Contracting Parties to include the storage of spent fuel at reactor sites as spent fuel management facilities since they generally provide storage for a period of time longer than one year, with the ultimate disposal at a geologic repository.

Article 3 of the Joint Convention allows Contracting Parties to declare facilities undergoing decommissioning as radioactive waste management facilities. The U.S. has facilities in the decommissioning phase declared as waste management facilities by constructing on-site disposal facilities for some of the radioactive waste being generated during cleanup activities. This report further discusses ongoing decommissioning and site remediation activities in Section D.3 and F.6.

D. INVENTORIES AND LISTS

This section covers U.S. obligations under Joint Convention Article 32, Paragraph 2, to report:

i.	*a list of the spent fuel management facilities subject to this Convention, their location, main purpose, and essential features*	D.1
ii.	*an inventory of spent fuel subject to this convention and being held in storage, and spent fuel disposed…a description of the material and…information on its mass and total activity*	
iii.	*a list of the radioactive waste management facilities subject to this Convention, their location, main purpose and essential features*	D.2
iv.	*an inventory of radioactive waste subject to this Convention and being held in storage at radioactive waste management and nuclear fuel cycle facilities; has been disposed of; or as resulted from past practices…and a description of the material and other appropriate information available, such as volume or mass, activity, and specific radionuclides*	
v.	*a list of nuclear facilities being decommissioned and the status of decommissioning activities at those facilities*	D.3

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

Most U.S. commercial spent fuel subject to the Joint Convention will remain at nuclear power plants until the planned geologic repository at Yucca Mountain is operating. Some spent fuel is also being stored away from reactors at Independent Spent Fuel Storage Installations (ISFSIs). The Joint Convention also applies to DOE governmental spent fuel storage facilities, including those used to store foreign research reactor and U.S. research reactor spent fuel transferred to DOE. Radioactive waste management practices are discussed in Sections F and G.

D.1.1 Spent Fuel Storage

The need for alternative storage began to grow in the late 1970s and early 1980s when pools at many commercial nuclear reactors began to fill with stored spent fuel. Dry cask storage allows spent fuel already cooled in the spent fuel pool for at least one year to be surrounded by inert gas inside a container called a canister. The canisters are typically steel cylinders either welded or bolted closed. The steel cylinder provides a leak-tight containment of the spent fuel. Additional steel, concrete, or other material surrounds each cylinder to provide radiation shielding to workers and the public. Some cask designs can be used for both storage and transportation.

Various dry cask storage systems are in use. In some designs, canisters containing the fuel are placed vertically or horizontally in a concrete vault to provide radiation shielding. In other designs the canister is placed vertically on a concrete pad and both metal and concrete outer cylinders are used for radiation shielding. Figure D-1 shows typical dry cask storage systems.

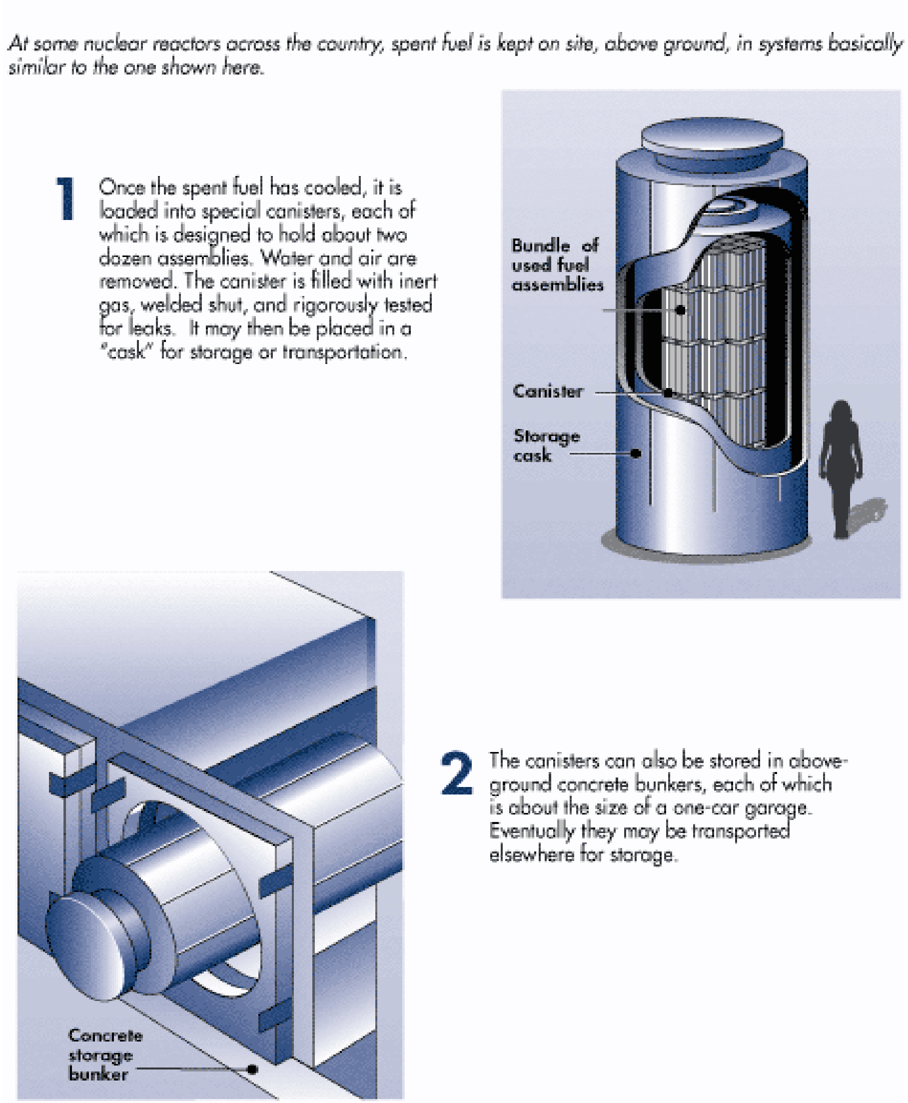

Figure D-1. Typical Dry Cask Storage Systems

The U.S. currently has 33 licensed dry cask storage facilities (ISFSIs), one licensed wet spent fuel storage facility (GE Morris, Illinois), 18 spent fuel storage facilities at government-owned sites, and one planned spent fuel geologic repository. Table D-1 summarizes the types and numbers of U.S. spent fuel storage facilities. A complete list of spent fuel storage facilities is provided in Annex D-1. Figure D-2 shows the location of ISFSIs and other spent fuel storage facilities.

The U.S. commercial nuclear power industry had generated about 47,000 metric tons heavy metal (MTHM) of spent fuel as of the end of 2002. About 4,200 MTHM of this spent fuel were in dry cask storage at 30 commercial nuclear power plants. About 2,450 MTHM of spent fuel is stored at government facilities. Table D-1 summarizes spent fuel storage inventories. Annex D-1 provides the most recent available detailed spent fuel inventories (2003 for Government and University facilities, 2002 for commercial facilities).

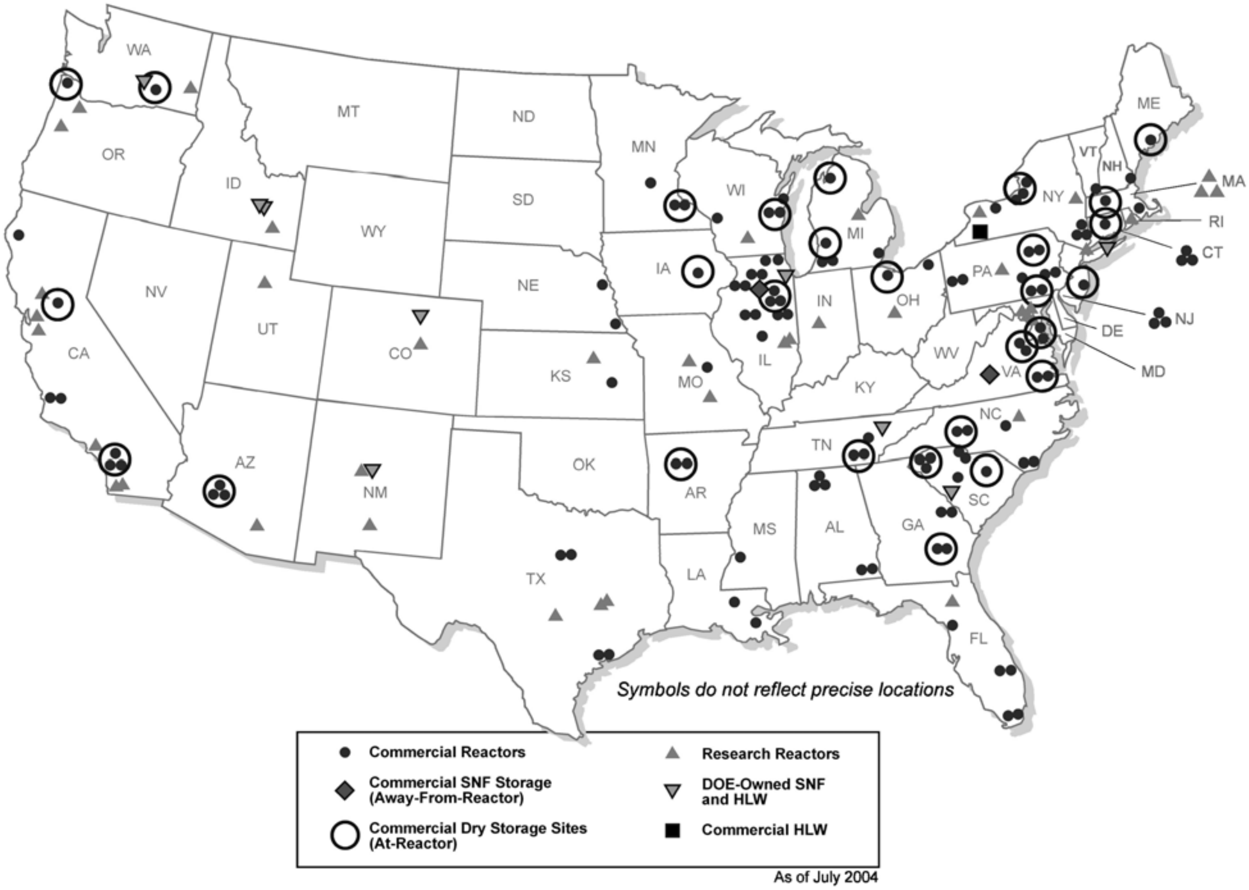

Figure D-2. Location of U.S. Spent Fuel and HLW Storage Installations

Table D-1. Spent Fuel Storage Facilities

Sector	Function	Number of Facilities[18]	Inventory (MTHM[19])
Government	Pool Storage	2	51
	Dry Cask Storage	7	2,399
	Research and Test Reactors	6	<1
Commercial	University Research Reactors	30	1
	Other Research and Test Reactors	5	<1
	At-Reactor Storage Pools	99	42,000[20]
	Independent Spent Fuel Storage Facilities (Dry Cask)[21]	33	4,200
	Independent Spent Fuel Storage Facilities (Pool)	1	700

About 13 percent of all commercial spent fuel assemblies were stored in dry casks at ISFSIs as of December 2004. This percentage is expected to increase as more commercial utility spent fuel pools reach capacity, because they are required to maintain full core reserve capacity.

[18]In some instances multiple facilities at a given installation are counted as a single facility.
[19]Metric tons of heavy metal is the conventional measure of fuel mass in nuclear reactor fuel assemblies.
[20]U.S. Energy Information Administration data as of 2002 for spent fuel in pools at commercial reactor sites.
[21]Includes government held licensed facilities for commercial fuel at Fort St. Vrain and Idaho National Laboratory.

These reactors were not designed to store all the spent fuel generated during their operational lives, and they contribute between 1,800 and 2,200 MTHM annually to the growing inventory of spent fuel. Projected spent fuel discharges (taking into account plant life extensions) could bring the total to 129,000 MTHM by the year 2055.

D.1.2 Spent Fuel Disposal

The Nuclear Waste Policy Act of 1982, as amended, provides for the siting, construction, and operation of a deep geologic repository for disposal of spent fuel and high-level radioactive waste. Any such repository would be licensed by NRC.

The President signed the Congressional Joint Resolution on July 23, 2002, designating the Yucca Mountain site to be developed as a geologic repository based on the results of more than 20 years of intensive science and engineering work. Figure D-3 is a picture of the planned repository site. DOE is preparing a license application for submission to NRC for authorization to begin construction of a repository at Yucca Mountain. NRC will review this application pursuant to 10 CFR Part 63. NRC's decision whether or not to grant the application will be based on the results of a comprehensive safety review and of a full and fair public hearing.

Yucca Mountain is located about 160 kilometers northwest of Las Vegas, Nevada, on unpopulated desert land owned by the Federal government. The long-term average precipitation has been about 30 centimeters per year. Yucca Mountain itself is a ridge of tilted layers of volcanic rock, called tuff that was deposited by a series of eruptions about 11 to 14 million years ago. Geological mapping of the surface and other studies show faults are present in the vicinity of Yucca Mountain. The host rock proposed for the planned repository is a welded tuff unit located about 300 meters below the surface and 300 meters above the water table.

DOE is responsible for transporting spent fuel and HLW from storage locations to the NRC-licensed geologic repository. Spent fuel and HLW would be transported by truck and rail in shipping casks certified by NRC. The material would then be transferred into robust corrosion resistant waste packages for disposal (Figure D-4). NWPA limits the emplacement of waste at the first geologic repository to 70,000 MTHM until a second repository is in operation. DOE will provide a report to the U.S. Congress between 2007 and 2010 on the need for a second repository. Spent fuel and HLW disposed at Yucca Mountain are expected to include about 63,000 MTHM of commercial spent fuel, and 7,000 MTHM from defense related activities (about 2,400 MTHM of DOE spent fuel, and the equivalent of about 4,600 MTHM of DOE HLW).

The design objectives of the repository are to: (1) protect the health and safety of both the workers and the public during the period of repository operations; (2) minimize the amount of radioactive material that may eventually reach the accessible environment; and (3) minimize life cycle costs. The design of the repository will permit it to be kept open, with only routine maintenance, for at least 50 years from the start of waste emplacement. Keeping the repository open means the underground storage areas can be directly inspected and the waste packages readily removed, if necessary. DOE's license application to NRC will describe systems, methods and procedures to enable safe inspection and removal during the operating period. This flexibility will enable repository operations to meet future

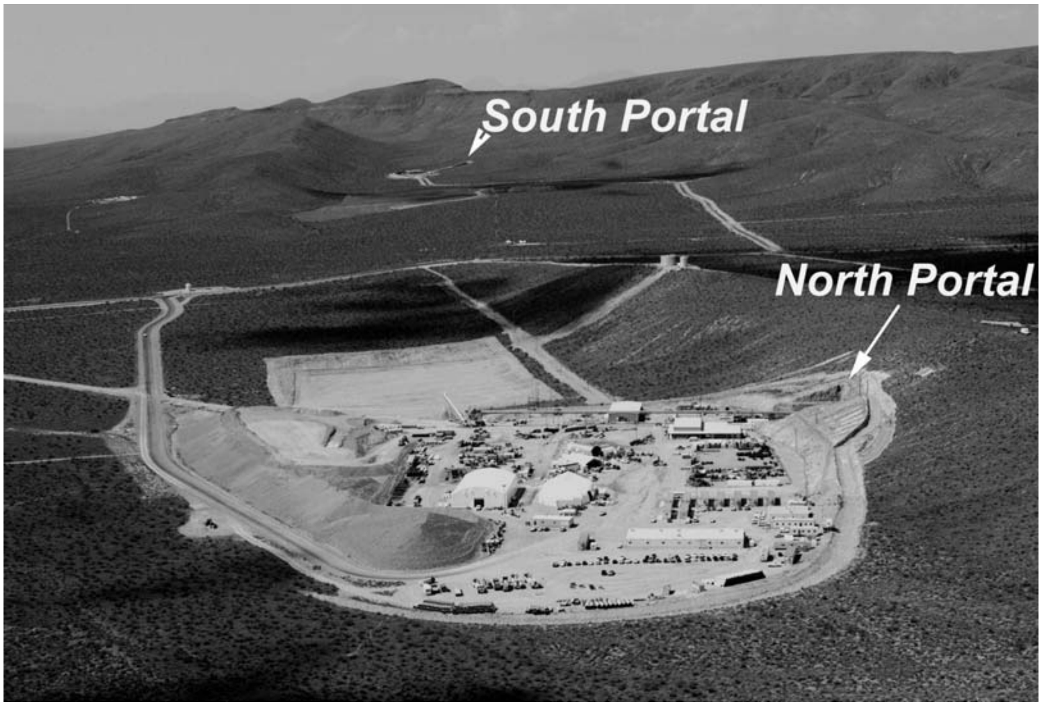

Figure D-3. Repository Site

societal needs. The geologic repository operations area (GROA) must be designed so any or all of the emplaced waste could be retrieved on a reasonable schedule at any time up to 50 years after waste emplacement operations begin, unless a different time period is approved or specified by NRC. Additional information on the licensing process is provided in Section F.3.

D.2 Radioactive Waste Management

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

D.2.1 Radioactive Waste Storage and Treatment

Radioactive wastes are treated primarily to produce a structurally stable final waste form and minimize the release of radioactive and hazardous components. The U.S. does not commonly make a differentiation between the terms treatment and conditioning. Conditioning is defined in the international community as an operation producing a waste package suitable for handling, such as conversion of a liquid to a solid, enclosure of the waste in containers, or overpacking. Treatment is defined as operations intended to improve the safety and/or economy by changing the characteristics of the waste through volume reduction, removal of radionuclides, and change in composition.[22] 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.

[22]International Atomic Energy Agency, *Establishing a National System for Radioactive Waste Management, Safety Series No 111-S-1.1*, Vienna, Austria, 1995.

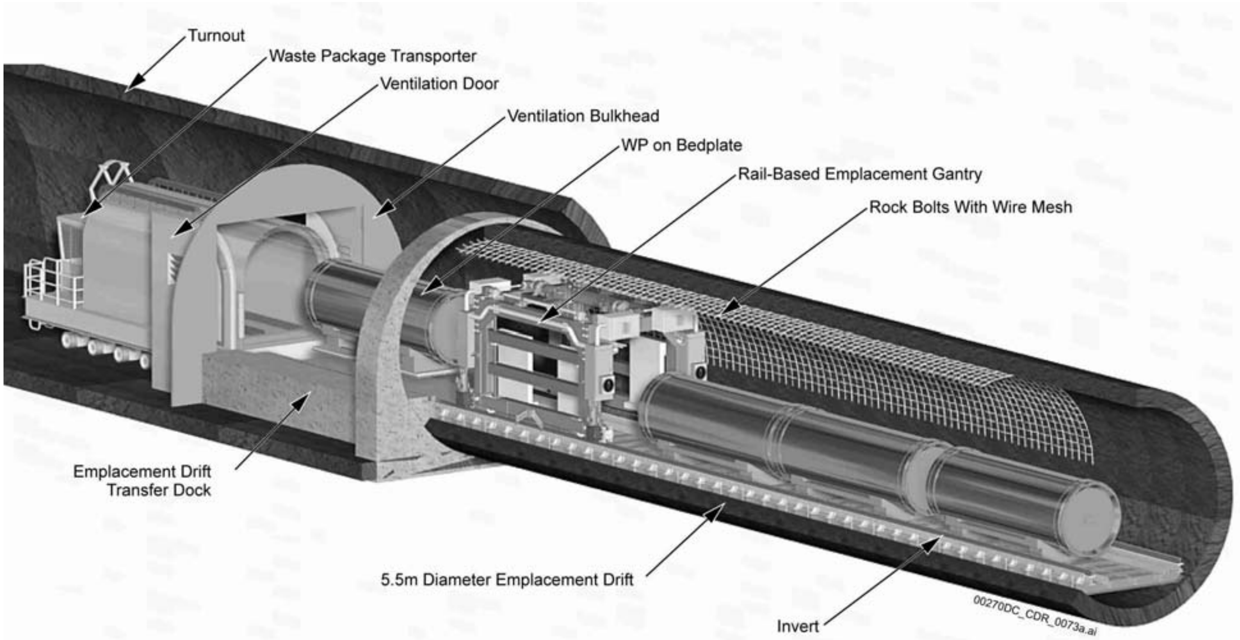

Figure D-4. Conceptual View of Waste Package Emplacement for Disposal

Table D-2 summarizes the U.S. radioactive waste treatment and storage facilities and the inventory in storage as of September 30, 2003. Annex D-2 provides a list of facilities, their location, main purpose, and essential features. The following sections provide a brief description of the major types of radioactive waste management facilities.

Table D-2. Radioactive Waste Storage and Treatment Facilities

Sector	Function	Waste/Material Type	Number[23]	Inventory
Government	Storage/Treatment	HLW	8	356,000 m^3
		TRU	16	136,000 m^3
		LLW [24]	25	104,000 m^3
		11e.(2)	2	206,000 m^3
Commercial	Treatment/Processing	LLW	44	Small volumes for collection

D.2.1.1 HLW Storage and Treatment

U.S. HLW remains in storage at 4 sites where it was generated from reprocessing of spent fuel.

All 2,270 cubic meters (600,000 gallons) of HLW generated from reprocessing at the former commercial reprocessing plant at West Valley, New York, between 1966 and 1972 was vitrified into 275 canisters awaiting disposal in the planned geologic repository. The vitrification plant at West Valley is now being decommissioned.

HLW from reprocessing of defense materials at the Savannah River Site resulted in both solid and liquid forms: insoluble solid chemicals and water soluble salts. The insoluble solids settle

[23]In some instances multiple facilities at a given installation are counted as a single facility.
[24]Includes Mixed LLW.

and accumulate on the bottom of storage tanks as "sludge." Liquid above the sludge is concentrated by evaporation to reduce its volume. The concentrate left behind is a damp "salt cake." About 378,000 cubic meters (100 million gallons) of high-level waste was concentrated by evaporation to a volume of about 140,000 cubic meters. The waste is stored at in steel tanks within concrete vaults until it is treated. The sludge remaining in the waste tanks (which contains most of the radioactivity), along with the radioactive cesium from the salt solution, are transferred to the site's Defense Waste Processing Facility for immobilization in borosilicate glass. The Defense Waste Processing Facility began radioactive operations on March 12, 1996, and will continue operations until all HLW is processed. There were 1,712 canisters of vitrified HLW stored at Savannah River Site in the Glass Waste Storage Building as of September, 2004 awaiting disposal in the planned geologic repository. Each canister is 3 meters (10 feet) tall and 0.6 meters (2 feet) in diameter; it takes about 24 hours to fill one canister. A filled canister weighs about 2.3 metric tons (2.5 tons).

Reprocessing of defense materials at the Hanford Site, began in 1944 and ended nearly 50 years later resulting in 207,000 cubic meters (53 million gallons) of radioactive waste stored underground in 177 tanks. The waste consists of sludge, supernate, and salt cake. The tanks are old. Sixty-seven tanks are believed to have leaked waste into the soil. Continued leakage could threaten the Columbia River, located between 7 and 10 miles away. The waste must be removed and processed to a form suitable for disposal, and the tanks stabilized to protect the Columbia River. DOE plans to process tank waste and dispose the high-level portion (vitrified HLW) at the planned geologic repository. The interim stabilization of all single-shell tanks has been completed (all pumpable liquids removed), and waste is being retrieved from these tanks in preparation for interim closure. Waste in one tank has been fully retrieved. Design and construction of the Waste Treatment Plant, which includes a pretreatment facility, low-activity waste treatment facility, high-level waste facility, and analytical laboratory is progressing. This project is one of the largest construction projects in the U.S. Treatment of Hanford HLW is planned to begin in 2011 and end in 2027.

Radioactive waste from for more than 50 years of defense spent fuel reprocessing at the Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, has been stored in tanks and treated for disposal in a geologic repository. The tank farm includes eleven 300,000-gallon underground storage tanks and four 30,000 gallon underground storage tanks. As of February 28, 2005, seven of the eleven 300,000-gallon storage tanks and all four 30,000-gallon tanks were emptied, with a remaining 3,300 cubic meters (873,700 gallons) in the remaining 3 tanks. Much of the waste was previously treated and is now stored as calcine (4,400 cubic meters) in bins. The remaining liquid HLW contains a high concentration of sodium. DOE has selected four technologies: calcination, steam reforming, cesium ion exchange and direct evaporation for further evaluation in treating the sodium-bearing waste. Treatment of all waste is expected to finish by the end of 2012. A decision on further treatment of calcine HLW is expected in 2009.

Although residual tank wastes have been managed as high level wastes, it should be noted that theses wastes may be determined to be low level wastes. Section 3116 of the National Defense Authorization Act (NDAA) for Fiscal Year 2005 provides that the Secretary of Energy, inconsultation with NRC, may determine that certain radioactive waste resulting from reprocessing of spent fuel is not high level waste. Furthermore, DOE also has the authority to determine that certain wastes are not high level waste under the Waste Incidental to Reprocessing (WIR) provisions of DOE Manual 435.1-1, *Radioactive Waste Management*.

D.2.1.2 Greater-Than-Class-C Low-Level Waste Storage and Treatment

Greater-than-Class-C (GTCC) waste is a form of low-level radioactive waste containing long- and short-lived radionuclides with properties dictating a more robust disposal strategy than for other classes of LLW.[25] The authority to possess this type of radioactive material is included in the reactor license. Most forms of GTCC waste are generated by routine operations at nuclear power plants, fuel research facilities, and manufacturers of radiopharmaceuticals and sealed sources. The decommissioning of nuclear power reactors also generates GTCC waste. Examples of GTCC waste include some activated metal hardware (e.g., nuclear power reactor control rods), spent fuel disassembly hardware, ion exchange resins, filters, evaporator residues, sealed sources used in medical and industrial applications, moisture and density gauges, and contaminated trash. Typical radionuclides associated with GTCC waste are ^{14}C, ^{59}Ni, ^{94}Nb, ^{60}Co, ^{99}Tc, ^{129}I, ^{90}Sr, and ^{137}Cs.[26]

Table D-3 provides estimates of GTCC LLW quantities. The estimates shown in this table, though a decade old, provide insight into future inventories. The quantity of GTCC waste being generated is generally lower than the estimates based on experience. The projected amounts of sealed sources in Table D-3 may be underestimated, however. GTCC waste is being stored until an adequate disposal method is established. The Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA) requires GTCC waste be disposed in a NRC-licensed facility. Environmental impacts of the various options for GTCC waste disposal are being examined.

Table D-3. Greater-Than-Class-C Waste Inventory[27]

Source	1993 Inventory (m^3)	Projected Future Life-Cycle Inventory (m^3)
Nuclear electric utility	26	1,300
Sealed sources	39	240
Other Generators	74	470
Totals	***139***	***2,010***

D.2.1.3 LLW Storage and Treatment

The U.S. treats radioactive wastes to remove free liquids, stabilize or destroy other hazardous components contained in the waste, and/or reduce the final disposal volume through compaction. This treatment is limited to some TRU wastes and some LLW. There are private companies in the U.S. called “waste brokers” providing packaging, treatment, and disposal services. Some of these waste brokers serve limited clientele. Others perform these services for a wider body of clients. Annex D-2 includes a number of these brokers.

D.2.2 Radioactive Waste Disposal

DOE HLW is planned to be disposed, along with spent fuel, in the planned geologic repository. See Section D.1.2. Radioactive waste management practices are discussed in Section F and Section H.

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[25]Title 10, *Code of Federal Regulations*, Part 61.55; Tables 1 and 2 for long and short lived radionuclides, respectively.

[26]Taken from http://www.state.nv.us/nucwaste/gtcc/gtcc.htm

[27]From Yucca Mountain EIS, primary source is DIRS 101798-DOE (1994).

The cumulative inventory of disposed radioactive waste September 30, 2004 is shown in Table D-4. Annex D-2 provides more detailed information on the quantities for each disposal facility.

Table D-4. Radioactive Waste Disposal Facilities

Sector	Facility Type	Waste Type	Number	Inventory
Government/ Commercial	Planned Geologic Repository (Yucca Mountain)	HLW (also Spent Fuel)	1	0
Government	Geologic Repository (WIPP)	TRU	1	24,000 m^3
	Closed Greater Confinement Disposal (boreholes)	TRU	1	200 m^3
	Near Surface Disposal	LLW [28]	19	5,800,000 m^3
Commercial	Operating Near Surface Disposal	LLW (Class A, B, C)	3	2,660,000 m^3
		11e.(2)	1	1,010,000 m^3
	Closed Near Surface Disposal	LLW	4	438,000 m^3
Government/ Commercial	Title I UMTRCA Disposal	Residual Radioactive Material (tailings)	20	163,000,000 Metric Tons
Commercial	Title II UMTRCA Disposal	11e.(2)	39	
Government	Other Closed Disposal Cells (Weldon Spring Site and Monticello)	Residual Radioactive Material (tailings)	2	3,120,000 m^3

D.2.2.1 Transuranic Waste Disposal

The Waste Isolation Pilot Plant (WIPP) is a geologic repository to safely and permanently dispose of TRU radioactive waste left from the research and production of nuclear weapons. WIPP began operations on March 26, 1999, after more than 20 years of scientific study, public input, and regulatory review.

WIPP is located in the remote Chihuahuan Desert of southeastern New Mexico, about 80 kilometers (50 miles) from Carlsbad, New Mexico. The repository consists of disposal rooms mined 655 meters (2,150 feet) underground in a 600 meter-thick (2,000 feet) salt formation. This formation has been stable for more than 200 million years (see Figure D-5). The TRU waste currently stored at 23 locations nationwide will be shipped to and disposed of at WIPP over the next 35 years. WIPP is expected to receive about 170,000 cubic meters of waste in 37,000 shipments. About 24,000 cubic meters of contact-handled TRU waste were disposed at WIPP as of September 30, 2004.

The WIPP cannot accept remote-handled TRU waste until ongoing regulatory actions are complete. By law, WIPP cannot accept:

- Remote-handled TRU waste with a surface dose rate in excess of 10 Sv per hour (1,000 rem per hour),
- More than 5 percent by volume of remote-handled TRU waste with a surface dose rate in excess of 1 Sv per hour (100 rem per hour), and
- More than 1.8E5 Tbq (5.1 million curies) of remote-handled TRU waste.

[28]Includes Mixed LLW.

If permitted, a limit of 7,079 cubic meters (250,000 cubic feet) of remote-handled TRU waste can be disposed in the WIPP.

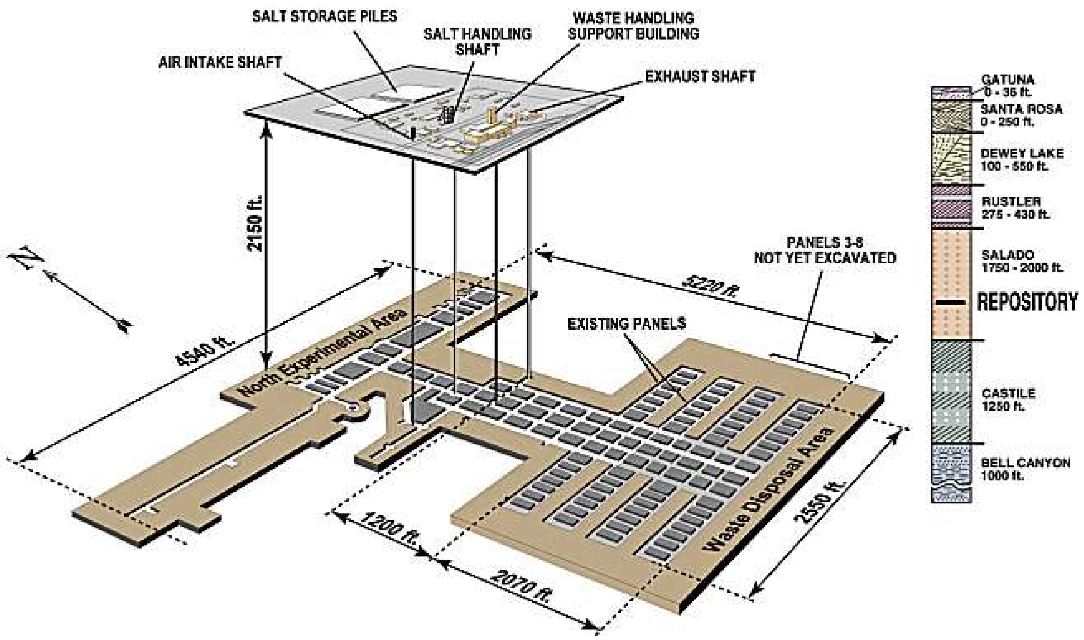

Figure D-5. WIPP Schematic and Stratigraphic Sequence

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

There are currently three active, licensed commercial LLW disposal sites; however, none can accept GTCC LLW. A license application for a fourth facility is pending:

- GTS-Duratek/Chem-Nuclear (Barnwell, South Carolina) - Access is currently authorized for LLW generators not limited or bound by compact rules (see Section H.1), but plans to close to waste outside of the Atlantic Compact (South Carolina, Connecticut, and New Jersey) in 2008. Barnwell disposes of Class A, B and C LLW.
- U.S. Ecology (on DOE's Hanford Site near Richland, Washington) - restricted access to only the Northwest and Rocky Mountain Compacts. U.S. Ecology disposes of Class A, B and C LLW.
- Envirocare of Utah (Clive, Utah) - accepts Class A LLW and mixed LLW for LLW generators not limited or bound by compact rules (see Section H.1).
- A license application is under review by the State of Texas for a new commercial LLW disposal site at Waste Control Specialists near Andrews, Texas. The proposed site includes a facility to dispose of LLW for the Texas compact and a facility to dispose of Federal mixed LLW and LLW. A licensing decision is not expected before December 2007.

Commercial LLW sites now closed are: Beatty, Nevada (closed 1993); Maxey Flats, Kentucky (closed 1977); Sheffield, Illinois (closed 1978), and West Valley, New York (closed 1975).

Table D-5 provides a breakdown of LLW commercially disposed in 2004, a representative year[29]. About 55 percent of the LLW commercially disposed in 2003 is from government

[29]Source MIMS database, DOE December 2004, see http://mims.apps.em.doe.gov/mims.asp#

sources, including Federal, state and local governments. No commercial LLW is disposed in DOE (government) facilities, but DOE does dispose of LLW at both government and commercial facilities, when economical. Industry, including waste brokers and processors, accounts for 30 percent of the volume of LLW disposed commercially. Nuclear power plant operations generate 15 percent of the volume of waste disposed commercially, and about 0.1 percent is from academic and medical sources.

Table D-5. Low-Level Waste Received at Commercial Disposal Sites in 2004
(Volume in cubic meters)

Source	Class A	Class B	Class C	Total
Academic	28	0	1.5	29
Government (from DOE)	258,000	0	0	258,000
Government (non-DOE)	17,613	20	26	17,659
Industry	35,491	7	15	35,513
Medical	1.6	0	0.7	2
Utility	55,391	385	447	56,223
Government Mixed LLW (from DOE)	8,900	0	0	8,900
All other Mixed LLW	273	0	0	273
Total	***376,000***	***412***	***490***	***377,000***

Over 99 percent of the LLW volume disposed of at commercial sites was Class A LLW, most of which was disposed of at the Clive, Utah site, with the remaining volume split between the Barnwell, South Carolina, and U.S. Ecology, Richland, Washington, sites. Over 97 percent of Class B LLW and over 99 percent of Class C waste was disposed at the Barnwell site, with the remainder disposed at Richland.

DOE operates disposal facilities for LLW at: Hanford, Washington; Idaho National Laboratory, Idaho; Los Alamos National Laboratory (LANL), New Mexico; Nevada Test Site, Nevada; and Savannah River Site, South Carolina. DOE also operates LLW disposal facilities for waste from cleanup projects (generally large volumes with low concentrations) at Fernald, Ohio; Hanford, Idaho National Laboratory, and Oak Ridge, Tennessee. Figure D-6 provides a conceptual illustration of a LLW disposal facility.

There are also closed disposal facilities managed by DOE. One such facility is greater confinement disposal (boreholes) used to dispose of certain transuranic and other defense waste at the Nevada Test Site. There are closed burial grounds for LLW used decades ago for disposal of wastes resulting from defense activities, e.g., at Hanford, Oak Ridge, and Savannah River. Hydrofracture was once used at Oak Ridge, Tennessee, for disposal of waste in slate formations beneath the site.

In addition to the LLW facilities discussed above, U.S. waste generators also may use hazardous waste disposal facilities for disposal of waste with very low-levels of radioactive constituents. These facilities are designed to isolate hazardous waste substances from the environment, but are also effective in isolating radioactive constituents and may offer cost and efficiency benefits. Some sites are used for disposal of naturally occurring radioactive materials, and therefore already have procedures and features for ensuring safety of disposal of low activity radioactive waste. Waste originating in the nuclear fuel cycle, if appropriate, is disposed in these facilities under specifically authorized limits, after a safety analysis is performed.

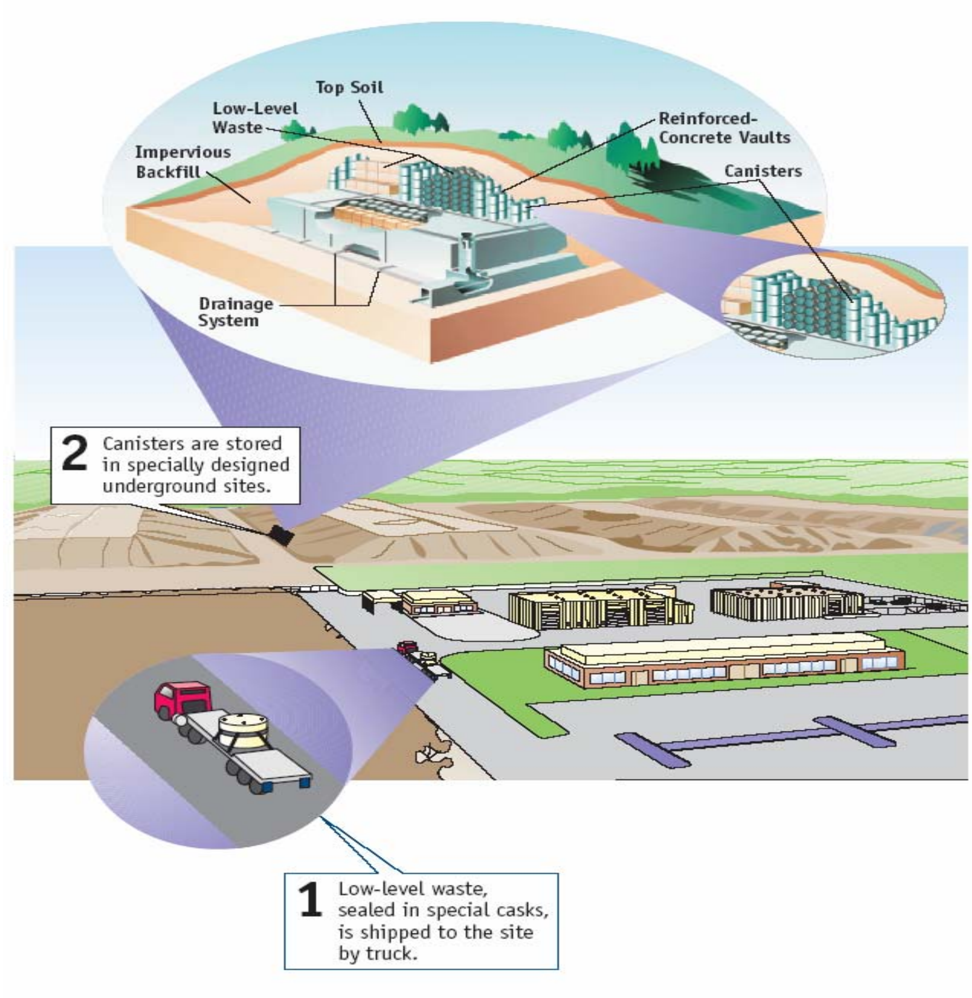

Figure D-6. Concept of a LLW Disposal Facility

D.2.2.3 Uranium Mill Tailings Disposal

Section B.4.4 describes uranium recovery in the U.S. The types of uranium recovery facilities are diverse, but the waste forms are classified either as residual radioactive material (UMTRCA Title I facility waste) or 11e.(2) byproduct material (UMTRCA Title II). Mill tailings consist of fine-grained, sand-like and silty materials, usually deposited in large piles next to the mill processing the ore. Tailings are generated during the milling of certain ores to extract uranium and thorium. These wastes have relatively low concentrations of radioactive materials with long half-lives, including radium (generates radon by radioactive decay), thorium, and small residual amounts of uranium not extracted during the milling process.

The conventional tailings pile is a constructed impoundment or a former uranium mine pit meeting criteria in 10 CFR Part 40, Appendix A (or compatible state regulations). These criteria include requirements for siting and design of the pile, cover performance, and financial surety for decommissioning, reclamation, and long-term surveillance.

Mills are typically located in areas of low population density, and process ores from mines within about 50 kilometers (30 miles) of the mill. Most mills in the U.S. are being decommissioned.

One is in standby and two are still in operation (International Uranium Corporation, White Mesa in Utah and Cotter Corporation in Colorado).

D.2.2.3.1 UMTRCA Title I Mill Tailings Sites

The Uranium Mill Tailings Radiation Control Act of 1978 required DOE to complete surface remediation and ground water cleanup at inactive uranium milling sites and contaminated vicinity properties where uranium was processed solely for sale to the Federal government and not licensed in 1978. Tailings from some sites were combined, resulting in 18 tailings sites under long-term surveillance and two being actively remediated. These piles range in size from 46,000 to 3.5 million cubic meters of material. The inactive sites are located in western states, except for a site at Canonsburg, Pennsylvania, and an associated property at Burrell, Pennsylvania.

DOE became a NRC licensee in 1993 under the general license provisions of 10 CFR 40.27. The covered sites are listed in Annex D-3.

D.2.2.3.2 UMTRCA Title II Licensed Uranium Recovery Facilities/Mill Tailings Sites

Uranium recovery facilities are located principally in the Western U.S., near deposits of uranium ore. NRC requires licensees to meet regulations compatible with EPA standards for cleanup of uranium and thorium milling sites after processing operations have permanently closed. This includes requirements for long-term stability of byproduct material disposal piles, radon emissions control, water quality protection and cleanup, and cleanup of land and buildings.

There are 16 conventional uranium mills and 12 in-situ leach (ISL) mining facilities in the U.S. Two of the conventional mill site licenses have been terminated and the reclaimed tailings areas transferred to DOE for long-term care under the general license provisions of 10 CFR 40.28. NRC-licensed sites are located in Nebraska, New Mexico, Utah, and Wyoming. There are five Agreement States (Colorado, Illinois, Texas, Utah, and Washington) licensing Atomic Energy Act section 11e.(2) byproduct material. NRC is required to determine applicable standards and requirements have been met by uranium mills before termination of their Agreement State license. Annex D-3 lists the uranium recovery facilities, both NRC and Agreement State regulated facilities. NRC transferred the responsibility for licensing, inspection, enforcement, and rulemaking activities for uranium and thorium milling operations and mill tailings and other wastes, known as 11e.(2) byproduct material, to Utah on August 16, 2004. The International Uranium Corporation– White Mesa facility, as well as 2 decommissioning UMTRCA Title II sites, Plateau Resources – Shootaring Canyon and Rio Algom – Lisbon, were transferred to Utah. There are now 20 UMTRCA Title II facilities licensed or under review regulated by the Agreement States.

Texas, an Agreement State, licenses eight ISL mining facilities and four more are licensed by NRC. Surface facilities may be dismantled after operations cease in one solution mine field area and reassembled and used in another licensed site. Final decommissioning includes the surface facilities and restoration of ground water quality in the mine site to achieve pre-mining conditions.

A separate 11e.(2) waste disposal facility, operated by Envirocare of Utah at South Clive, Utah, was licensed as a commercial facility in November 1993 to receive and dispose of 11e.(2) byproduct material, including radioactive waste from conventional and other milling operations. This license has been transferred to Utah Agreement State authority. The site also has disposal cells licensed under Utah Agreement State authority, for disposal of low-level radioactive waste and mixed waste. The Envirocare facility was never an active uranium recovery operation site. It is listed under the Radioactive Waste Management Facilities (Annex D-2).

D.2.2.4 Mine Overburden Remediation

The Atomic Energy Act does not specify uranium mining overburden as a radioactive material to be controlled, and NRC and DOE do not regulate the disposition of conventional mining wastes. However, EPA has authority, under a variety of legal statutes, for radiation protection of the public and environment from exposures to naturally occurring radioactive materials (NORM) and technologically enhanced NORM (TENORM), including their hazardous and toxic impacts. This authority is frequently extended to the individual states, or federal land management agencies, which regulate the environmental impacts under clean water and clean air legislation, as well as having a general authority to address any mining activity having deleterious effects on humans and habitats. Once uranium mining product is beneficiated or is brought into the milling circuit, including production from in-situ leach operations, then NRC and its Agreement States regulate its possession, use, transport, etc.

Mine overburden is not classified in the U.S. as a radioactive waste requiring restricted disposal, but, an estimate of mine overburden is provided at the request of other Contracting Parties to the Joint Convention. Unless otherwise noted, the information which follows can be found at the U.S. EPA Internet site http://www.epa.gov/tenorm/about.htm.

The uranium mining industry began in the 1940s primarily to produce uranium for use in weapons and later for nuclear fuel fabrication. Although there are about 4000 mines with documented production, a database compiled by EPA, with information provided by other federal, state, and tribal agencies, includes 15,000 mine locations with uranium occurrence in 14 western states. Most of those locations are found in Colorado, Utah, New Mexico, Arizona, and Wyoming, with about 75% 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 1980's U.S. producers turned to in-situ leaching operations as a principal means of extracting uranium from ore bodies. There were only six uranium mines operating in the U.S. in 2004 according to the DOE's Energy Information Administration[30], and half of those were in-situ operations. However, the number of operating mines of all kinds may increase as a result of higher world uranium prices and decreasing supply in the U.S.

Mining of uranium ores by surface and underground methods produces large amounts of radioactive waste material classified as NORM or TENORM, including overburden, unreclaimed, subeconomic ores (protore)[31], "barren" rock, and drill cuttings. The volume of waste produced by surface, open-pit mining is a factor of approximately 45 greater than for underground mining, based on their respective averages. Thus, the amount of overburden generated from open-pit mines far exceeds that of underground mines. The U.S. Geological Survey estimated for EPA that the total amount of waste rock generated by the approximately 4,000 conventional mines in their data files ranged from one billion to nine billion metric tons of waste, with a likely estimate of three billion metric tons. Given the larger number of mine locations identified by EPA, the amount of waste rock is likely to be higher.

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[30] U.S. Energy Information Administration, 2005. "Domestic Uranium Production Report" (2003-2004), U. S. Uranium Mine Production and Number of Mines and Sources, 2003-2004. http://www.eia.doe.gov/cneaf/nuclear/dupr/umine.html

[31] Material, such as containing uranium that cannot be produced at a profit under existing conditions but that may become profitable with technological advances or price increases; mineralized material too low in concentration to constitute ore, but from which ore may be formed through secondary enrichment.

Studies from mine reclamation assessments indicate that material identified as “waste” or “overburden” varies widely in radium-226 activity, but that for most waste piles dominated by overburden material, measurements higher than 0.74 Bq/g (20 pCi/g) are unusual. Protore, on the other hand, can be considerably higher in radium-226 activity, with most material in the range of 1.11–22.2 Bq/g (30–600 pCi/g). Radon measurements in some abandoned mines where mechanical ventilation has ceased are quite high, and pose risks for prolonged human exposure. Field measurements indicate that average radon flux rates vary from about 0.07–2.22 Bq/m^{2}s (2–60 pCi/m^{2}s) for overburden materials, to greater than 7.4 Bq/m^{2}s (a few hundred pCi/m^{2}s) for low-grade ore materials. The broad range of radon flux rates is due in part to varying radium concentrations (the parent radionuclide) found in low-grade ores that are at times disposed of with overburden. Gamma exposure rates for overburden materials range from 20 µR/hr to 300 µR/hr, with an average value of perhaps 50 µR/hr, including background. Protore ranges from 80 to 1,250 µR/hr, with an average value estimated at 350 µR/hr.

Programs such as the Abandoned Mine Land Program and DOE Uranium Mill Tailings Remedial Action Project focused on restoration of legacy mining and milling sites in the last 50 years. Many of the individual states and tribes also have reclaimed mine sites. These programs were not limited to uranium, but included other conventional mining operations, such as coal and metals. There are no reliable estimates of the total number of abandoned uranium mines which have been reclaimed. Although most areas where uranium mining has occurred are remote and arid, a principal EPA concern is the recycling of uranium mine waste for other uses, including residential construction materials.

D.3 Nuclear Facility Decommissioning

Table D-6 summarizes ongoing U.S. decommissioning activities within the Joint Convention context. More information is provided in the following subsections corresponding to each of the entries in Table D-6.

Table D-6. Summary of Decommissioning Activities in Progress

Sector	Type	Number
Government	DOE Nuclear/Radioactive Facilities for which Decommissioning is Ongoing or Pending	1186
Government/Commercial	Formerly Utilized Sites Remedial Action Program Sites (FUSRAP)	27
	Decommissioning Materials Sites	39
Commercial	Nuclear Power Plants	16
	Other Non-Power Reactor Facilities	20

D.3.1 DOE Sites with Decommissioning/Remediation Projects

The U.S. has a legacy of radioactive waste from past government activities and events spanning nearly five decades. A total of 114 sites covering more than two million acres of land are used by the U.S. Government for nuclear research and development and nuclear weapons production activities. Most of the land at these sites is not contaminated. Within the boundaries of these 114 sites are numerous radiological-controlled areas with thousands of individual facilities, encompassing 10,400 discrete contaminated locations (“release sites”). Over 5,000 of these release sites have been cleaned up. This constitutes full remediation at 75 of the 114 DOE sites to date. Some DOE sites, such as Rocky Flats, are near growing suburban populations, while others are secluded and far from any community.

The U.S. Government continues to safeguard its nuclear materials, dispose of waste, remediate extensive surface and ground water contamination, and deactivate and decommission thousands of excess contaminated facilities. The Fernald Environmental Management Project, Fernald, Ohio, a former defense uranium processing plant, is now undergoing decommissioning and includes an on-site waste disposal cell. Annex D-4 shows a summary of the remaining nuclear/radioactive facility decommissioning projects, and also a summary of remaining remediation projects at DOE sites undergoing cleanup. Some of the large decommissioning projects now in progress are:

- Brookhaven Graphite Research Reactor,
- Rocky Flats (expected to be complete soon after the publication of this report),
- Plutonium Finishing Plant at the Hanford Site,
- Fast Flux Test Facility at the Hanford Site,
- East Tennessee Technology Park (formerly the Oak Ridge Gaseous Diffusion Plant), and
- Alpha-4 Building at Oak Ridge Y-12 Complex.

D.3.2 Formerly Utilized Sites Remedial Action Program

Work was performed at sites throughout the U.S. during the 1940s, 1950s, and 1960s as part of the nation's early atomic energy program. Some sites' activities can be traced back as far as World War II and the Manhattan Engineering District (MED). Other sites were involved in peacetime activities under the AEC. Most sites contaminated during the early atomic energy program were cleaned up under the guidelines in effect at the time. Those cleanup guidelines were generally not as strict as today's, so trace amounts of radioactive materials remained at some of the sites. Contamination was then spread to other locations, either by demolition of buildings, intentional movement of materials, or by natural processes.

DOE established the Formerly Utilized Sites Remedial Action Program (FUSRAP) in 1974 to study these sites and take appropriate cleanup action. When contamination is suspected at a site, old records are reviewed and the site is surveyed. Additional cleanup is authorized under FUSRAP if contamination connected to a MED or AEC activity is found. The U.S. Congress also added some sites to FUSRAP with industrial contamination similar to that produced by MED or AEC activities. The Energy and Water Development Appropriations Act for Fiscal Year 1998, P.L. 105-62 (October 13, 1997) transferred responsibility for the administration and execution of FUSRAP from DOE to the U.S. Army Corps of Engineers (COE). The COE contract strategy concentrates on individual site-specific remediation contracts. The COE pursues more efficient remedial actions through the use of performance-based specifications, using fixed-price and cost-type contracts.

The contaminants at FUSRAP sites are primarily low levels of uranium, thorium, and radium, with their associated decay products. None of these sites pose an immediate threat to human health or the environment. Materials containing low levels of radioactive residues are excavated, packaged, and transported for disposal at licensed commercial disposal sites, such as Envirocare of Utah, or to hazardous waste landfills, as appropriate. Annex D-5 lists FUSRAP sites with ongoing remediation.

D.3.3 Complex Licensed Materials Sites Decommissioning (NRC)

NRC has taken a comprehensive approach to its decommissioning program to achieve better effectiveness (see Section F.6.1). NRC developed a Site Decommissioning Management Plan (SDMP) in 1990 for timely cleanup of certain unusual and difficult sites, particularly those with high soil contamination or with old, contaminated buildings. The SDMP was originally created to develop a comprehensive strategy for achieving timely closure of decommissioning issues and to develop a list of contaminated sites ("SDMP sites") in order of cleanup priority. Forty-nine sites were originally identified as SDMP sites.

The goals of the SDMP since that time (i.e., to achieve closure on cleanup issues so cleanup could proceed in a timely manner) have been achieved. NRC has eliminated the SDMP designation and now manages the SDMP sites as complex sites under its broader decommissioning program. This comprehensive decommissioning program includes routine decommissioning sites, formerly licensed sites, SDMP sites, non-routine/complex sites, fuel cycle sites, and test/research and power reactors. The cleanup of these sites is now managed more effectively as part of this larger program.

There are now 39 complex decommissioning materials sites. Between October 2003 and August 2005, NRC terminated the license for 10 “complex sites”: (1) Babcock & Wilcox-Parks Township; (2) Envirotest Laboratories; (3) Molycorp, Inc.-York; (4) University of Wyoming; (5) Watertown-GSA; (6) Alliant Ordinance & Ground Systems; (7) Engelhard Minerals-Ravenna; (8) Kiski Valley Water Pollution Control Authority (KVWPCA); (9) Augustana College; and (10) Kerr McGee-Technical Center. Annex D-6 provides a list of the 39 “complex sites” subject to decommissioning. NRC is committed to terminating one site each year from the list of complex material sites under decommissioning.

More specific information on the status of NRC regulated sites can be found at NRC’s website[32], including status information for complex sites:

- Status of complex material sites: name, location, and status of complex sites currently undergoing decommissioning;
- Sites removed from SDMP after successful remediation: name, location, and current use of sites for which decommissioning has been completed;
- Sites removed from SDMP after transfer to EPA or an Agreement State: name, location, and status these sites.
- Site status summaries: Status of each complex decommissioning site and summary of technical and regulatory issues impacting completion of the decommissioning.

D.3.4 Power and Non-Power Reactor Decommissioning

NRC has regulatory project management responsibility for decommissioning 16 power reactors. NRC also provides project management and inspection oversight for the decommissioning of 20 research and test reactors. Annex D-7 lists these reactors. Currently, 13 research and test reactors have been issued decommissioning orders or amendments by NRC. Three research and test reactors are in “possession-only” status, either waiting for shutdown of another research or test reactor at the site or removal of the spent fuel from the site by DOE. One research and test reactor is preparing to submit a decommissioning amendment request, and one of the three research and test reactors in possession-only status still has fuel in storage at the reactor.

D.3.5 Other Non-Power Facility Decommissioning

NRC provides project management and technical review for decommissioning and reclamation of facilities regulated under 10 CFR Part 40, Appendix A. These licensees include conventional

[32] http://www.nrc.gov/what-we-do/regulatory/decommissioning.html

uranium mills and in-situ leach (ISL) facilities and NRC-licensed [Uranium Mill Tailings Radiation Control Act (UMTRCA) Title II] sites in decommissioning. These sites are shown in Annex D-3.

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. One conversion facility (Honeywell) and two fuel manufacturers (Framatome Richland and General Atomics) continued some decommissioning in 2004, although all are still operating.

E. LEGISLATIVE & REGULATORY SYSTEMS

E.1 Legislative System

The national policy on regulatory control of radioactive waste management in the U.S. has evolved through a series of laws establishing the Federal government agencies responsible for the safety of radioactive materials as described in Section A. Federal legislation is enacted by the U. S. Congress and signed into law by the President. Laws of the nation apply to all 50 states and territories. Legislation on safety of spent fuel and radioactive waste can be traced back for 5 decades. Table E-1 provides a summary of the legislation mentioned below.

The U.S. Congress passed legislation in 1954, for the first time permitting the wide peaceful use of atomic energy. The 1954 Atomic Energy Act (AEA) redefined the atomic energy program by ending the government monopoly on technical data and making the growth of a private commercial nuclear industry an urgent national goal.

Three types of commercial nuclear materials are regulated:

- Special nuclear material - uranium-233 or uranium-235, enriched uranium, or plutonium,
- Source material - natural uranium or thorium, or depleted uranium not suitable for use as reactor fuel, and
- Byproduct material - generally nuclear material (other than special nuclear material) produced or made radioactive in a nuclear reactor. Also the tailings and waste produced by extraction or concentration of uranium or thorium from an ore processed primarily for its source material content.

The Atomic Energy Act directed the AEC "...to encourage widespread participation in the development and utilization of atomic energy for peaceful purposes." It instructed the AEC to prepare regulations to protect public health and safety from radiation hazards. The 1954 Act assigned AEC three major roles: to continue its weapons program, to promote the private use of atomic energy for peaceful applications, and to protect public health and safety from the hazards of commercial nuclear power.

Congress passed the National Environmental Policy Act (NEPA) in 1969, among other things, establishing a national policy for the environment and the Council on Environmental Quality. EPA was subsequently created in 1970 by Presidential Executive Order. EPA was given AEA authority for setting generally applicable standards for radioactivity in the environment outside the boundaries of AEC-owned facilities. A separate statute, the Waste Isolation Pilot Plant Land Withdrawal Act (WIPP LWA) provides EPA authority to periodically certify WIPP meets EPA generally applicable standards (40 CFR Part 191). EPA also has responsibility for regulating and enforcing the levels of radioactivity in air emissions and in drinking water under the Clean Air Act and the Safe Drinking Water Act.

Table E-1. Key U.S. Policy Laws Governing Radioactive Waste Management
Atomic Energy Act of 1954, as amended, established the Atomic Energy Commission, the predecessor to NRC and DOE, with Federal responsibility to regulate the commercial use of nuclear materials, byproducts and sources including the regulation of civilian nuclear reactors. Under Reorganization Plan No. 3 of 1970, which created EPA, authority to establish generally applicable environmental standards was transferred to EPA. **National Environmental Policy Act (NEPA) of 1969**, as amended, requires Federal agencies to consider environmental values and factors in agency planning and decision-making. Full compliance with the letter and spirit of the NEPA, the U.S. national charter for protection of the environment, is an essential priority for EPA, Council on Environmental Quality, DOE and NRC. **The Marine Protection, Research, and Sanctuaries Act (MPRSA) of 1972**, also known as the Ocean Dumping Act, prohibits the dumping of material into the ocean that would unreasonably degrade or endanger human health or the marine environment. **Energy Reorganization Act of 1974**, as amended, established NRC and ERDA – the predecessor of DOE. **Uranium Mill Tailings and Radiation Control Act of 1978**, as amended, vested EPA with overall responsibility for establishing health and environmental cleanup standards for uranium milling sites and contaminated vicinity properties, NRC with responsibility for licensing and regulating uranium production and related activities, including decommissioning, and DOE with responsibility for long-term monitoring of the decommissioned sites. Uranium recovery and tailings disposal sites are divided into two categories: Title I dealing with DOE-remedial action programs of former mill tailings sites in which all or substantially all of the uranium was produced for sale to any Federal agency prior to January 1971 under a contract with any Federal agency; and Title II dealing with non-DOE mill tailings sites; and *in-situ* leach uranium solution mining sites licensed by NRC or an Agreement State according to NRC regulations. **Low-Level Radioactive Waste Policy Act of 1980 and the Low-Level Radioactive Waste Policy Amendments Act of 1985** authorized the states – rather than the Federal Government – responsibility to provide additional disposal capacity for commercial LLW from regional compacts (groups of states) for the safe disposal of such LLW; and decide whether to exclude waste generated outside a Compact. The Act also provided a system of milestones, incentives, and penalties to encourage states and regional compacts to be responsible for their own LLW. **National Security and Military Applications of Nuclear Energy Authorization Act of 1980** (Public Law 96-164). Section 213 (a) of the Act authorizes WIPP "for the express purpose of providing a research and development facility to demonstrate the safe disposal of radioactive wastes resulting from defense activities and programs of the United States exempted from regulation by the U.S. Nuclear Regulatory Commission." **West Valley Demonstration Act of 1980** authorized DOE to conduct a technology demonstration project for solidifying HLW, disposing of waste created by the solidification, and decommissioning the facilities used in the process. The Act required DOE to enter into an agreement with the State of New York for carrying out the Project. **Nuclear Waste Policy Act of 1982 (NWPA) and the Nuclear Waste Policy Amendments Act of 1987 (NWPAA)** provide for the siting, construction, and operating of a deep geologic repository that could be used to dispose of spent fuel and HLW. Any such repository would be licensed by NRC. Pursuant to the NWPA, the Secretary of Energy, the President, and the U.S. Congress have acted to designate Yucca Mountain as the site of the first such repository. DOE is preparing a license application for submission to NRC to receive authorization to begin construction of a repository at Yucca Mountain. NRC will review this license pursuant to 10 CFR Part 63. **Waste Isolation Pilot Plant Land Withdrawal Act (WIPP LWA) of 1992,** as amended withdraws land from the public domain for operation of the Waste Isolation Pilot Plant. Defines operational limitations and the role of the U.S. Environmental Protection Agency and the U.S. Mine Safety and Health Administration. Exempts TRU mixed waste destined for disposal at WIPP from treatment requirements and land disposal prohibitions under the Solid Waste Disposal Act. Includes provisions for economic assistance to the State of New Mexico. The Act also defines transportation and emergency preparedness requirements pertaining to WIPP, including NRC certification of WIPP shipping containers. The Act provides for EPA continuing regulatory role at WIPP, including recertification that WIPP meets EPA standards.

Table E-1. Key U.S. Policy Laws Governing Radioactive Waste Management
Energy Policy Act (EnPA) of 1992 mandated a new and different process for developing the HLW disposal regulations for the planned repository at Yucca Mountain, Nevada. Congress, through EnPA, directed the National Academy of Sciences (NAS) to evaluate the scientific basis for a Yucca Mountain standard, and directed EPA to promulgate site-specific public health and safety standards based on and consistent with the findings and recommendations of the NAS. Once the final standards are promulgated by EPA, the EnPA directs NRC to modify its technical requirements to conform to the new EPA standards.
Energy Policy Act of 2005 (EPACT05) Sets forth an energy and development program and includes specific provisions addressing, among other things, disposal of GTCC waste (including certain sealed sources), NORM, and accelerator-produced waste.

EPA can determine soil cleanup values and other residual radioactivity limits at contaminated sites where there are releases or potential for releases of hazardous substances into the environment under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). EPA also has authority to provide Federal guidance on radiation protection matters affecting public health.

Congress passed the Energy Reorganization Act in 1974, separating the AEC into NRC and ERDA, predecessor of DOE. Additional legislation further defined the roles of NRC and DOE and introduced a role for the states through the Low-Level Radioactive Waste Policy Act of 1980 (LLRWPA) and the Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA). This legislation assigned to the states, rather than the U.S. Government, the responsibility to provide additional disposal capacity for commercial LLW.

The NWPA and the NWPAA provide for siting, construction, and operation of a deep geologic repository to dispose of spent fuel and HLW. Any such repository would be licensed by NRC. The Secretary of Energy, the President, and the U.S. Congress have now acted to designate Yucca Mountain as the site of the first such repository. DOE is preparing a license application to submit to NRC for authorization to begin construction of a repository at Yucca Mountain. NRC will review this license under 10 CFR Part 63.

NWPA defined the relationship between the Federal Government and the state governments on disposal of spent fuel and HLW, and established:

- A schedule for the siting, construction, and operation of repositories that will provide a reasonable assurance the public and the environment will be adequately protected from the hazards posed by repository disposal;
- The disposal of such waste as a matter of Federal policy, and;
- The creation of a Nuclear Waste Fund, composed of payments made by the generators and owners of waste to ensure the costs of disposal will borne by the persons responsible for generating the waste.

Congress amended NWPA through NWPAA in 1997 to:

- Create a Nuclear Waste Technical Review Board (NWTRB) as an independent review body;
- Establish a Nuclear Waste Negotiator;
- Direct DOE to study (characterize) only the Yucca Mountain site;
- Require a report to Congress between 2007 and 2010 on the need for a second repository; and
- Establish a consultant role of NRC during the site characterization process, on which DOE makes a recommendation of a potential site as a candidate for a geologic repository.

The Energy Policy Act (EnPA) of 1992 mandated a new and different process for EPA to develop the HLW disposal standards for a repository at Yucca Mountain. The U.S. Congress directed the National Academy of Sciences (NAS) to evaluate the scientific basis for a Yucca Mountain standard, and directed EPA to promulgate new public health and safety standards based on and consistent with the findings and recommendations of the NAS. Once the final standards were promulgated, EnPA directed NRC to modify its technical requirements to conform to the new EPA standards. EnPA directed the NAS to provide EPA with recommendations on the following issues:

- Whether health-based standards based on doses to individual members of the public from releases to the accessible environment will provide a reasonable standard for protection of the health and safety of the general public;
- Whether it is reasonable to assume a system of post-closure oversight of the repository can be developed, based on active institutional controls, preventing an unreasonable risk of breaching the repository's engineered or geologic barriers or increasing the exposure of individual members of the public to radiation beyond allowable limits, and
- Whether it is possible to make scientifically supportable predictions of the probability the repository engineered or geologic barriers will be breached as a result of human intrusion over a period of 10,000 years.

EPA issued its radiation protection standards in 40 CFR Part 197, on June 13, 2001. These standards are designed to protect public health and safety by establishing a maximum dose level for the first 10,000 years. As discussed further in Section E.2.1.2, EPA proposed revised standards for the period beyond 10,000 years, and up to one million years after disposal, in response to the July 2004 Court ruling.

NRC's role is to implement the public health and safety standards established by EPA in any licensing process conducted for a repository at Yucca Mountain. NRC finalized its licensing criteria and published 10 CFR Part 63 on November 2, 2001, incorporating EPA public health and environmental standards issued in June 2001. A licensing process involving an adjudicatory hearing will result in a determination by NRC on authorization to construct a repository at the planned Yucca Mountain site. NRC must make another determination authorizing DOE to receive and possess waste at the repository prior to the start of repository operation. As EPA revises its standards because of the judicial review, NRC will make corresponding changes as necessary to 10 CFR Part 63.

DOE's role is to characterize the Yucca Mountain site and determine whether it should be recommended to the President for development as a repository. DOE issued its final repository site suitability guidelines, *General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories; Yucca Mountain Site Suitability Guidelines*, 10 CFR Part 963, on November 14, 2001. DOE used the guidelines in 10 CFR Part 963 to determine whether the planned Yucca Mountain site is suitable for development as a repository. DOE will submit a license application for the planned repository construction to NRC following the regulatory requirements in 10 CFR Part 63.

E.2 Regulatory System

The regulatory system for spent fuel and radioactive waste management in the U.S. involves several agencies. The key agencies are NRC, regulating the commercial nuclear sector, EPA establishing and regulating environmental standards, and DOE regulating its government programs. Some NRC regulatory authority functions, excluding spent fuel and HLW, can be relinquished to the 50 U.S. States (including territories, Puerto Rico, and the District of

Columbia) under its Agreement State Program. This authority includes regulating commercial LLW disposal sites and uranium mill tailings sites, and regulatory authority over the disposal of mill tailings. Some states have regulatory authority delegated to them by EPA, such as for discharges of some industrial or mining practices.

The general regulations for the three Federal Agencies responsible for radioactive waste regulation are contained in Title 10 (for NRC and DOE) and Title 40 (for EPA) of the U.S. Code of Federal Regulations (CFR). A compendium of these regulations is published annually, but regulations are frequently revised and in force before the next annual compendium. U.S. Government regulations are developed through an open process, including the opportunity for public comment. New regulations are published daily in the Federal Register, in proposed or final forms. A listing of specific regulations for each Agency is in Table E-2. Copies of these regulations are available in print and electronically[33].

Table E-2. Spent Fuel and Radioactive Waste Management Regulations
U.S. Nuclear Regulatory Commission • 10 CFR Part 20, *Standards for protection against radiation* • 10 CFR Part 30, *Rules of general applicability to domestic licensing of byproduct material* • 10 CFR Part 40, *Domestic Licensing of Source Material* • 10 CFR Part 51, *Environmental protection regulations for domestic licensing and related regulatory functions* • 10 CFR Part 60, *Disposal of High-Level Radioactive Wastes in Geologic Repositories* • 10 CFR Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste* • 10 CFR Part 62, *Criteria and Procedures for Emergency Access to Non-Federal and Regional Low-Level Waste Disposal Facilities* • 10 CFR Part 63, *Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada* • 10 CFR Part 70, *Domestic Licensing of Special Nuclear Material* • 10 CFR Part 72, *Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste* • 10 CFR Part 73, *Physical Protection of Plants and Materials* • 10 CFR Part 75, *Safeguards on Nuclear Material Implementation of U.S./IAEA Agreement* • 10 CFR Part 76, *Certification of Gaseous Diffusion Plants* • 10 CFR Part 110, *Export and Import of Nuclear Equipment and Material*
U.S. Department of Energy • 10 CFR Part 765, *Reimbursement of Costs for Remedial Action at Active Uranium and Thorium Processing Sites* • 10 CFR Part 766, *Uranium Enrichment Decontamination and Decommissioning Fund; Procedures for Special Assessment of Domestic Utilities* • 10 CFR Part 820, *Procedural Rules for DOE Nuclear Facilities* • 10 CFR Part 830, *Nuclear Safety Management* • 10 CFR Part 835, *Occupational Radiation Protection* • 10 CFR Part 960, *General Guidelines for the Recommendation for Sites for Nuclear Waste Repositories* • 10 CFR Part 963, *Yucca Mountain Site Suitability Guidelines* • 10 CFR Part 1021, *National Environmental Policy Act Implementing Procedures* The following DOE Orders are applicable to safety: • Order 151.1B, *Comprehensive Emergency Management System*

[33]Electronic versions of the Code of Federal Regulations are available on the Internet at: http://www.gpoaccess.gov/cfr/index.html

Table E-2. Spent Fuel and Radioactive Waste Management Regulations

- Order 231.1A, *Environment, Safety, and Health*
- Order 360.1B, *Federal Employee Training*
- Order 414.1C, *Quality Assurance*
- Order 420.1A, *Facility Safety*
- Guide 421.1-2; Guide 423.1-1; DOE Guide 424.1-1, *Implementation Guides for 10 CFR 830*
- Order 425.1C, *Startup and restart of Nuclear Facilities*
- Order 430.1B, *Real Property Asset Management*
- Order 433.1, *Maintenance Management Program*
- Order 435.1, *Radioactive Waste Management*
- Order 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees*
- Order 470.2B, *Independent Oversight and Performance Assurance Program*
- Order 5400.5, *Radiation Protection of the Public and the Environment*
- Order 5480.19A, *Conduct of Operations Requirements for DOE Facilities*
- Order 5480.20A, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*

U.S. Environmental Protection Agency

40 CFR Part 61, *National Emission Standards for Hazardous Air Pollutants*

- Subpart B, radon from underground uranium mines,
- Subpart H, radionuclide emissions, other than radon, from DOE facilities,
- Subpart I, radionuclide emissions from Federal facilities other than DOE or NRC licensed facilities,
- Subpart K, radionuclide emissions from elemental phosphorus plants,
- Subpart Q, radon from DOE facilities,
- Subpart R, radon from phosphogypsum stacks,
- Subpart T, radon from disposal of mill tailings, and
- Subpart W, radon from tailings at operating mills.

40 CFR Part 191, *Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes*

40 CFR Part 192, *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings*

40 CFR Part 194, *Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's (WIPP) Compliance with the 40 CFR Part 191 Disposal Regulations*

40 CFR Part 197, *Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada*

Title 40, Code of Federal Regulations relating to radiation protection include:

- Part 141, *National Primary Drinking Water Regulations*,
- Part 147, *State Underground Injection Control Programs*,
- Part 148, *Hazardous Waste Injection Restrictions*,
- Part 195, *Radon Proficiency Programs*,
- Parts 220 and 133, *Ocean Dumping*,
- Part 300, *National Oil and Hazardous Substances Pollution Contingency Plan*,
- Part 302, *Designation, Reportable Quantities, and Notification*, and
- Part 440, *Ore Mining and Dressing Point Source Category (Uranium, Radium, and Vanadium Ores subcategory)*.

E.2.1 U.S. Nuclear Regulatory Commission

NRC is an independent regulatory agency established by Congress under the Energy Reorganization Act of 1974 to ensure adequate protection of the public health and safety and the environment, and to promote the common defense and security in the civilian use of byproduct, source, and special nuclear materials. NRC regulates:

- Commercial nuclear power; non-power research, test, and training reactors;
- Fuel cycle facilities; medical, academic, and industrial uses of nuclear materials; and
- Transportation, storage, and disposal of nuclear materials and waste.

NRC regulates manufacture, production, transfer or delivery, receiving, acquisition, ownership, possession, and use of commercial radioactive materials, including waste. The NRC regulatory process has six key components:

- Regulations and Guidance: Developing regulations and guidance for applicants and licensees,
- Licensing and Certification: Licensing or certifying applicants to use nuclear materials or operate nuclear facilities,
- Oversight: Inspecting licensee operations and facilities to verify and enforce licensee compliance with safety requirements, which includes holding hearings to address the concerns of parties affected by agency decisions,
- Emergency Response: Leading and coordinating NRC response to safety-related incidents based on their severity
- Lessons Learned: Evaluating operational experience at licensed facilities or involving licensed activities, and
- Decision Support: Conducting research and obtaining independent reviews to support regulatory decisions.

NRC regulates waste in three broad classification types as described in Section B:

- LLW - includes radioactively contaminated protective clothing, tools, filters, rags, medical waste, and many other items.
- HLW – includes "irradiated" or spent fuel (spent fuel is classified in the broader context of HLW in NRC regulations)
- Uranium Mill Tailings - the residues remaining after the processing of natural ore to extract uranium and thorium, referred to in section 11e.(2) of the Atomic Energy Act as byproduct material.

The following activities are key components of NRC regulatory program.

<u>Regulations and Guidance</u>

- Rulemaking—developing and amending regulations licensees must meet to obtain or retain a license or certificate to use nuclear materials or operate a nuclear facility.
- Guidance Development—developing and revising guidance documents, such as regulatory guides, standard review plans, and the NRC Inspection Manual to guide NRC in implementing regulations and acceptable approaches to licensees for meeting regulations.
- Generic Communications—sending applicants and licensees information about operational events at other nuclear facilities and/or requests for information from licensees related to operations.

- Standards Development—working with industry standards organizations to develop consensus standards for design, construction and inspection of systems, equipment, or materials used by the nuclear industry. This would allow these standards to be referenced in NRC regulations or guidance. Where industry standards are not available, developing standards with public involvement.

Licensing and Certification

- Licensing - authorizing an applicant to use or transport nuclear materials or to operate a nuclear facility (includes new licenses, renewals, amendments, transfers and related Topical Reports).
- Certification - authorizing an applicant to manufacture spent fuel casks and transportation packages for nuclear materials, the design of sealed sources and devices, and authorizing an applicant to operate a gaseous diffusion plant. Certification does not authorize the manufacture of sealed sources and devices; it approves the design of the device/source; separate licenses authorize possession and distribution.

Oversight

- Inspection - verifying a licensee's activities are properly conducted to ensure safe operations in accordance with NRC regulations.
- Enforcement - issuing sanctions to licensees who violate NRC regulations and license conditions.
- Performance Assessment - determining agency action from reviews of licensee performance documented in inspection reports.
- Allegations- responding to and investigating reports of wrongdoing by NRC licensees, applicants for licenses, licensee's contractors or vendors, or employees of the above.
- Investigations - investigating wrongdoing by NRC licensees.

Emergency Response and Assessments

- Emergency Response - leading and coordinating NRC response to safety-related incidents based on their severity.
- Events Assessment - daily review and long term trend analysis of accidents and other reportable incidents to determine regulatory response.
- Generic Issues - identifying and resolving safety issues affecting more than one licensed facility.

Decision Support

- Research – conduct experiments, technical studies, and analyses to help NRC make realistic decisions, assess the safety significance of potential technical issues, and prepare the agency for the future by evaluating potential safety issues involving new designs and technology.
- Advisory Activities - Establishing independent advisory bodies reporting to or chartered by NRC, to review and independently assess regulatory proposals.
- Adjudication - Establishing independent bodies to address concerns of parties affected by licensing or enforcement actions in a legal setting.

NRC conducts licensing and inspection activities associated with domestic nuclear fuel cycle facilities, uses of nuclear materials, transport of nuclear materials, management and disposal of LLW and HLW, and decontamination and decommissioning of facilities and sites. NRC is also responsible for establishing the technical basis for regulations, and provides information and technical basis for developing acceptance criteria for licensing reviews.

An important aspect of NRC's regulatory program is its inspection and enforcement activities. NRC has four regional offices (Region I in King of Prussia, Pennsylvania; Region II in Atlanta, Georgia; Region III in Lisle, Illinois; and Region IV in Arlington, Texas). These offices conduct inspections of licensed facilities including nuclear waste facilities. NRC also has an Office of State and Tribal Programs to establish and maintain communication with state and local governments and Tribes, and administer the Agreement States Program. An Agreement State is a state signing an agreement with NRC allowing the State to regulate the use of radioactive material within that State, consistent with NRC regulations. There are 33 Agreement States.

NRC issues guidance on implementing its regulations in documents, among these are Regulatory Guides, NRC Regulatory Guides (NUREGs) (reports), Standard Review Plans, and Interim Staff Guidance documents. NRC develops guidance to set a standard approach to licensing. They are not regulatory requirements, but do reflect methods, procedures, or actions acceptable to the staff for implementing specific parts of NRC regulations.

Guidance documents also provide the standard format and content for license applications. Staff technical positions are divided into two general types: so-called "generic" positions, on issues relating to licensing activities for nuclear facilities independent of the technology or site selected; and site-specific positions, giving site guidance or advice for a specific site. NRC also uses Standard Review Plans, providing guidance to NRC staff for reviewing licensee submittals. These are public plans so licensees and applicants understand what is needed to comply with regulations. Licensees and applicants have this third type of guidance to assist in preparing license applications to demonstrate compliance with the regulations. A listing of guidance issued by NRC is provided in Annex E-1.

Important guidance for radiation protection programs is in International Commission on Radiation Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP) technical guidelines (See Section E.2.6). Recommendations are cited in NRC staff documents, focusing on dose assessments.

Table E-3 lists the strategic goals and corresponding outcomes to measure results for meeting NRC strategic goals.

Table E-3. NRC Strategic Goals and Outcomes
NRC's strategic objective is to enable the use and management of radioactive materials and nuclear fuels for beneficial civilian purposes in a manner that protects public health and safety and the environment, promotes the security of our nation, and provides for regulatory actions that are open, effective, efficient, realistic, and timely. The goals to meet this objective are: I. **Safety**: Ensure protection of public health and safety and the environment. II. **Security**: Ensure the secure use and management of radioactive materials. III. **Openness**: Ensure openness in our regulatory process. IV. **Effectiveness**: Ensure that NRC actions are effective, efficient, realistic, and timely. V. **Management**: Ensure excellence in agency management to carry out NRC's strategic objective. Specific outcomes which will serve as measuring sticks for the success or failure in meeting these goals for spent fuel and radioactive waste management include: • No inadvertent criticality events. • No acute radiation exposures resulting in fatalities.

- No releases of radioactive materials that result in significant radiation exposures.
- No releases of radioactive materials that cause significant adverse environmental impacts.
- No instances where licensed radioactive materials are used domestically in a manner hostile to the security of the United States.
- Stakeholders are informed and involved in NRC processes as appropriate.
- No significant licensing or regulatory impediments to the safe and beneficial uses of radioactive materials.

Reference: FY 2004-2009 Strategic Plan (NUREG-1614, Vol. 3) URL: http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1614/v3/index.html#pub-info

E.2.1.1 Uranium Recovery Regulation

NRC is responsible for planning and implementing regulatory programs under UMTRCA. Title I (of UMTRCA) involves managing, coordinating, and conducting the safety and environmental reviews of remediation activities, and reviewing and concurring in documents related to the cleanup and licensing of abandoned uranium mill tailings sites.

UMTRCA charged EPA to issue generally applicable standards for control of uranium mill tailings. EPA issued standards for both Title I and Title II 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 license from NRC. NRC, under Title I, must evaluate DOE designs and concur that DOE actions meet standards set by EPA. The Atlas site (Moab, Utah) was recently designated a Title I site and will undergo surface remedial action. Only reviews for the ground water remedial action program for all other title I sites remain, as all surface remedial action was completed in fiscal year 1999. NRC and DOE have a memorandum of understanding to clarify their roles and responsibilities, e.g., to minimize or eliminate duplication of effort between the two agencies.

NRC changed its regulations in November 1995 in 10 CFR Part 40, Appendix A, to be consistent with EPA Title II standards and meet UMTRCA requirements. Various changes have been made to Part 40 for the Title II sites since 1985. EPA issued final Title I UMTRCA ground water standards in 1995.

UMTRCA Title II involves planning and directing activities for active, licensed uranium recovery facilities, including facility licensing and operation, and mill tailings management and decommissioning. The Title II program deals with sites under license to NRC or Agreement States. NRC has the authority under Title II to control radiological and non-radiological hazards and ensure NRC-licensed and Agreement State-licensed sites meet all standards and requirements during operations and before termination of the license. NRC reviews Title II license applicant's plans for operation, reclamation, decommissioning, and ground-water corrective action; license applications and renewals; license conditions changes; and annual surety up-dates. NRC also prepares environmental assessments for certain licensing actions. Long-term care of reclaimed tailings sites (by a state or DOE) is licensed by NRC under general licenses at 10 CFR Part 40.27 (for Title I sites) and 40.28 (for Title II sites).

Specific NRC activities under the (UMTRCA) include:

- Oversight and program direction for the uranium recovery program;
- Implementing policies and programs; and
- Reviewing uranium recovery licensing and inspection programs for technical adequacy and consistency.

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

E.2.1.2 HLW Regulation

The responsibility of regulatory agencies for disposal of HLW and spent fuel is described in the Nuclear Waste Policy Act. NRC is the U.S. regulator for disposal of HLW, including:

- Preparing to review a DOE license application for a HLW repository at a pace consistent with the national program.
- Implementing EPA's site-specific HLW radiation safety standards, using site-specific, performance (assessment)-based regulation, both of which were developed in open, public rulemaking processes.
- Conducting pre-licensing consultation and beginning regulatory activity when the application for the Yucca Mountain repository is received.
- Certifying transportation casks.
- Hosting meetings at NRC Headquarters, in Nevada, and along major transportation corridors to the planned high-level radioactive waste repository at Yucca Mountain, including workshops to assist in understanding NRC's regulatory role and licensing process.
- Implementing and maintaining the high-level waste Licensing Support Network, a system to store documents on the high-level radioactive waste repository, make such documents available to the public, and provide training to assist stakeholders in using the system.
- Performing a comprehensive, independent safety review of DOE's license application and conducting a full and fair public hearing, to ensure an open, objective decision on whether or not to construct a planned repository at Yucca Mountain.

EPA issued final standards for Yucca Mountain on June 13, 2001, codified at 40 CFR 197. NRC published conforming licensing regulations on November 21, 2001, codified at 10 CFR Part 63. These standards and regulations withstood multiple legal challenges except for the part of the EPA regulation governing the period of time after disposal for which compliance must be demonstrated. In July 2004, the Court of Appeals for the D.C. Circuit vacated the 10,000-year compliance period established in EPA standards and incorporated in NRC regulations. EPA's August 2005 proposal to revise its regulations retains the 10,000-year compliance period with a maximum dose level, and adds a compliance period for the time period after 10,000 years and up to one million years after disposal with a separate maximum dose level based on natural background radiation levels for people currently living within the United States. The proposed standards for the period after 10,000 years incorporates specific direction on analyzing features, events and processes (e.g., earthquakes, volcanoes, increased water flow due to climate changes) that may affect performance. NRC will amend its regulations as necessary to be consistent with the final changes to EPA standards for Yucca Mountain.

NRC regulations contain risk-informed, performance-based criteria for both pre-closure operations and post-closure performance of the planned geologic repository. EPA standards and NRC regulations are generally consistent with recommendations of the NAS and with national and international recommendations for radiation protection standards.

NRC's regulatory program for HLW disposal is now focused on its transition from prelicensing to licensing activities as NRC prepares for receipt of a license application. NRC's prelicensing activities with DOE have been conducted under a formal prelicensing agreement, and have been open to participation by the states, Indian tribes, local governments, industry, and other stakeholders. The NRC website contains information on pre-licensing activities, site characterization, resolution of Key Technical Issues, the YM EIS (NEPA Process), site recommendation, communications with NRC, Advisory Committee on Nuclear Waste (ACNW) public hearings, etc.[34] The NRC site characterization review included identifying specific concerns impacting licensing. NRC observed and commented on DOE plans for repository surface and subsurface facilities, its quality assurance (QA) program, evaluations of potential performance, and other activities.

A web-based Licensing Support Network (LSN) was established to facilitate meeting a Congressional mandate for NRC to reach a determination on DOE's license application for a repository in three years. The parties and potential parties to the hearing on DOE's application will make their documents available via the internet before the license application is submitted. This will enable NRC to shorten the time spent on the exchange of documents that may be used as evidence in the NRC licensing proceeding. The LSN provides a single place where the parties and potential parties to the licensing hearing can search for documents from any of those collections in a uniform way. Access to the system during peak usage may be restricted to participants in the licensing process. The LSN is codified in 10 CFR 2, Subpart J.[35]

E.2.1.3 LLW Regulation

NRC activities supporting its strategic objectives[36] for LLW regulation include:

- Assessing key issues affecting the safe management of civilian low-level waste disposal to ensure potential disruption in access to the three licensed disposal sites does not adversely affect licensees' ability to operate safely and decommission their plants safely.
- Working cooperatively with the Agreement States through the National Materials Program to agree on priorities to enhance the regulatory framework for materials licensees.
- Conducting periodic reviews of Agreement State programs to ensure they are adequate to protect health and safety and are compatible with NRC's program and their programs and ensure a sound and consistent regulatory framework.
- Working closely with the Agreement States to develop consistent, risk-informed processes to review event information and identify safety issues for materials licensees.

States were in various stages of planning, siting and licensing LLW disposal facilities in the late 1980s and early 1990s in an attempt to meet the milestones of LLRWPAA. NRC developed Standard Format and Content (NUREG-1199) and Standard Review Plan (NUREG-1200), providing guidance on licensing LLW disposal facilities to enable NRC to meet its statutory requirements of reviewing a license application within 15 months of receipt and to provide technical guidance to Agreement States. NRC published a final report, *A Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities: Recommendations of NRC's Performance Assessment Working Group* (NUREG-1573) in October 2002. NRC has not received a license application for a new LLW disposal facility, although an application is being processed by the State of Texas, an Agreement State.

[34] http://www.nrc.gov/waste/hlw-disposal/pre-licensing.html.
[35] The web site is located at: http://www.lsnnet.gov and is administered by the Atomic Safety and Licensing Board Panel of NRC.
[36] Extracted from NRC Strategic Plan, NUREG 1614, Volume 3, August 2004

E.2.1.4 Decommissioning Regulation

Decommissioning involves safely removing an NRC-licensed 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 terminating the license. Non-licensed facilities may also be required to decontaminate and decommission the site to meet NRC release limits.

NRC Commissioners directed their staff in July 1998 to prepare guidance documents for the *Final Rule on Radiological Criteria for License Termination*. The staff has completed several other guidance documents (see list of decommissioning guidance documents in Annex E-1) to help licensees prepare decommissioning documents and provide the staff with uniform criteria for reviewing licensee submittals. The staff conducted several workshops with stakeholders to obtain input on the development of a standard review plan. The staff consolidated and updated numerous decommissioning guidance documents in September 2003 into a three-volume guidance called NUREG-1757, *Consolidated NMSS Decommissioning Guidance*, superseding all previous material guidance for decommissioning materials sites.

NRC has started an initiative to continually improve the licensing process for decommissioning sites and terminating NRC licenses in accordance with 10 CFR Part 20, Subpart E. This effort is referred to as the Integrated Decommissioning Improvement Plan. Its specific purposes include: describing a "continuous improvement" plan for decommissioning during FY 2004-2007; and integrating and tracking regulatory improvements from the License Termination Rule (LTR) Analysis, program management improvements from the Decommissioning Program Evaluation, and other staff improvements. Issues being considered include:

- Restricted use/institutional controls, including engineered barriers and long-term monitoring
- On-site disposal
- Realistic scenarios
- Removal of material after license termination (relationship of LTR and control of disposition of solid material), and
- Other non-LTR Analysis topics (e.g., ground water monitoring)

E.2.1.5 NRC's Integrated Materials Performance Evaluation Program (IMPEP)

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

The IMPEP process employs a team of NRC and Agreement State staff to assess both Agreement State and NRC Regional radioactive materials licensing and inspection programs. All reviews use the following common indicators in the assessment and place primary emphasis on performance:

- 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 (Compatibility Requirements, Sealed Source and Device Evaluation Program, Low Level Radioactive Waste Disposal Program, Uranium Recovery Program, Regional Fuel Cycle Inspection Program, and Site Decommissioning Management Plan) and may also be addressed in the assessment.

Both Agreement States and Regional NRC Offices are reviewed under this program. About 10-12 reviews are scheduled each year. Regions and Agreement States are routinely reviewed every 4 years, although the timeline may be adjusted depending on performance. The final determination of adequacy of each NRC Regional program and both adequacy and compatibility of each Agreement State program, based on the review team's report, is made by a Management Review Board (MRB). This Board is composed of NRC managers and an Agreement State program manager who serves as an Agreement State liaison to the MRB.

The Organization of Agreement States is invited to nominate liaisons to participate in MRB meetings, as a nonvoting participant. The State representative receives all relevant documents and engages in all MRB discussions except those potentially involving the Agreement State liaison's own State. Agreement States and Regional representatives are also invited to attend their individual MRB meetings to discuss the IMPEP team's findings with the MRB.

The range of possible findings for an Agreement State program is as follows:

1. Adequate to protect the public health and safety and compatible/not compatible
2. Adequate, but needs improvement and compatible/not compatible
3. Inadequate to protect public health and safety and compatible/not compatible

Regional NRC Offices are rated in the same manner, but without the additional compatibility finding.

E.2.1.6 Advisory Committee on Nuclear Waste

The Advisory Committee on Nuclear Waste was established in June 1988 to provide independent technical advice to NRC Commissioners on agency activities, programs, and key technical issues on NRC regulation, management, and safe disposal of radioactive waste.

The ACNW interacts with NRC, the Advisory Committee on Reactor Safeguards, other Federal, State, and local agencies, Indian tribes, the public, and other stakeholders to fulfill its responsibilities. The bases for the Committee's advice include the regulations for high-level waste disposal, LLW disposal, and other regulations and legislative mandates. The ACNW examines and reports on areas of concern as requested by NRC Commissioners and may undertake studies and activities on its own initiative, as appropriate.

The ACNW is independent of NRC and reports directly to the Commissioners who appoint its members. The provisions of the Federal Advisory Committee Act govern the operational practices of the ACNW. Advisory committees are structured to provide a forum where experts representing many technical perspectives can provide independent advice factored into the Commissioners' decision-making process. Most advisory committee meetings are open to the public and any person may request an opportunity to make an oral statement during the committee meeting.

E.2.2 U.S. Environmental Protection Agency

EPA has several regulatory functions associated with radioactive waste. These areas are described in more detail below.

E.2.2.1 Waste Isolation Pilot Plant Oversight

EPA enforces its radiation standards and provides oversight of DOE WIPP disposal facility for transuranic radioactive waste. The Waste Isolation Pilot Plant Land Withdrawal Act (WIPP LWA), requires EPA to issue final regulations for disposal of spent fuel, HLW, and TRU waste. It also gave EPA the authority to develop the criteria implementing final WIPP radioactive waste disposal standards. EPA must also determine every five years whether or not the WIPP facility continues to be in compliance with 40 CFR Part 191. The WIPP LWA required EPA to determine whether WIPP complies with other Federal environmental and public health and safety regulations, such as the Clean Air Act and the Solid Waste Disposal Act.

EPA issued final amendments to its radioactive waste disposal standards on December 20, 1993, initially promulgated in 1985 (40 CFR Part 191). The amendments address the individual and ground water protection requirements of the original standards which had been remanded by the U.S. Court of Appeals. The other portions of the standards were not remanded. The final individual protection standards require disposal systems to limit the amount of radiation an individual can be exposed for 10,000 years, rather than for 1,000 years as was required in the original standard. The final ground water protection standards require disposal systems to be designed, for 10,000 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.

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 (40 CFR Part 191). The compliance criteria are divided into four subparts:

- Subpart A contains definitions of terms, references, and reporting requirements for DOE. It also describes EPA authority to modify, suspend, or revoke certification or recertification.
- Subpart B describes the format and content of the initial compliance certification and subsequent compliance re-certifications.
- Subpart C consists of requirements applying to activities undertaken to demonstrate compliance with EPA disposal standards. General requirements pertain to quality assurance, the use of computer models to simulate the WIPP performance, and other areas. Containment requirements limit releases of radionuclides to specified levels for 10,000 years after the facility accepts its final waste for disposal. Assurance requirements involve additional measures intended to provide confidence in the long-term containment of radioactive waste. Subpart C also implements requirements in the disposal standards for protecting individuals and ground water from exposure to radioactive contamination.
- Subpart D describes the process for public participation EPA will follow for certification and recertification decisions.

DOE submitted a Compliance Certification Application (CCA) to EPA on October 29, 1996, to demonstrate WIPP complies with the criteria at 40 CFR Part 194. EPA then published an Advance Notice of Proposed Rulemaking announcing receipt of the application and initiated a 120-day public comment period. Copies of the application were made available to the public. Written comments were solicited, and public hearings were held. EPA requested additional information from DOE on completeness and technical sufficiency of the CCA. EPA announced its finding and the CCA was complete on May 22, 1997. EPA published a Notice of Proposed Rulemaking on October 30, 1997, announcing the proposed certification the WIPP will comply with EPA disposal standards. The proposed decision was accompanied by Compliance Application Review Documents further explaining the technical basis for the EPA decision and EPA responses to comments received on the Advance Notice of Proposed Rulemaking. EPA provided a 120-day comment period on the Proposed Certification and also held public hearings. The EPA Final Rulemaking Notice on the certification decision was announced on May 18, 1998 (95 FR 27354, May 18, 1998).

DOE submitted an application for recertification of WIPP in March 2004, which by statute is required every five years. EPA is reviewing the application and will respond through the rulemaking process.

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

The State of New Mexico is authorized by EPA to carry out the State's base RCRA and mixed waste programs in lieu of the 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.

E.2.2.2 HLW Disposal Standards

EPA has responsibility for developing HLW disposal standards and has issued two separate standards. EPA issued the final amendments in 1993 to complete its generally applicable standards for any land disposal of spent fuel, HLW and TRU waste at 40 CFR Part 191. These standards apply to WIPP, as described in the previous section, but do not apply to the planned Yucca Mountain repository. The U.S. Congress enacted the Energy Policy Act (EnPA) of 1992 (Public Law 102-486) and mandated a new and different process for developing the HLW disposal regulations for a repository at Yucca Mountain, Nevada. EnPA directed the NAS to evaluate the scientific basis for a Yucca Mountain-specific standard (see Appendix E for detailed issues to be addressed) and directed EPA to promulgate new public health and safety standards based on and consistent with the findings and recommendations of the NAS. The EnPA also directed NRC to modify its technical requirements to conform to the new EPA standards within 1 year. NAS issued its findings and recommendations on public health and safety standards for HLW specific to Yucca Mountain[37] in August 1995.

EPA issued 40 CFR Part 197 in 2001 to limit radiation doses received by the public from a HLW disposal facility at Yucca Mountain.[38] The standards set a 0.15 mSv (15 mrem) per year dose limit for the first 10,000 years after the facility was closed. The NAS had recommended that EPA set a dose limit at the time of peak dose.

[37] National Academy of Sciences/National Research Council, 1995.
[38] This activity is described in further detail at the following EPA web site: http://www.EPA.gov/radiation/yucca.

In July 2004, the U.S. Court of Appeals for the District of Columbia Circuit ruled the 10,000-year time period when the post-closure standards would be in effect was inconsistent with recommendations made by the NAS. The protectiveness of the 15 mrem/yr dose limit was not challenged nor was it addressed by the Court decision. It ruled EPA standards were invalid to the extent they were not consistent with or based upon a longer time period, when the highest doses of radiation from the waste are most likely to occur, as recommended by the NAS.

The standards proposed in August 2005 retain and add to EPA's original Yucca Mountain standards issued in 2001 and are also responsive to the Court ruling.

The following is a summary and explanation of these proposed standards[39]:

For the first 10,000 years:

- Retain the original 0.15 mSv (15 mrem) per year individual protection standard.
- This standard ensures that people living near Yucca Mountain are protected to the same level as those living near the Waste Isolation Pilot Plant in Carlsbad, New Mexico , currently the only operational deep geologic radioactive waste disposal facility in the U.S.

From 10,000 years up to 1 million years:

- Add a limit of 3.5 mSv (350 mrem) per year.
- This standard limits the maximum radiation from the facility so people living close to Yucca Mountain during the 1 million-year time frame will not receive total radiation any higher than natural levels experienced by people currently living in other areas of the country.

The standards further protect public health by requiring DOE to conduct analyses covering a 1 million-year time frame to assess the potential effects of natural processes or disruptive events affecting how well Yucca Mountain contains the waste. These include:

- Earthquakes, affecting the facility tunnels and breakdown of the waste containers.
- Volcanic activity, affecting the waste containers directly or cause releases of radionuclides to the environment.
- Climate change, causing increased water flow through the facility, resulting in the release of radionuclides to the environment.
- Corrosion processes, causing breakdown of the waste containers.

The proposal also extends the time DOE must assess events and processes affecting the safety of Yucca Mountain from 10,000 to 1 million years.

The proposal also includes requirements for:

[39] EPA standards specify the characteristics of a RMEI for use in performance assessments used to demonstrate compliance with the standards for disposal. EPA also specifies the criteria that pertain to the characteristics of the reference biosphere for use in the post-closure performance assessments. EPA standards exclude unlikely features, events, and processes from performance assessment analyses for estimating compliance with the standards for human intrusion and ground-water protection.

- Use by DOE of the middle, or median, value in calculating radiation dose. This ensures compliance is judged using the most likely performance of the disposal facility, and not against either very optimistic or pessimistic projections of its behavior.
- Use of updated scientific factors to calculate radiation dose. These represent the most recent international consensus and guidance on estimating the health effects of radiation.

In addition, EPA has a 0.04 mSv/year (4 mrem/year) ground-water protection standard and associated requirements for determining compliance with the standard over 10,000 years after closure.

E.2.2.3 Mixed Waste Regulation

A dual regulatory framework exists for mixed waste with EPA or authorized states regulating the hazardous component of the waste and NRC, NRC Agreement States, or DOE regulating the radioactive component. NRC and DOE regulate mixed waste radiation hazards using the AEA authority. EPA regulates mixed waste chemical hazards 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 the1984 Amendments to RCRA prohibit disposal of most mixed waste until it meets specific treatment standards. Most of the commercial mixed waste generated and stored can be treated to meet the Land Disposal Restriction regulations by 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.

E.2.2.4 Uranium Mining and Milling Air Emission Standards

EPA has established national Emission Standards under the Clean Air Act for Hazardous Air Pollutants (NESHAPs) for airborne radionuclide emissions from a variety of industrial sources of radionuclide emissions (40 CFR Part 61, 54 FR 51654, December 15, 1989). Three particular standards relate to uranium mining or mill tailings.

Subpart B protects the public and the environment from the radon-222 emissions to the ambient air from underground uranium mines. It sets a limit on the emission of radon-222 ensuring no member of the public in any year receives an effective dose equivalent of more than 0.1 mSv/yr (10 mrem/yr). Operating mine ventilation systems discharge large amounts of radon into the atmosphere. Radon in an unventilated mine is hazardous to miners. Ventilating to reduce radon exposure to the miners, however, increases exposure to the general population. Owners/operators of each mine must calculate the effective dose equivalent to any member of the public and report this information to EPA annually.

Subpart T protects people and the environment from radon-222 emissions from uranium mill tailings piles no longer operational. The radon-222 emission rate from a uranium mill tailings pile to the surrounding (ambient) air must not exceed 0.74 Bq/m^2-sec (20 pico curies/m^2-sec). Subpart T does not apply to NRC's licensees because they are covered by NRC's regulatory system. Releases occur both during and following the processing of uranium ores and originate from residual radioactive material and the disposal of uranium mill tailings. DOE controls 24 abandoned uranium mill tailings piles. The original deadline for bringing uranium mill tailings piles into compliance with the standard was December 15, 1991. EPA establishes compliance agreements with owners or operators of uranium mill tailings piles not in compliance by then to assure they are disposed of as quickly as possible. Owner operators must conduct emissions tests on piles they have sealed to prevent the escape of the radon gas and notify EPA of both what they have done and the results of the emissions tests.

Subpart W protects the public and the environment from the emission of radon-222 from active uranium mills and their associated tailings. The standard limits radon-222 emissions rate to 0.74 Bq/m^2-sec (20 pico curies/m^2-sec) and requires that new tailings impoundments meet one of the two following work practices:

1. There are a maximum of two impoundments in operation at any time (including existing impoundments) and they cannot be more than 0.16 km^2 (40 acres). Tailings management and disposal is by phased disposal.
2. Tailings are immediately dewatered and disposed of with no more than 0.04 km^2 (10 acres) uncovered at any time. Operators must also follow applicable NRC requirements in 40 CFR 192.32.

Uranium milling produces large quantities of tailings since uranium ore generally contains less than 1 percent uranium. These tailings are collected in impoundments varying in size from 0.08 to 1.6 km^2 (20 to 400 acres). The tailings contain large amounts of radium, and therefore, they emit large quantities of radon. Owners or operators must test emissions and report to EPA annually.

E.2.2.5 Other EPA Radiation-Related Authorities

EPA has regulatory responsibilities for a variety of other man-made and naturally-occurring radioactive wastes:

- General radiation protection guidance to the Federal government. Section F contains additional information about radiation protection;
- EPA has established national Emission Standards under the Clean Air Act for Hazardous Air Pollutants (NESHAPs) for airborne radionuclide emissions from a variety of facilities (40 CFR Part 61, 54 FR 51654, December 15, 1989). Subpart H of this regulation limits the airborne emissions of radionuclides (other than radon) from DOE sites managing defense-related spent nuclear fuel and radioactive waste. A limit of 0.1 mSv (10 mrem) per year 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 report of compliance to EPA;
- Drinking water regulations, under the Safe Drinking Water Act, as amended, including standards for radionuclides in community water systems;
- Works with state radiation protection agencies to protect the environment, workers, and the public from naturally occurring radioactive materials exposed or concentrated by mining or processing; and

- Coordinates with DOE, NRC and states on orphaned sources, recycled materials, and control of imports and exports to prevent radioactively-contaminated scrap from entering the U.S.

EPA is composed of a headquarters organization and 10 regional offices. Each EPA Regional Office is responsible within its states for the execution of the Agency's programs. EPA also has 17 laboratory facilities located across the nation.

E.2.3 U.S. Department of Energy

DOE is responsible for regulating the management of its radioactive waste and spent fuel, other than the disposal of HLW and spent fuel. DOE spent fuel and radioactive waste management activities designated under the Joint Convention receive oversight from DOE Office of Environment, Safety and Health (DOE-EH) and Office of Security and Safety Performance Assurance (DOE-OA). DOE oversight functions performed by DOE-EH include:

- Ensuring conformance of DOE activities with applicable laws and requirements for protecting the environment, and the safety and health of the public and the workers at DOE facilities;
- Conducting scientific and technical programs to enhance DOE ability to protect the health and safety of workers and the public;
- Developing effective, efficient, and state-of-the-art environmental, occupational safety and health, and medical policies and rules for operation of DOE facilities;
- Providing technical assistance to DOE programs to foster the identification and resolution of environment, safety, health, safeguards, and security issues; and
- Ensuring compliance with nuclear safety requirements.

DOE-EH develops, manages, and directs comprehensive programs providing effective health and safety policy for protecting the health and safety of workers and the safety of facility and systems operations at all DOE facilities. It also maintains a formal liaison role with external safety and health regulators, with internal DOE programs, and line elements and with contractor organizations on health and safety policy and regulatory issues. DOE-EH develops and manages health and safety programs to improve safety performance.

DOE-EH develops, coordinates, and promulgates DOE policy, orders, and standards for safety and health of workers, facilities, and working conditions. It establishes state-of-the-art programs, policies, and standards, assuring protection of DOE Federal and contractor personnel from occupational injury and illness, and safety of facility design and operations. It also ensures the adequacy of health and safety training for DOE and contractor employees.

DOE-EH develops policies and guidance and implementing strategies for the specialized safety disciplines of nuclear safety, health physics, industrial hygiene, fire protection, electrical safety, high explosives, firearms safety, pressure safety, and chemical safety. It establishes DOE policy and guidance and evaluates risk assessment processes for worker safety. It serves as the primary DOE liaison with the Department of Labor Occupational Safety and Health Administration and NRC on health and safety regulation reviews and pending regulatory reform. It also maintains nuclear safety and occupational safety and health technical expertise and provides DOE with consulting services to assist workers in understanding and implementing policies, standards, and guidance, in response to compliance and program requirement issues. It develops DOE directives and policies for radiation protection of the public and environment and guidance for environmental protection. These are promulgated as regulations or issued as DOE Orders.

DOE-EH also has approval authority for DOE environmental impact statements (EIS). It coordinates with and assists in preparing adequate environmental impact statements for major DOE proposed actions. It develops written orders, policies, regulations, and guidance documents for environmental review requirements and implementation.

DOE-EH performs independent technical reviews of facility nuclear safety authorization basis documents and the implementation process to ensure the establishment and maintenance of an adequate safety margin and the control of hazards resulting from DOE activities during routine and upset conditions for all facility life cycles. It also performs facility reviews, walk-downs, and personnel interviews to ensure actual facility conditions (including operations, where appropriate) are consistent with the authorization basis.

DOE-EH is responsible for investigations of potential violations of enforceable requirements, as well as nuclear safety concerns raised by workers at DOE facilities. It initiates and resolves enforcement actions where warranted in accordance with the process and procedures of 10 CFR Part 820.

The primary mechanism for enforcement is contractor self-identification and reporting of potential non-compliant activities as set forth in 10 CFR Part 820, Appendix A (Enforcement Rule and Policy). The incentive for contractor self-reporting lies in DOE Enforcement Policy, providing for up to 100 percent mitigation of civil penalties when contractors promptly identify, report, and correct violations. The fundamental tenet of the enforcement policy is to focus on those violations, due to the actual or potential safety significance of the violations, are cause for regulatory concern. Analysis of existing nuclear safety related events information was used to develop a safety significance threshold for evaluating potential violations for enforcement.
The 1988 Price-Anderson Amendments Act (PAAA) extended indemnification to DOE operating contractors for the consequences of a nuclear incident. Congress also gave DOE the authority to take enforcement actions against those contractors violating DOE nuclear safety rules. The PAAA, in effect, required DOE to establish an internal self-regulatory process. DOE's Office of Price-Anderson Enforcement maintains the internal self-regulatory program; investigates potential violations; and, where warranted, initiates enforcement action. Those actions are performed in accordance with the processes and procedures in 10 CFR Part 820. DOE enforces two substantive nuclear safety rules: 10 CFR Part 830 Subpart A, *Quality Assurance* and Subpart B, *Safety Basis Requirements,* and 10 CFR Part 835, *Occupational Radiation Protection.* Other requirements found in 10 CFR Part 820.11, *Information Requirements*, and 10 CFR Part 708, *DOE Contractor Employee Protection Program,* are also subject to DOE enforcement.

DOE ensures contractor accountability by conducting investigations and program reviews at selected sites. Two concerns have arisen: (1) issues are sometimes revealed by safety events preventable through effective performance assessment programs, and (2) corrective actions not effective in preventing recurrence. DOE developed and maintains the Noncompliance Tracking System (NTS) database where contractors voluntarily report non-compliances. Because DOE enforcement policy provides substantial incentives for contractors to self-identify, report, and correct nuclear safety concerns, voluntary reports into the NTS may result in enforcement discretion. DOE may either forego or mitigate enforcement action. Some contractors have begun to move from "event-driven" to "assessment-driven" NTS reports, indicating a proactive approach to identifying issues and taking actions to address them. Two important goals remain, however: continued improvement in contractor performance assessment and a decrease in programmatic or repetitive non-compliances.

DOE's Office of Security and Safety Performance Assurance (DOE-OA) was formed in May 1999. This organization performs independent oversight inspections of DOE facilities, including the functional area of environmental compliance and safety and health. The authority for DOE-OA to conduct independent oversight is formally established through DOE Order 470.2B, *Independent Oversight and Performance Assurance Program*. The requirements in DOE Order 470.2B detail the basis for independent oversight activities; conduct of appraisals; response to significant vulnerabilities; reporting of appraisal results; and the corrective action development, approval and closure (follow-up) process for all findings, issues, or concerns identified during appraisals. The changing mission of many DOE facilities, as well as the aging of those facilities, increases the importance of assessing ES&H policies and programs, as well as the implementation of those programs, to evaluate their effectiveness in protecting workers, the public, and the environment. DOE-OA also ensures identified deficiencies and other important issues are tracked and corrective actions are taken.

E.2.4 Defense Nuclear Facilities Safety Board

The Defense Nuclear Facilities Safety Board (DNFSB) is an independent Federal agency established by Congress in 1988. The Board's mandate under the Atomic Energy Act is to provide safety oversight of the nuclear weapons complex operated by DOE. DNFSB has authority for oversight of most DOE facilities—those that were or are in a defense mission. DNFSB is broadly responsible for independent oversight of all activities affecting nuclear safety within DOE nuclear weapons complex. This includes waste management facilities such as the WIPP and DOE LLW disposal sites. The nuclear weapons complex formerly concentrated on the design, manufacture, test, and maintenance of the nation's nuclear arsenal. The complex is now cleaning up contaminated sites and facilities, disassembling nuclear weapons to achieve arms control objectives, maintaining the smaller stockpile, and storing and disposing of excess fissionable materials.

All of these hazardous activities must be carried out in strict observance of health and safety requirements. The Board's enabling statute, 42 U.S.C. § 2286 et seq., requires review and evaluation of the content and implementation of DOE health and safety standards for the design, construction, operation, and decommissioning of defense nuclear facilities. The Board must then recommend to the Secretary of Energy any specific measures, such as changes in the content and implementation of those standards, DNFSB believes should be adopted to ensure the public health and safety are adequately protected. DNFSB also is required to review the design of new defense nuclear facilities before construction begins, as well as modifications to older facilities, and to recommend changes necessary to protect health and safety. Review and advisory responsibilities of the DNFSB continue throughout the full life cycle of facilities, including shutdown and decommissioning phases.

E.2.5 Nuclear Waste Technical Review Board

The U.S. Congress created the U.S. Nuclear Waste Technical Review Board (NWTRB) in 1987 to review DOE scientific and technical activities for management and disposal of the nation's spent fuel and HLW. NWTRB evaluates the characterization of Yucca Mountain, Nevada, as a potential repository site, as well as the packaging and transportation of commercial spent fuel and defense HLW.

The Nuclear Waste Policy Amendments Act authorized a board of 11 part-time members who are eminent in a field of science or engineering, including environmental, and social sciences, and selected solely on the basis of distinguished service. The National Academy of Sciences recommends candidates, and the President makes the appointments.

NWTRB makes scientific and technical recommendations to DOE to ensure a technically defensible site suitability decision and disposal program. It also advises DOE on the organization and integration of scientific and technical work on the Yucca Mountain site. It provides an ongoing forum that fosters discussion and understanding among DOE and its contractors of the complex scientific and technical issues facing the program.

NWTRB monitors DOE work to ensure technically sound and scientifically credible site characterization, reports to Congress on issues involved in characterizing the potential site at Yucca Mountain, and points out concerns from a variety of outside parties of interest to the scientific community.

E.2.6 National Council on Radiation Protection and Measurement

The National Council on Radiation Protection and Measurement (NCRP) is a private, Congressionally-chartered organization of radiation protection experts established in 1964. It has predecessor functions dating back to 1928, such as formulating and disseminating information, guidance, and recommendations on radiation protection and measurements, which represent the consensus of leading scientific thinking. The recommendations of NCRP are important to radiation users, the public, and other state, national and international groups concerned with radiation matters. Individuals and industrial organizations employing radiation sources turn to these recommendations to be sure their equipment and practices embody the latest concepts of protection. Non-governmental groups concerned with improving protection efforts and disseminating information on radiation protection look to NCRP for guidance. Governmental organizations, including NRC, EPA, DOE, the U.S. Public Health Service, and state governments use NCRP recommendations as the scientific basis of their radiation protection activities. NCRP also works closely with various international bodies concerned with radiation protection, such as ICRP.

F. GENERAL SAFETY PROVISIONS

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

- Responsibility of license holders,
- Human and financial resources,
- Quality assurance
- Operational radiation protection,
- Emergency preparedness, and
- Decommissioning.

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

- General safety requirements,
- Existing facilities,
- Siting of proposed facilities,
- Design and construction of facilities,
- Facility safety assessment, and
- Facility operation.

Sections G and H, address these same areas plus Articles 10 and 17 for Spent Fuel Disposal and Institutional Measures after Closure, and provide additional information specific to management of spent fuel or radioactive waste.

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

F.1 Responsibilities of the License Holder (Article 21)

The Joint Convention specifies each Contracting Party must ensure the prime responsibility for safety rests with the licensee, and each licensee take the appropriate steps to meet its responsibility. The government has the responsibility if there is no licensee. NRC regulations ensure its licensees are responsible for safety. DOE's Integrated Safety Management Program described in Section F.7.2 fulfills responsibility for the U.S. Government spent fuel and radioactive waste management facilities.

F.1.1 Safety Responsibility of NRC License Holders

The licensee/operator is ultimately responsible for safe radioactive waste and spent fuel management. Commercial licensees or operators will eventually transfer control to Federal or state governmental agencies, which in turn will be responsible for the short- and long-term protection of the public and the environment.

F.1.2 Integrated Safety Management at DOE

DOE's Integrated Safety Management System (ISMS) applies to all programs and activities within the agency, including spent fuel management. Integrated safety management is an overarching combination of all elements of environment, safety, and health into one system focused on accomplishing work safely. This is accomplished by formal processes building in rigorous safety discipline from definition and planning of work, through performance of work, and lessons learned/feedback. ISMS is derived from DOE Policy 450.1, Environment, Safety, and Health Policy for the Department of Energy Complex. Additional direction on addressing environmental issues within the ISMS framework can be found in DOE Order 5400.1, Environmental Protection Program, DOE Guide 450.1-1, Implementation Guide for Use with DOE Order 450.1 and DOE Guide 450.1-2, Implementation Guide for Integrating Environmental Management Systems into Integrated Safety Management Systems.[40]

Seven Guiding Principles of ISM

1. Line management is directly responsible for the protection of the public, the workers, and the environment;
2. Clear and unambiguous lines of authority and responsibility for ensuring safety are established and maintained at all organized levels within the Department and its contractors;
3. Personnel must possess the experience, knowledge, skills, and abilities necessary to discharge their responsibilities;
4. Resources are effectively allocated to address safety, programmatic, and operational considerations. Protecting the public, the workers, and the environment is a priority whenever activities are planned and performed;
5. Before work is performed, the associated hazards are evaluated and an agreed-upon set of safety standards and requirements are established which, if properly implemented, provide adequate assurance that the public, the workers, and the environment are protected from adverse consequences;
6. Administrative and engineering controls to prevent and mitigate hazards are tailored to the work being performed and associated hazards; and
7. The conditions and requirements to be satisfied for operations to be initiated and conducted are clearly established and agreed-upon.

ISMS focuses on the responsibility of line management, and of all workers, to protect the environment, safety and health. DOE Policy 450.4 also states "as a complement to line management, DOE's Office of Environment, Safety and Health provides …enforcement and independent oversight functions." DOE's statutory basis for its Enforcement Program is in 42 USC § 2271 et seq. Regulatory procedures to fulfill this statutory mandate are published in 10 CFR Part 820, *Procedural Rules for DOE Nuclear Activities*. Independent oversight includes: (1) DOE's Office of Security and Safety Performance Assurance, reporting directly to the Secretary of Energy, and provides an independent assessment of the effectiveness of policies and programs in environment, safety and health, emergency management, safeguards and security, including cyber security; (2) DOE's Office of Price-Anderson Enforcement, implementing DOE's congressional mandate to apply sanctions to contractors for unsafe actions or conditions violating nuclear safety requirements for protecting workers and the public; and, (3) the Defense Nuclear Facilities Safety Board, providing oversight independent of DOE.

F.2 Human and Financial Resources (Article 22)

Both commercial (NRC-regulated) and government (DOE) sectors 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 staff dedicated to regulation in various strategic areas. Table F-2 provides a crosscut of a subset of data in Table F-1 for specific regulatory areas.

[40] Can be found at http://www.eh.doe.gov/environment/index.html

Table F-1. Distribution of NRC Fiscal Year 2006 Full-Time Equivalents in Staff	
Strategic Category[41]	**FTEs during FY 2006**
Nuclear Reactor Safety	2174
Nuclear Materials and Waste Safety	912
Inspector General	49

The strategic categories of nuclear waste safety and material safety consist of 912 full time equivalent (FTE) staff. Approximately 45% of these FTEs are allocated to nuclear waste and spent fuel management.

Table F-2. NRC Staff for HLW, Spent Fuel, Decommissioning, LLW, and Enforcement Activities	
Regulatory Program[42]	**FTEs during FY 2006**
High-Level Waste	164
Spent Fuel Storage and Transportation (includes licensing and inspection)	116
Decommissioning and Low-Level Waste	127
	FTEs during FY 2004
Enforcement[43]	22

F.2.1 Personnel Qualifications for NRC Licensees

NRC regulations require applicants and licensees to have qualified personnel. The requirements provide for an organizational structure of the applicant, both off site and on site, including a description of lines of authority and assignments of responsibilities, whether in the form of administrative directives, contract provisions, or otherwise. NRC also has qualification requirements for its personnel working on spent fuel and radioactive waste management regulatory activities. Qualification protocols for NRC staff are mentioned in Annex F-1.

NRC establishes qualifications for those operational employees responsible for safety and radiological health. These also include the radiation safety officer and health physics personnel. The technical qualifications include training and experience so the applicant and members of the applicant's staff are competent to engage in the proposed activities. The applicant must additionally establish a personnel training program and a plan to maintain an adequate complement of trained personnel to carry out licensed activities in a safe manner.

Operations of systems and components identified as important to safety must be performed only by trained and certified personnel or by personnel under the direct visual supervision of an individual with training and certification in such operation. Supervisory personnel directing operations important to safety must also be certified in such operations. For certain materials licenses, applicants must be qualified by training and experience to use the material for the purpose requested in such manner as to protect health and minimize danger to life and property.

The physical condition and the general health of personnel certified for radioactive waste and spent fuel management operations important to safety may not be such as might cause operational errors that could endanger the public health and safety. Any condition potentially

[41] Source: U.S. Nuclear Regulatory Commission.
[42] Source: http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1100/v21/sr1100v21.pdf
[43] Source: http://www.nrc.gov/reading-rm/doc-collections/enforcement/annual-rpts/04report.pdf

causing impaired judgment or motor coordination must be considered in the selection of personnel for activities important to safety. These conditions need not categorically disqualify a person, as long as appropriate provisions are made to accommodate the conditions.

F.2.2 DOE Qualification Requirements

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

DOE directives impose additional training and qualification requirements for its activities. DOE implemented a plan requiring its managers to develop a staffing plan identifying critical technical capabilities and positions essential to safe operations at defense nuclear facilities as a result of a recommendation by the DNFSB in 1993. The staffing plan provides a basis for assessing staffing needs and filling technical vacancies. Shortages were identified in nuclear criticality safety skills at some defense facilities in July 2001. Steps were taken to address these shortages.

DOE is committed to developing and maintaining a technically competent workforce to accomplish its missions in a safe and efficient manner through the Federal Technical Capability Program. DOE, through this program, strives to recruit and hire technically capable personnel, continuously develop the technical expertise of its existing workforce and, within the limitations of executive policy and Federal law, retain critical technical capabilities within DOE at all times. These principles for defense facilities and intent of the Federal Technical Capability Program are also applied to organizations falling outside the purview of the DNFSB. Most of DOE spent fuel and radioactive waste management facilities are considered defense nuclear facilities. DOE is determined to continue making improvements in the capabilities of the Federal workforce and to fully use all of the tools at its disposal.

F.2.3 Financial Surety

Licensees in the commercial sector must meet NRC requirements for financial surety. Spent fuel and radioactive waste management activities in the government sector (DOE facilities) have the financial assurance of the U.S. Government. Annual appropriations are made by the U.S. Congress. Special considerations are discussed below for the planned Yucca Mountain repository, where disposal of both government and commercial spent fuel and high-level waste are proposed.

F.2.3.1 Commercial LLW Management Facilities

The financial information must be sufficient to demonstrate the financial qualifications of the applicant are adequate to carry out the activities for which the license is sought and meet other financial assurance requirements. Each applicant must show it either possesses the necessary funds or has reasonable assurance of obtaining the necessary funds, or a combination of the two, to cover the estimated costs of conducting all licensed activities over the planned operating life of the project, including costs of construction and disposal.

Waste processors and brokers are subject to NRC regulations in 10 CFR 20.1403 requiring sufficient financial assurance to enable an independent third party, including a governmental custodian of a site, to assume and carry out responsibilities for any necessary control and maintenance of the site where the license is terminated with restrictions on future site use. The financial assurance mechanism and amount are reviewed and approved by NRC before the license is terminated. No post-closure activities or institutional controls are needed for sites released after closure without restrictions on future site use.

The licensee's surety mechanism for commercial disposal facilities is reviewed annually by NRC to assure sufficient funds are available for completion of the closure plan, assuming the work has to be performed by an independent contractor. NRC regulations (10 CFR 61.62) require funding for disposal site closure and stabilization of commercial waste disposal sites. The applicant must provide assurance sufficient funds are available to carry out disposal site closure and stabilization, including: (1) decontamination or dismantlement of land disposal facility structures; and (2) closure and stabilization of the disposal site so that following transfer of the disposal site to the site owner, the need for ongoing active maintenance is eliminated to the extent practicable and only minor custodial care, surveillance, and monitoring are required. The applicant's cost estimates must take into account total capital costs incurred if an independent contractor were hired to perform the closure and stabilization work.

NRC accepts financial sureties consolidated with earmarked financial or surety arrangements established to meet requirements of other Federal or state agencies and/or local governing bodies for such decontamination, closure and stabilization to avoid unnecessary duplication and expense. NRC accepts this arrangement only if it is adequate to satisfy these requirements and the portion of the surety, covering the closure of the disposal site, is clearly identified and committed for use for these activities.

The amount of surety changes with the predicted cost of future closure and stabilization. Factors affecting closure and stabilization cost estimates include: inflation; increases in the amount of disturbed land; changes in engineering plans; closure and stabilization already accomplished and other conditions affecting costs. This yields a surety at least sufficient at all times to cover the costs of closure of the disposal units expected to be used before the next license renewal. The term of the surety mechanism is open-ended unless it can be demonstrated another arrangement would provide an equivalent level of assurance.

Financial surety arrangements generally acceptable to NRC include: surety bonds, cash deposits, certificates of deposits, deposits of government securities, escrow accounts, irrevocable letters or lines of credit, trust funds, and combinations of the above or other arrangements approved by NRC. Self-insurance, or any arrangement, constituting pledging the assets of the licensee, does not satisfy the surety requirement for private sector applicants since this provides no additional assurance other than through license requirements.

Further financial assurances for institutional controls are found in 10 CFR 61.63. The State has responsibility for review and acceptance of financial sureties in Agreement States.

F.2.3.2 Spent Fuel and HLW Management Facilities

The policy of the U.S., as implemented through the Nuclear Waste Policy Act (NWPA), requires utility customers who receive benefits of electricity generated by nuclear power to pay costs for site characterization and development of geologic repositories to dispose of spent nuclear fuel and high-level radioactive wastes. These consumers currently pay a fee of $0.001 per kilowatt-hour of nuclear generated power used. The fee is periodically analyzed to determine adequacy in meeting the estimated life cycle costs for disposal. It is collected by utilities and deposited into the Nuclear Waste Fund (NWF). The U.S. Congress appropriates funds annually for the development of Yucca Mountain and attendant management costs. The U.S. Congress also provides an annual appropriation from the General Fund of the Treasury to pay for costs for disposal of defense-related high-level radioactive waste. Financial and technical assistance funds from the NWF are also provided to the State of Nevada, local counties (nine in Nevada and one in California), and educational institutions conducting oversight and monitoring activities as required under a 1987 amendment to the NWPA.

Financial assurance for the storage of spent fuel is required under provisions in 10 CFR Part 72 to ensure funds are available to store spent fuel in ISFSIs and for future decommissioning of nuclear reactor facilities. Financial mechanisms used include surety/insurance or other guarantee method, external sinking funds, government statement of intent, or contractual obligations on the part of the firm's customers.

The Government Accountability Office, an arm of the U.S. Congress, is required by the NWPA to conduct annual audits of the NWF. A certified public accounting firm also conducts independent audits of the NWF annually.

F.2.3.3 Uranium Recovery Waste Management Facilities

Financial surety arrangements must be established by each mill operator prior to the start of operations to assure sufficient funds will be available to carry out the decontamination and decommissioning of the mill and site and for the reclamation of any tailings or waste disposal areas. This may be accomplished by a third party. The amount of funds to be guaranteed by such surety arrangements must be based on NRC-approved cost estimates in an NRC-approved plan for:

- Decontamination and decommissioning of mill buildings and the milling site to levels allowing unrestricted use of these areas upon decommissioning, and
- Reclamation of tailings and/or waste areas in accordance with technical criteria in Section I of Appendix A to 10 CFR Part 40.

The licensee must submit this plan in conjunction with an environmental report addressing the expected environmental impacts of the milling operation, decommissioning and tailings reclamation, and evaluates alternatives for mitigating these impacts. The surety must also cover payment of the charge for long-term surveillance and control. The licensee's surety mechanism is reviewed annually by NRC to recognize any increases or decreases resulting from inflation, changes in engineering plans, activities performed, and any other conditions affecting costs.

This process will yield a surety at least sufficient at all times to cover the costs of decommissioning and reclamation of the areas expected to be disturbed before the next license renewal. Financial surety arrangements generally acceptable to NRC are: surety bonds, cash deposits, certificates of deposits, deposits of government securities, irrevocable letters or lines of credit, and combinations of the above or other arrangements approved by NRC.

A variance in funding requirements may be specified by NRC if site surveillance or control requirements at a particular site are determined, on the basis of a site-specific evaluation, to be significantly greater than annual site inspections.[44] Eventual ownership of the uranium mill disposal site will be to an agency of the U.S. Government (DOE) or an appropriate state agency for perpetuity.

[45]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.

A minimum charge of $250,000 (1978 U.S. dollars) to cover the costs of long-term surveillance is paid by each mill operator to the General Treasury of the United States or to an appropriate state agency prior to the termination of a uranium or thorium mill license.

F.2.3.4 Complex Material Sites Decommissioning

Many of the existing NRC regulated decommissioning sites are complex and difficult to decommission for a variety of financial, technical, or programmatic reasons. These sites can be thought of as NRC "legacy" sites -- those sites where past financial or operational events have created the existing problems that must now be overcome, to conduct sufficient cleanup and ultimately complete decommissioning and license termination. NRC evaluated the lessons from these existing legacy sites and plans on changes to financial assurance and licensee operational requirements to minimize or prevent future legacy sites.

A number of sites licensed before the financial assurance regulations were issued in 1988 now find that the full cost of decommissioning exceeds their projections and fund balances. Furthermore, NRC experience applying the financial assurance regulations has resulted in many lessons that can be applied to improve the regulations and reduce the risks to decommissioning financial assurance. Based on this experience, NRC identified specific risks possibly causing shortfalls in decommissioning funding including: 1) underestimation of decommissioning costs caused by a restricted release assumption; 2) operational indicators of increasing costs; 3) unavailability of funds in bankruptcy; 4) inadequate financial disclosure; 5) reaching assets after corporate reorganization; 6) investment losses reducing trust account balances; and 7) increased decommissioning cost because of accidental release.

NRC evaluated options for each of these funding risks and made recommendations for both existing and future licensees. To resolve the risk of underestimating decommissioning costs, NRC recommends requiring a licensee to either: 1) obtain NRC approval of the decommissioning funding plan and prepare a cost estimate and financial assurance amount assuming unrestricted release or 2) demonstrate its ability to meet the restricted release requirements. NRC also recommends using a risk-informed approach to identify high risk operational indicators (e.g., spills, ground water contamination, and facility modification) and requiring updates to decommissioning cost estimates and financial assurance coverage.
New requirements are recommended for additional certification of financial statements; holding both parent company and subsidiaries liable for decommissioning costs by license conditions and/or agreements; and for licensees to perform periodic evaluations of the impact of investment losses on their trust fund balances and sufficiency of financial assurance coverage. NRC has plans to conduct a new rulemaking and developing new guidance to resolve these issues. A proposed rule and draft guidance is planned to be issued in FY 2006 and the final rule and guidance in FY 2007.

F.3 Quality Assurance (Article 23)

The following subsections provide a summary of quality assurance (QA) requirements prescribed by NRC and DOE for spent fuel and waste management activities.

F.3.1 NRC Quality Assurance

An application to receive, possess, and dispose of wastes containing source, byproduct or special nuclear material by land disposal must contain a description of the quality assurance program for the determination of natural disposal site characteristics and for quality assurance during the design, construction, operation and closure of the LLW facility[NRC regulation 10

CFR 61.12(j)]. Guidance to applicants on how to meet the QA regulatory requirements in Part 61 is provided in NUREG-1293, Rev. 1, *QA Guidance for Low-level Waste Disposal Facilities*. QA requirements for packaging and transportation of licensed radioactive material are provided in Subpart H of 10 CFR Part 71.

The scope of the NRC QA Program for HLW disposal in a geological repository is described in 10 CFR Part 60, while the QA program for storage of spent nuclear fuel in an ISFSI is described in 10 CFR Part 72. The QA program for the Yucca Mountain project is in 10 CFR Part 63. These regulations comprise all planned and systematic actions necessary to provide adequate confidence the geologic repository and its structures, systems, or components will perform satisfactorily in service. Quality assurance includes quality control, which comprises those quality assurance actions for the physical characteristics of a material, structure, component, or system. An entire subpart is devoted to quality assurance: 10 CFR Part 60 Subpart G.[45] Subpart G for the QA program for 10 CFR Part 72 and 10 CFR Part 63 can also be accessed on the internet. NRC observes audits conducted by DOE's Office of Quality Assurance. DOE audits assess whether their contractors have satisfactorily implemented the DOE Office of Civilian Radioactive Waste Management quality assurance program. NRC documents its observations of DOE audits and transmits its observations to DOE.[46]

Quality assurance is addressed as part of the license requirements for uranium extraction operations. Some specific areas are addressed for the disposal unit performance; e.g., where ground-water impacts are occurring or expected to occur, action must be taken to alleviate conditions that lead to excessive seepage impacts and restore ground-water quality for the reclaimed tailings impoundment where tailings are buried and stabilized for the long term (200–1000 year design). Technical specifications must be prepared to mitigate these impacts. A quality assurance, testing, and inspection program including supervision by a qualified engineer or scientist, is established to assure the specifications are met. A general license is issued by NRC to the custodial agency when the operations are terminated, the site reclaimed and disposal strategy is realized. There is no termination of this general license. A site Long-Term Surveillance Plan (LTSP) is prepared by the custodial agency and accepted by NRC as part of this action. The LTSP must include, among many safety-related provisions: a description of the long-term surveillance program, including proposed inspection frequency and the frequency and extent of ground water monitoring if required, appropriate constituent concentration limits for ground water, inspection personnel qualifications, inspection procedures, record keeping, and QA procedures.

F.3.2 DOE Quality Assurance

DOE quality assurance requirements are specified in 10 CFR Part 830.120. Some DOE work is subject to regulation by quality assurance requirements from NRC, an Agreement State, or other government agencies. DOE elements may impose additional quality requirements or specific standards, as needed, for certain types of work.

DOE programs must implement the quality assurance criteria 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 quality assurance programs by applying 10 quality assurance criteria using a graded approach. The 10 quality assurance criteria fall within three areas: management, performance, and assessment. The management criteria are QA program, personnel training, and qualification, quality improvement, documents and records.

[45] http://www.nrc.gov/reading-rm/doc-collections/cfr/part060
[46] http://www.nrc.gov/waste/hlw-disposal/quality-audits.html

The performance criteria are work processes, design, procurement, and inspection, and acceptance testing. The assessment criteria are management assessment, and independent assessment. The QA program plan must describe how the criteria will be satisfied and how the graded approach will be applied.

DOE's Office of Quality Assurance Programs was established in 2003 to provide DOE-wide leadership in the area of quality assurance and to develop necessary quality assurance programs, processes, and procedures, resulting in:

- Software quality assurance (SQA) standards and identified improvements for safety analysis software,
- An SQA Knowledge Portal as a central repository for software quality assurance knowledge and reference including a central registry of toolbox codes, criteria review and approach documents, a discussion forum, SQA training information, information on current directives and those under development, and SQA lessons learned, and
- Establishment of a self-assessment certification program based on criteria and processes from the Institute for Nuclear Power Operations principles for self-assessment, corrective actions, and tracking and trending.

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 and the NCRP (see Section E.2.6). The NAS is a private, nonprofit institution providing science, technology and health policy advice under a congressional charter. The NAS established a Board of Radioactive Waste Management focusing on waste management and disposal.

F.4.1 U.S. 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 and local and tribal governments and works closely with other national and international radiation protection organizations to further our scientific understanding of radiation risks.

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

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

The *Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada*,[47] promulgated in 40 CFR Part 197 by EPA, became effective on July 13, 2001. EPA was directed to develop these standards by law in Section 801 of the Energy Policy Act of 1992

[47]EPA Yucca Mountain Standards, http://www.epa.gov/radiation/yucca/index.html

(EnPA, Public Law No. 102-486). The EnPA also required EPA to contract with the National Academy of Sciences to conduct a study and provide findings and recommendations on reasonable standards for protection of the public health and safety. The National Academy of Sciences released its report, *Technical Bases for Yucca Mountain Standards*, on August 1, 1995. This report was used by EPA in their development of Part 197 standards, which are now being revised to respond to a recent Court decision. See Section E.2.2.2 for details.

Federal guidance is a set of guidelines developed by EPA, for use by Federal and state agencies responsible for protecting the public from the harmful effects of radiation. Guidance documents produced by EPA are available on the internet.[48] Some key radiation protection guidance documents are listed in Annex F-2.

F.4.2 NRC General Radiological Protection Limits

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

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

The provisions in 10 CFR Part 20 also include

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

NRC regulates commercial power generation as well as medical, academic, and industrial uses of radioactive material. NRC has published additional regulations addressing reactors, medical uses of isotopes, large irradiators and other commercial uses of radioactive material, in addition to the radiation protection requirements contained in 10 CFR Part 20. NRC is developing regulations and procedures to address its new EPACT05 responsibilities.

NRC promulgates safety regulations expressed in annual total effective dose equivalents, as well as air and liquid effluent release concentrations for restricted and unrestricted areas.

F.4.2.1 Occupational Dose Limits

Operations are conducted so the occupational dose to individual adults complies with an annual limit, which is the more limiting of: (1) The total effective dose equivalent being equal to 0.05 Sv (5 rems); or (2) The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 0.5 Sv (50 rems). Annual occupational dose limits are established in 10 CFR 20.1201 for adults and §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 milligrams in a week. The NRC limit of 10 mg/week for soluble uranium is contained in 10 CFR 20.1201(e), and is based on the onset of heavy metal poisoning to the kidney. This limit is

[48] EPA Radiation Protection Program, http://www.epa.gov/radiation/federal/index.html

further addressed in footnote 3 of Appendix B to Part 20. Dose limits for a fetus are contained in 10 CFR 20.1208 and are applicable only for a "declared pregnant woman," which is defined in 10 CFR 20.1003. The dose to an embryo/fetus as a result of occupational exposure should be as low as reasonably achievable (ALARA) and should not exceed 0.5 rem (0.005Sv) during the entire gestation period.

Figures F-1 and F-2 provide average measured doses (TEDE) for over 15 years for low-level waste disposal facilities and ISFSIs, respectively. In 1999 NRC relinquished its regulatory authority of the existing LLW disposal sites to the Agreement States. This information and other details on occupational exposure are available on the internet.[49] This document is published as: NUREG-0713 Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities 2003, Vol. 25, U.S. Nuclear Regulatory Commission, October 2004. It is updated annually.

F.4.2.2 Public Dose Limits

Operations must be conducted so the total effective dose equivalent to individual members of the public from the licensed operation does not exceed 1 mSv (0.1 rem) in a year for release to unrestricted areas and protection of the public. This dose is exclusive of the contributions from background radiation, any medical administration to individuals, and other contributions not attributable to the operation or other licensed operations.

[49] http://www.reirs.com/nureg2002/nureg2002.pdf

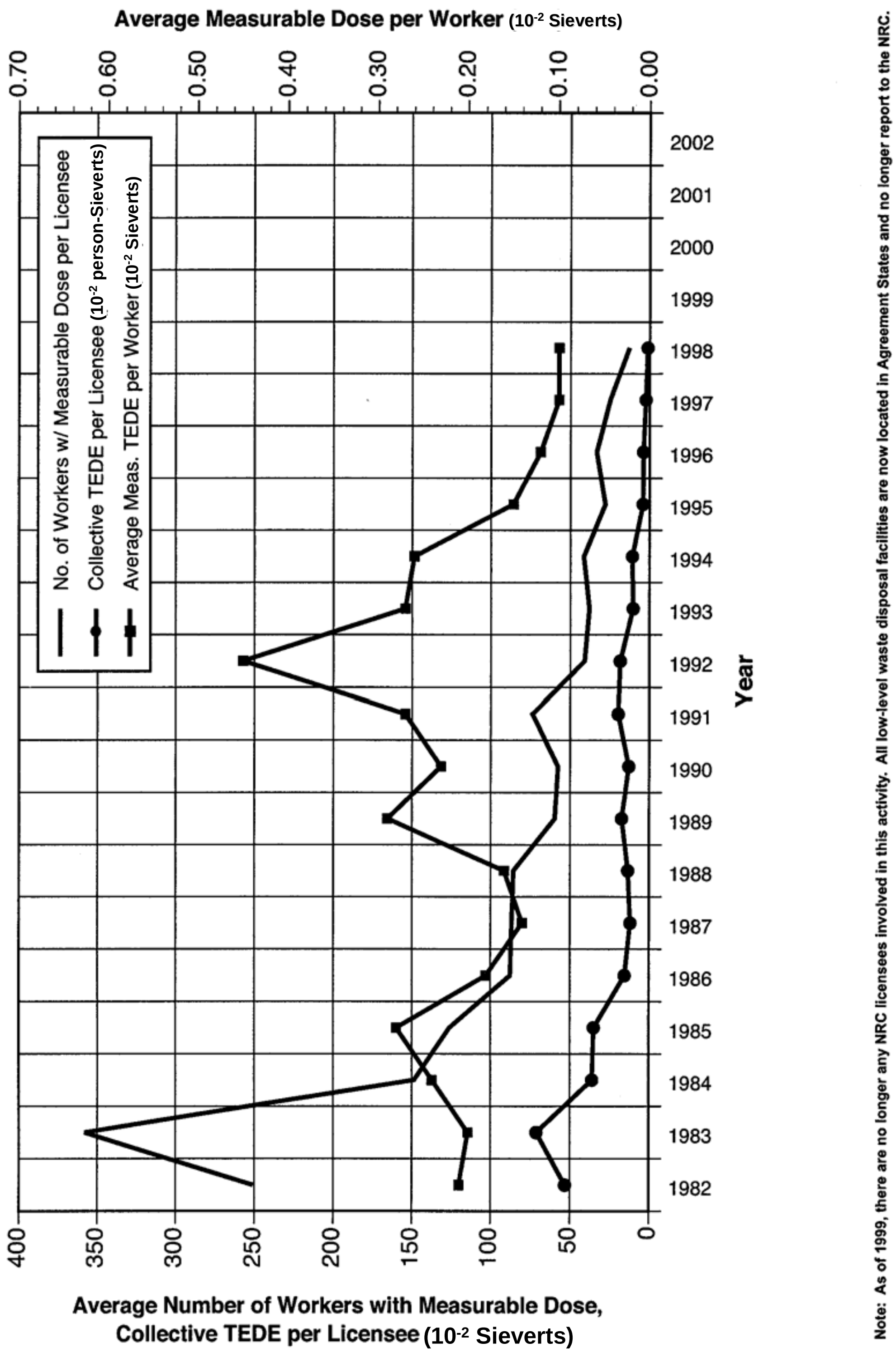

Figure F-1. Average Annual Values at Low-Level Waste Disposal Facilities, 1982-1998

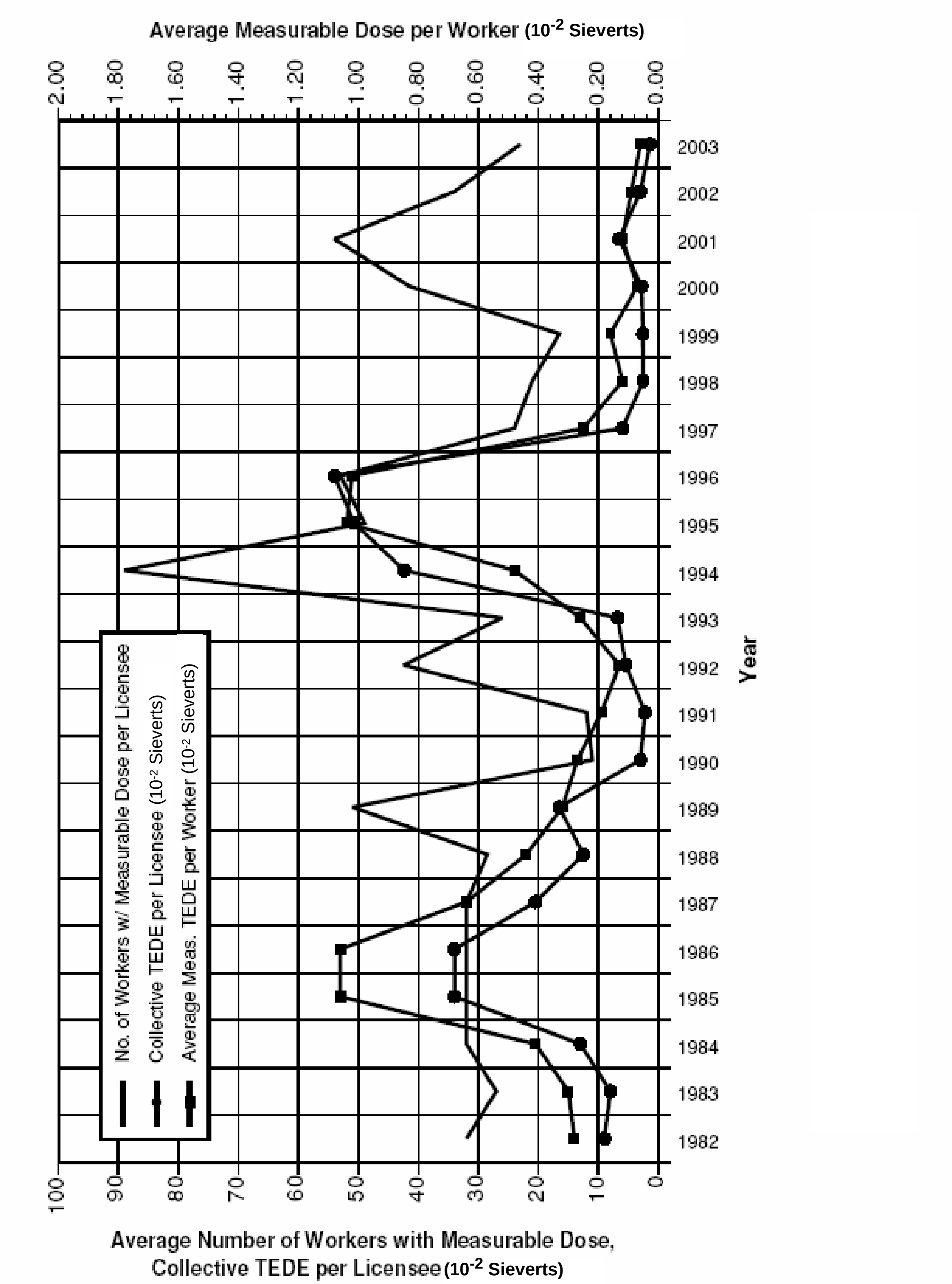

Figure F-2. Average Annual Values at Independent Spent Fuel Storage Facilities, 1982-2003

Yucca Mountain standards provide for the protection of ground water (40 CFR 197.20 and 197.31) in addition to the dose-based individual protection standard (40 CFR 197.20). This assures ground water resources will be safe for use by future generations while protecting a diverse agricultural community and important geological systems. NRC adopted the 0.15 mSv (15 mrem) per year individual protection standard for the postclosure of the planned Yucca Mountain repository (10 CFR 63.311) in compliance with 40 CFR Part 197.

There are provisions where an individual member of the public may be exposed to higher levels. These provisions are addressed in NRC regulations for protection against radiation (10 CFR Part 20). The dose limits in Part 20 include consideration of both internal and external doses. Specific reporting requirements are contained in Subpart M of Part 20.

The dose levels associated with disposal of radioactive wastes and for the release of facilities used for licensed activities are also contained in Part 20 (e.g., 20.1402, 20.1403, and Subpart K), and include requirements for surveys and measurements for residual radioactivity. Solid materials can be released for unrestricted use if the survey or measurement does not detect residual radioactivity from the licensed operations, or if it does detect residual radioactivity, the amount is below a level considered to be protective of the public health and safety and the environment.

Subpart B of 10 CFR Part 20 provides NRC's regulatory requirements for Radiation Protection Programs, and includes the requirements for licensees to establish programs for ALARA. These requirements specifically address the release of radioactive effluents to the environment.

F.4.2.3 Radiological Criteria for License Termination (Decommissioning)

Public protection levels from all sources and practices must not exceed 1 mSv/year. Each nuclear facility or other licensed operation (e.g., medical laboratory) is held to a fraction of this limit upon its decommissioning and license termination. Subpart E of 10 CFR Part 20 specifies a site will be considered acceptable for unrestricted use if the residual radioactivity distinguishable from background radiation results in a total effective dose equivalent to an average member of the critical group not exceeding 0.25 mSv (25 mrem) per year, including contribution from ground water sources of drinking water, and the residual radioactivity has been reduced to levels as low as reasonably achievable. Determination of the ALARA levels takes into consideration any detriments, such as deaths from transportation accidents, expected to potentially result from decommissioning, and waste disposal. ALARA evaluations in some simple cases only include a qualitative assessment of levels ALARA; in more complicated cases ALARA evaluations may include a quantitative cost-benefit assessment. The non-radiological risks of death from transportation accidents and other causes are included as costs in such cost-benefit assessments,. The calculated risk of death is converted to cost by using a monetary value per fatality. That value is consistent with the acceptable cost to avoid future doses (monetary cost per person-sievert averted).

F.4.2.4 LLW Disposal Sites

Protecting the general population from releases of radioactivity from a LLW disposal facility is also dose-based. The concentrations of radioactive material released to the general environment in ground water, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 0.25 mSv (25 mrem) to the whole body, 0.75 mSv (75 mrem) to the thyroid, and 0.25 mSv (25 mrem) to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment ALARA.

F.4.2.5 Uranium Mill Tailings Disposal Sites

Reclaimed uranium mills are required to meet a radon release constraint in 10 CFR Part 40, Appendix A in addition to the annual dose limits described in the previous section. There is a radon (radon-222 from uranium byproduct materials and radon-220 from thorium byproduct materials) flux limit for a stabilized mill tailings disposal site of 0.7 Bq/m^2-s (20 pCi/ m^2-s). The 0.7 Bq/m^2-s radon release from uranium mill tailings was based on the cost-effectiveness of control for a thick earthen cover design, taking into consideration individual and population doses. There are also ground water concentration limits for radionuclides and certain hazardous constituents. A design must provide reasonable assurance of control of radiological hazards to be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years. This design must also inhibit misuse of tailings, stabilizes the tailings against erosion and contamination of land and water, minimizes gamma radiation exposure, and avoid ground water contamination.

F.4.3 DOE Radiation Protection Regulations

DOE requires radiation protection for workers and the public in its regulations and directives. 10 CFR Part 835 governs radiation protection of workers at DOE facilities and activities not licensed by NRC. DOE regulations in 10 CFR Part 835 are similar to NRC regulations in 10 CFR Part 20, but there are some differences resulting from the types of radiological activities regulated by DOE and NRC, respectively. DOE 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. Further directives are found in *Radiation Protection of the Public and the Environment*, DOE Order 5400.5.

Compliance with these regulations is generally determined by inspectors using survey equipment to measure radionuclide airborne or liquid concentrations within and at control boundaries. These concentrations are determined to be representative of total effective dose equivalents (TEDEs) or of effective doses corresponding to individuals exposed to such concentrations.

Safety assessment computer models 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. Such assessments support a risk-informed operational, closure and post-closure monitoring strategy in order to provide an effective measure of performance.

DOE estimates radiation doses to the public around its many sites through extensive continuous radiological monitoring and surveillance programs as part of its commitment to communities where its facilities are located. The estimated annual collective dose to the public has been very small and has stabilized at approximately 0.40 person-sievert (40 person-rem), well below both DOE limits and EPA National Emission Standards for Hazardous Air Pollutants (NESHAPs), despite cleanup and stabilization activities at contaminated sites. Background radiation dose to the population in a large metropolitan area would be more than two million person-rem annually, from natural and man-made sources to put the estimated DOE-wide annual collective dose in perspective. Figure (F-3) shows the historical trend.

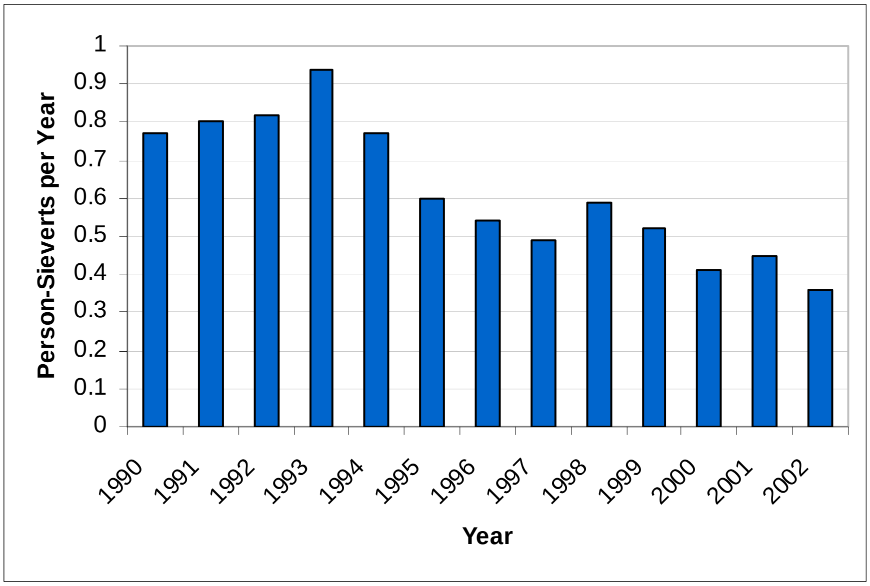

Figure F-3. Estimated Off-Site Radiation Dose to the Public

DOE keeps radiation exposures to workers ALARA, keeping worker doses as low as reasonably achievable within the constraints imposed by work, equipment, and technical conditions. The ALARA concept is accomplished through work planning that considers a worker's time in the area, distance from the work, and required shielding. Workers are monitored for radiological skin contamination, exposures, and uptakes. Administrative control levels are established to manage exposures to workers so no one exceeds these levels without prior approval. Two individuals exceeded the 50 mSv (5 rem) annual limit in 2003. Only 17 percent (17,484 out of 102,509) of DOE workers monitored for radiation dose received a measurable dose in 2003. The average annual measurable dose to a worker was 0.83 Sv (83 millirem), and the collective dose was 14.446 person-Sv (1444.6 person-rem).

The average American receives approximately 3 Sv (300 millirem) per year from all natural and man-made sources of radiation to place the DOE dose in perspective. The majority of those workers with a measurable dose in 2003 - 13,865 out of 17,484 - received less than 1 Sv (100 mrem) total effective dose equivalent. Thousands of people work in radiation areas every day without receiving significant radiation exposure, showing ALARA controls are in place and working.

F.4.4 Other Radiation Protection Regulations

EPA has the prime role in setting U.S. radiation protection regulations, but other Federal agencies also regulate radiation protection:

- The Occupational Health & Safety Administration of the Department of Labor (DOL) has regulations dealing with worker protection from ionizing radiation found in 29 CFR;
- The Mine Safety and Health Administration of the DOL has safety and health regulations related to underground mining in 30 CFR Part 57, subparts 4037 to 5047; and
- The Department of Transportation Act of 1966 assigns overall regulatory responsibility for safety in transporting all hazardous materials, including radiological material, to the U.S. Department of Transportation (DOT). NRC also has responsibility for safety in possession, use, and transportation of by-product, source, and special nuclear material, or "licensed material" under the Atomic Energy Act of 1954, as amended. NRC and DOT signed a Memorandum of Understanding in 1979 to resolve any overlap in statutory authority. An overview of DOT's hazardous materials regulations is provided in *Radioactive Material*

Regulations Review, Research and Special Programs, RAMREG-001-98. This is a guidance document.

- The U.S. Postal Service (USPS) regulates transportation of radioactive material by mail. The *USPS Domestic Mail Manual* contains requirements for transportation and is incorporated by reference into 39 CFR Part 111, *General Information on Postal Service*. Further guidance is in USPS Publication 52, *Hazardous, Restricted and Perishable Mail*,

Limits for air and water discharges from spent fuel/radioactive waste facilities are established through rulemaking by the responsible agency; (see Section E of this report). EPA has issued rules for spent nuclear fuel, high-level radioactive waste, transuranic waste, commercial nuclear fuel cycle and uranium/thorium mill tailings facilities. NRC implements these rules and has established rules for commercially generated low-level radioactive waste facilities except for transuranic waste. DOE regulates air and water discharges from its radioactive waste facilities through its internal orders, while airborne emissions from DOE facilities are regulated by EPA.

NRC has transferred control of certain radioactive waste and materials to many of the states through written agreement under the authority of the Atomic Energy Act. "Agreement States" must operate programs to protect public health and safety from these materials under comparable regulations to those of NRC. 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)

Article 25 specifies spent fuel and radioactive waste management facilities must have appropriate on-site and, if necessary, off-site emergency plans, and should be tested at an appropriate frequency. Additionally, Article 25 requires each Contracting Party to prepare and test emergency plans on its territory in the event of a radiological emergency at a spent fuel or radioactive waste management facility in the vicinity of its territory. The following subsections describe the extensive emergency preparedness and emergency management programs in place at NRC-licensed and DOE facilities.

F.5.1 Emergency Preparedness within NRC

The licensee is always held responsible for consequence mitigation for incidents at NRC-licensed facilities. The licensee is also responsible for providing appropriate protective action recommendations to State and local officials. NRC has responsibility for on-site Federal emergency response to incidents and events involving NRC-licensed or Agreement-State-licensed radioactive material. The Federal Emergency Management Agency (FEMA), which has been incorporated into the Department of Homeland Security (DHS), has responsibility for off-site Federal emergency response. DHS is working with all Federal departments and agencies, and State and local governments to create a single, comprehensive approach to domestic incident management. NRC staffs a Liaison Team in its Operations center to interact with other government entities during exercises and in response to actual incidents.

The U.S. has entered into bilateral agreements with other countries in addition to being Party to IAEA Conventions on the Early Notification of a Nuclear Accident and on Assistance in the Case of a Nuclear Accident or Radiological Emergency. There are general agreements as well as special classified information exchange agreements that provide for the sharing of significant sensitive information to prepare for and respond to emergency situations. The U.S., Canada, and Mexico have a tri-lateral agreement related to emergency response and the control of nuclear materials across national borders.

Incidents associated with performance failure at radioactive waste disposal sites after closure are not treated the same as operational facilities with sequential handling, processing and transport of highly radioactive material. Part of the performance assessment for long-term integrity, stability, and isolation of waste disposal in post-closure is contingent on engineering measures and geologic and other natural barriers, which may not fail for thousands of years. Emergency planning is part of the NRC regulatory regime for nuclear safety during the operational phase of these radioactive material storage and/or disposal facilities. Radioactive waste storage, handling, conditioning, treatment and other predisposal management activities are addressed as components of the overall operational emergency preparedness program for most of the reactor and nuclear materials facilities.

NRC does not identify a critical radiological accident for decommissioning. Licensees are required to analyze their particular facility to determine the appropriate health and safety measures necessary to maintain worker and public health and safety doses with NRC limits. The health and safety plan is provided to NRC as part of a decommissioning plan (DP) or license termination plan (LTP), and NRC reviews it as part of the review and approval process for decommissioning or license termination.

F.5.1.1 Nuclear Facility Response Plans

NRC regulations require comprehensive emergency plans be prepared and periodically exercised to assure actions are taken to notify and protect citizens in the vicinity of a nuclear facility during an emergency. Although nuclear power plants, as well as fuel fabrication and uranium conversion and enrichment facilities, have active components that could require immediate protective response to mitigate the effects of an accident, radioactive waste disposal systems are passive. For radioactive waste management and spent fuel management at a nuclear power plant or other significant nuclear fuel cycle facility, the emergency preparedness program is modified by license condition upon the facility's entry into the decommissioning phase. The revised provisions for emergency preparedness and response will be modified commensurate with the hazard of the materials remaining within the former controlled areas.

NRC Regulatory Guide 3.67,[50] provides information on the classification of emergencies as either “alerts” or “general site emergencies” for general materials facilities. Categories of emergencies are identified in Annex F-3. DOE also has published classification guidance in DOE G151.1-1 Categorization and Classification of Operational Emergencies.[51]

NRC reevaluated the emergency preparedness for nuclear fuel cycle facilities after a large, toxic release of uranium hexafluoride (UF_6) at the Sequoyah Fuels Corporation conversion facility in 1986. The significant potential accidents at uranium conversion, fuel fabrication, and enrichment facilities are UF_6 releases, fires, and criticality accidents; the latter being an unintended, self-sustaining nuclear chain reaction. These types of accidents are likely to be controlled within about half an hour although there may be little or no warning.

Although the severity and extent of hazards associated with spent fuel or radioactive waste management facilities are different than those associated with a nuclear power plant, many of the elements for emergency response are still applicable. The same is true for an incident involving sealed sources, disused or otherwise.

[50] http://www.nrc.gov/reading-rm/doc-collections/reg-guides/fuels-materials/active/03-067/index.html
[51] http://www.directives.doe.gov/.

F.5.1.2 NRC Response to an Emergency

NRC activates its incident response program at its Headquarters Operations Center and one of its four Regional Incident Response Centers (Region I in King of Prussia, PA, Region II in Atlanta, Georgia, Region III, in Lisle, IL, and Region IV in Arlington, TX) in response to an event at an NRC-licensed facility that could threaten public health and safety, or the environment. NRC's highest priority is to provide expert consultation, support, and assistance to state and local public safety officials responding to the event. Teams of specialists are assembled at the Headquarters Operations Center and Regional Incident Response Center to obtain and evaluate event information and to assess the potential impact of the event on public health and safety and the environment once NRC incident response program is activated. Scientists and engineers analyze the event and evaluate possible recovery strategies. Other experts evaluate the effectiveness of protective actions that have been recommended by the licensee and implemented by state and local officials to minimize the impact on public health and safety and the environment. Communications with the news media, state, other Federal agencies, the Congress, and the White House are coordinated through the Headquarters Operations Center.

NRC's role, as well as the roles of other Federal agencies in the coordinated emergency response to a nuclear accident, is described in the Nuclear/Radiological Incident Annex of the National Response Plan.[52] NRC will immediately dispatch a team of experts from the Regional Office to the site if event conditions warrant.

F.5.1.3 NRC Emergency Response Exercises

NRC Headquarters and Regional staff members typically participate in five full-scale emergency response exercises each year, selected from among the list of full-scale, Federal Emergency Management Agency (FEMA)-graded exercises required of U.S. nuclear facilities. Regional staff members and selected headquarters staff also participate in post-plume, ingestion phase response exercises. On-scene participants include NRC licensee, and State, county, and local emergency response agencies. Annex F-4 provides a list of the exercises in which NRC participated in 2004.

F.5.1.4 Incident Investigation and Event Reporting

Incident investigation is a formal process conducted to help prevent accidents. The NRC Incident Investigation program provides a formal, structured, and appropriately measured NRC investigative response to significant operational events based on their safety significance. This process includes gathering and analyzing information; determining findings and conclusions, including the causes of a significant operational event; and publishing the investigation results for NRC, industry, and public review.

The types of NRC incident investigations include:

- Establishing an Accident Review Group for events of extraordinary safety significance
- Establishing an Incident Investigation Team, by NRC Executive Director for Operations, for events of potentially major safety significance
- Establishing an Augmented Inspection Team, by senior NRC management, for events of lesser safety significance

[52] See http://www.dhs.gov/interweb/assetlibrary/NRP_FullText.pdf for more detail.

The NRC Incident Investigation program, outlined in Management Directive 8.3, NRC Incident Investigation Program, ensures the investigation of significant events is performed in a timely, objective, systematic, technically sound, and independent way by NRC staff associated with the licensing and inspection of the affected facility; that factual information about the event is documented; and probable cause(s) are also documented.

A senior NRC manager reporting directly to NRC Executive Director for Operations leads the Incident Investigation Team. The team is technically and administratively supported by the Office of Nuclear Security & Incident Response.

Annex F-5 provides a list of investigation reports for non-reactor incidents and the requirements under which such reports are made. Annex F-5 also provides links to additional Information on response to incidents.

F.5.1.5 Emergency Preparedness at Radioactive Materials Facilities

NRC regulations in 10 CFR Part 30, *Rules of General Applicability to Domestic Licensing of Byproduct Material*; 10 CFR Part 40, *Domestic Licensing of Source Material*; and 10 CFR Part 70, *Domestic Licensing of Special Nuclear Material*, require some fuel cycle and materials licensees to prepare emergency plans. These emergency plans are required to comply with the requirements of 10 CFR 30.32(i)(3), 10 CFR 40.31(j)(3), or 10 CFR 70.22(i)(3). Generally, the types of information to be submitted in these emergency plans include: facility description, types of accidents, classification and notification of accidents, detection of accidents, mitigation of consequences, assessment of releases, responsibilities, notification and coordination, information to be communicated, training, safe shutdown, exercises, and hazardous chemicals.

NRC performed a regulatory analysis on emergency preparedness for nuclear fuel cycle facilities and other radioactive material licensees in 1988.[53] The analysis addressed uranium mining and milling, UF_6 conversion plants, enrichment plants, fuel fabrication, spent fuel storage, new fuel storage, reprocessing and research. In terms of byproduct material facilities such as radiopharmaceutical operations, sealed source manufacturing, depleted uranium production and waste warehousing and burial were considered. The study concluded accidents at these types of facilities pose a very small risk to the public. Serious accidents are infrequent and would generally involve relatively small radiation doses to a few people located in limited areas. The costs for extraordinary precautions were not justified.

The most potentially hazardous accident, by a large margin, was determined to be the sudden rupture of a heated multi-ton cylinder of UF_6. The most critical injury would be from the chemical toxicity; the accompanying radiation doses would not be significant. Prevention would be the best strategy, because – in most instances – actions taken 30 minutes after accident detection would be mostly ineffective. The most effective approach to emergency response would be a simple approach consisting of:

- Identification of accidents where protective actions should be taken off site,
- Listing the licensee's responsibilities for each type of accident, including notification of local authorities (e.g., fire and police), and
- Providing sample messages for local authorities including protective action recommendations.

[53]The findings for this analysis were published in NUREG-1140, *A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees*.

Specific thematic information on emergency preparedness and planning for specific waste management facility types is summarized in Annex F-6 for geologic, near surface, uranium mills, and decommissioning.

F.5.2 Emergency Preparedness and Management within DOE

DOE has implemented an emergency management system for all its sites and facilities. DOE Order 151.1, *Comprehensive Emergency Management System*, describes the DOE emergency management system, by establishing policy; assigning roles and responsibilities; and providing the framework for development, coordination, control, and direction. This Order establishes requirements for emergency planning, preparedness, response, recovery, and readiness assurance activities and describes the approach for effectively integrating these activities under a comprehensive, all-emergency concept. DOE facilities, sites, or activities and organization offices are required to develop emergency management programs as elements of DOE's comprehensive emergency management system. The pieces of the system are integrated to ensure that DOE is prepared to respond promptly, efficiently, and effectively to any emergency involving DOE, including events at spent fuel and radioactive waste management facilities, to protect workers, the public, the environment, and national security.

DOE's Emergency Management Guide (DOE Guide 151.1-1) provides an acceptable approach for implementing the requirements and expectations of Order 151.1. DOE Order 151.1 discusses 14 emergency management programmatic elements of a comprehensive system of emergency management: hazards survey and hazards assessment, emergency response organization, off-site response interfaces, categorization and classification, notifications and communications, consequence assessment, protective actions and reentry, emergency medical support, emergency public information, emergency facilities and equipment, termination and recovery, program administration, training and drills, and exercises. The Emergency Management Guide, composed of seven volumes, discusses each of these elements in detail.

The DOE approach to emergency management is composed of a three-tiered management structure consisting of facilities and sites, DOE field organization offices, and DOE headquarters. The facility or site level manages the tactical response to the emergency by directing actions necessary to resolve the problem, protect the workers, the public and the environment and return the facility to a safe condition. The DOE field organization office oversees the facility response and provides assistance and guidance to the facility management. The Headquarters organization provides strategic direction to the response, provides assistance and guidance to the field organization, evaluates impacts to the larger DOE complex, and coordinates with other Federal governmental agencies and branches and the national media.

Because there is a wide variety of hazards that must be considered, the emergency management program for a facility must be commensurate with the hazards present at a facility or site. This is often referred to as a tailored or graded approach. Each facility is required to have an operational emergency base program. The base program requirements cover aspects such as medical support, worker evacuation plans, fire drills, worker notification systems, hazardous material responder training, hazardous material communication labeling and transport logistics, contingency planning for oil spills, environmental spill drills and exercises, and security and safeguards requirements. The objective of the base program is to achieve an effective integration of emergency planning and preparedness requirements into an emergency management program that provides capabilities for all-emergency response, through communication, coordination, and an efficient and effective use of resources. A hazards assessment is required for each facility or site where hazardous materials are present in quantities exceeding specified thresholds. The hazards assessment results determine whether an operational emergency hazardous materials program is required on top of the foundation of the base program.

Requirements in DOE Order 151.1 specify an operational emergency be declared when events or conditions at a DOE facility or site require response outside the immediate/affected facility, site, or area of the event. This is the process of categorizing an event or condition as an operational emergency. Such events or conditions cause, or have the potential to cause: serious health and safety impacts to workers or the public, serious detrimental effects on the environment, direct harm to people or the environment as a result of degradation of security or safeguards conditions, or loss of control over hazardous materials.

Operational emergency events or conditions involving loss of control over hazardous materials (including radioactive materials) are classified based on the severity of potential consequences at a specific distance from the source of the release. Classes include alert, site area emergency, or general emergency, in order of increasing severity. This classification scheme facilitates early decision-making particularly with respect to response activities, off-site notifications, and protective actions, by making decisions during planning rather than during actual response.

DOE’s emergency management programs are subject to periodic independent assessments by DOE Office of Emergency Management Oversight. This Office conducts regular independent assessments of DOE emergency management policies and programs at DOE sites having significant hazards and follow-up reviews to ensure corrective actions are effective. The Office also conducts complex-wide studies of issues and generic weaknesses in emergency management programs.

Programs are evaluated against the requirements and guidance found in various documents, including DOE Order 151.1, the associated emergency management guide, and appraisal process protocols. The inspectors develop lines of inquiry using these guidance documents applicable to their assigned program element to guide field activities. Another reference providing information for evaluating DOE emergency management programs is DOE Order 470.2, *Independent Oversight and Performance Assurance Program*. DOE Order 470.2 describes the basis and purpose of oversight activities and specifies requirements for reviewing and commenting on appraisal reports and developing corrective action plans.

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 NRC Decommissioning Approach

NRC regulations assign responsibility for decommissioning licensed and unlicensed facilities to the licensee or other responsible parties. NRC regulations at 10 CFR 50.75 specify the requirements for a power reactor licensee to provide funds for decommissioning. Regulations at 10 CFR 30.35, 40.36, 70.25, and 72.30 provide the requirements for non-reactor licensees. These regulations also specify record keeping requirements as well as acceptable mechanisms for providing the decommissioning funding.

NRC evaluates the licensee's or responsible party's proposed decommissioning plan, including the licensee's justification for using a particular remediation methodology, to determine if it is appropriate for the specific decommissioning project. The decommissioning process consists of a series of integrated activities, beginning with the facility in transition from "active" to "decommissioning" status and concluding with the termination of the license and release of the site. Decommissioning may be relatively simple and straightforward or complex. Depending on several factors, including the type of license, the use of radioactive material at the facility, or past management of radioactive material at the facility,

DOE and NRC sponsored development of the probabilistic RESRAD (Version 6.22) and RESRAD-BUILD (Version 3.22) computer codes for site-specific dose impact analysis in support of the decommissioning license termination rule (10 CFR Part 20, Subpart E). Final versions of each of the computer codes were tested and issued by Argonne National Laboratory - East (the code developer) and NRC. NRC regulations do not prescribe specific computer models to be used by licensees in determining potential doses to the average member of the critical group at license termination. NRC has derived tables of screening values for use by non-complex sites that do not need to develop site-specific clean-up levels. NRC typically would accept the use of the RESRAD suite of computer codes, or any other code, as long as the licensee could demonstrate the code was applicable for the type of media being evaluated. Doses are calculated using the ICRP 26 effective dose equivalent dosimetry system.

Soil cleanup limits are derived from basic dose limits by means of an environmental pathway analysis using site-specific data for land cleanup associated with decommissioning of nuclear facilities. The RESRAD code can be used to calculate specific isotopic concentrations allowable in the soil based on chosen numerical dose limits. The soil cleanup limits are established before cleanup begins and depend on the future use of the site, e.g. unrestricted release. Basic dose limits needed to begin the calculation are arrived at in consultation with regulators and the public. Some of the factors taken into account are DOE Order 5400.5 on radiation protection, the ALARA principle, applicable NRC or Agreement State Decommissioning Rule, and EPA Guidance on excess lifetime cancer risk. DOE has a database of site cleanup criteria on the internet.[54]

NRC has consolidated its decommissioning guidance for materials licensees into a more risk-informed and performance based document. This consolidation was performed to incorporate over 80 decommissioning guidance documents (including NUREG-1727), now superseded by NUREG-1757 Consolidated NMSS Decommissioning Guidance - Decommissioning Process for Materials Licensees, and published in 3 volumes. These volumes address 1) *Decommissioning Process for Materials Licensees* (being revised); (2) *Characterization, Survey, and Determination of Radiological Criteria*; and (3) *Financial Assurance, Recordkeeping, and Timeliness*. This consolidation of guidance was completed in 2003. The three-volume NUREG report provides NRC staff and nuclear material licensees with a single reference guidance document.[55]

Licensees must notify NRC in writing within 30 days once a decision is made to shut down a nuclear power plant. As soon as the fuel is permanently removed from the reactor vessel and NRC receives a certification of this event, the licensee may no longer operate the reactor or place fuel back into the reactor vessel. Licensees must then submit a *Post-Shutdown Decommissioning Activity Report* prior to or at least 2 years following permanent cessation of operations. This report is then made available to the public and a public meeting will be held near the plant. The report provides a description of the licensee's planned decommissioning activities, a schedule of significant milestones, and an estimate of the expected costs, and documentation of considered environmental impacts. NUREG-1700 Revision 1 is the Standard

[54] Available from DOE at http://c2d2.eml.doe.gov/index.cfm
[55] http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1757/

Review Plan for a Nuclear Power Plant license termination plan and describes the information requirements for a License Termination Plan.

A License Termination Plan is submitted at least 2 years before license termination and addresses detailed plans for meeting final site residual radioactivity criteria, site characterization and remediation plans, estimates of remaining costs, and any new information. Before approval of the plan, an opportunity for a hearing is published and a public meeting is held near the facility.

Reactor licensees may choose one of the following methods for decommissioning their plants: DECON, SAFSTOR or ENTOMB.

- DECON (immediate dismantlement), soon after the nuclear facility closes, equipment, structures, and portions of the facility containing radioactive contaminants are removed or decontaminated to a level that permits release (consistent with 10 CFR Part 20, Subpart E) of the property and termination of NRC license.
- SAFSTOR, a nuclear facility is maintained and monitored in a condition that allows the radioactivity to decay, and is later dismantled.
- ENTOMB, radioactive contaminants are encased in a structurally sound material such as concrete and appropriately maintained and monitored until the radioactivity decays to a level permitting release of the property.

Current regulations require decommissioning be completed within 60 years. Additional time will be considered only when necessary to protect public health and safety. ENTOMB is not considered a viable option for reactor decommissioning because some of the long-lived radioisotopes present at the facility may not decay to acceptable levels within the 60-year period.

Wastes with relatively low concentrations of radionuclides (LLW) are sent to a licensed LLW disposal facility after components and materials are dismantled and decontaminated,. Spent fuel could remain stored in the spent fuel pool or in dry cask storage facilities until such time that a geologic repository is built and operating. The regulations also require the ISFSI be designed for decommissioning. Provisions must be made to facilitate decontamination of structures and equipment, minimize the quantity of radioactive wastes and contaminated equipment, and facilitate the removal of radioactive wastes and contaminated materials when the ISFSI is permanently decommissioned.

Decommissioning is also accounted for in NRC's design criteria for construction of a geologic repository for high level waste. NRC regulations contained in 10 CFR 60.132(3) require that the surface facility in the geologic repository operations area be designed to facilitate decontamination or dismantlement. While current regulations for Yucca Mountain (10 CFR Part 63) do not contain general design criteria, the safety of the preclosure design is being addressed through a safety analysis and is required to meet certain dose limits. The dose limits/performance objectives are specified in 10 CFR 63.111, and the requirements for the preclosure safety analysis are specified in 10 CFR 63.112.

F.6.2 DOE Decommissioning Approach

DOE's management approach to disposing of excess DOE facilities is described in DOE Order 430.1A, *Life Cycle Asset Management*. The phases generally involved in excess facility disposition encompass transition, deactivation, surveillance and maintenance, and decommissioning:

Period 1. Operations. Operations is characterized by an operating or shut down facility under the control of a program other than the program responsible for decommissioning. It is declared excess and a candidate for transfer once the program establishes that there is no further need for the facility.

Period 2. Transition. Transition occurs between operations and disposition in a facility lifecycle. Transition begins once a facility has been declared or forecast to be excess to current and future needs. Transition includes placing the facility in stable and known conditions, identifying hazards and characterizing the facility conditions, eliminating or mitigating hazards and conducting stabilization, and transferring programmatic and financial responsibilities from the operating program to the disposition program. It is important that material, systems, and infrastructure stabilization activities be initiated prior to the end of facility operations in preparation for disposition. Materials requiring special handling (e.g., classified equipment or nuclear materials) should be removed at shutdown where possible. During transition, a determination is made as to whether the facility will be either deactivated for reuse, deactivated in preparation for eventual decommissioning (decontamination and/or dismantling), or decommissioned immediately. The organization that will be responsible for follow on activities must be involved in this determination. An operational campaign may be required to establish stabilized conditions for some facilities before proceeding to final shutdown. Examples include: 1) a run to process a large quantity of highly radioactive or chemically reactive liquids for the purpose of cleaning a process system, and 2) removal of nuclear fuel so an area can be made accessible.

Period 3. Deactivation. Surveillance and maintenance continues during this period to assure public, environment, and worker safety. As deactivation proceeds, unneeded systems within the facility are terminated, additional hazard reduction may be conducted, and the surveillance and maintenance burden decreases commensurate with achieved risk reduction, resulting in a stable, low risk condition which is economically and technically practical to maintain for an extended period. Updates of safety documentation to reduce a nuclear facility's hazard classification are of value to post-deactivation surveillance and maintenance. Activities during this period include, for example, disposal of remaining hazardous chemicals, isolation of systems and equipment, and removal of valuable excess equipment. Appropriate characterization and documentation should be conducted for remaining contamination and waste, and for other sensitive materials that cannot be removed (chemical, hazardous, radioactive, fissile, nuclear fuel, special nuclear, and other accountable materials). This is to support safety updates, specifying deactivation end points, and planning post-deactivation surveillance and maintenance.

Period 4. Post-Deactivation Surveillance and Maintenance. The facility is in a safe storage mode, with ongoing, low levels of surveillance and maintenance. The facility is generally unoccupied and locked except for periodic inspections. If the period between completion of deactivation and beginning of decommissioning becomes extended, an occasional need for refurbishment or repair may be needed; for example, roof repairs, exhaust fan replacement, surveillance instrumentation maintenance, etc. Radioactive and hazardous materials may remain in the facility and are subject to ongoing regulatory oversight.

Period 5. Decommissioning. Decommissioning and ultimate disposition of a facility will be scheduled in accordance with an overall national priority based on resources.

The regulatory process for decommissioning varies depending upon the specific activity. Additional information on waste management from cleanup of past practice sites is provided in Section H.2.1.

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

The U.S. is fully compliant with the General Safety Requirements found in Article 4 and 11. General safety requirements addressed in the subsections below were called out specifically in the report preparation guidance.[56]

F.7.1 Criticality Control and Removal of Residual Heat

F.7.1.1 Criticality Control

The American Nuclear Society Standards Subcommittee 8, *Operations with Fissionable Materials Outside Reactors* (ANS-8), has developed national standards for the prevention and mitigation of criticality accidents during handling, processing, storing, and transporting special nuclear materials at fuels and material 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.

The licensing criteria for the disposal of Spent Fuel and HLW in the planned geologic repository at Yucca Mountain are set forth in 10 CFR Part 63. There are no formal regulatory guidance documents or industry standards specific to criticality in a permanent HLW repository. NRC regulatory general design criteria for disposal of high-level waste (and spent fuel), contained in 10 CFR 60.131, however, state the following:

> *(h)* Criticality control*. All systems for processing, transporting, handling, storage, retrieval, emplacement, and isolation of radioactive waste shall be designed to ensure that nuclear criticality is not possible unless at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. Each system must be designed for criticality safety assuming occurrence of design basis events. The calculated effective multiplication factor must be sufficiently below unity to show at least a 5 percent margin, after allowance for the bias in the method of calculation and the uncertainty in the experiments used to validate the method of calculation.*

Criticality is one of the processes or events considered in the assessment of overall system performance (in 10 CFR Part 63). Treatment of criticality within the total system performance assessment (TSPA) is considered acceptable if the acceptance criteria from the total system performance assessment and integration are met (see Section F.5). In addressing criticality as part of the TSPA, the model abstraction for criticality should meet the acceptance criteria in NUREG-1804, *Yucca Mountain Review Plan*, on model abstraction. Formal expert elicitation can be used to support data synthesis and model development for DOE's criticality analysis provided that the elicitation is properly conducted and documented.

Evaluating of the probability and consequences of in-package criticality on waste package (WP) and engineered barrier subsystem performance should address whether the conditions inside

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[56] 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), Vienna, Austria, December 13, 2002.

the WP could influence the occurrence of criticality and how in-package criticality could affect WP and engineered barrier subsystem performance.

Criteria for criticality for the independent storage of spent fuel, HLW, and GTCC waste are defined in NRC regulations in 10 CFR Part 72, *Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-level Radioactive Waste, and Reactor-related Greater Than Class C Waste*, subpart F, Criteria for Nuclear Criticality Safety. This addresses design for criticality safety, methods of criticality control, and criticality monitoring.

F.7.1.2 DOE Nuclear Criticality Safety Review

DOE demonstrated a stable nuclear criticality infrastructure with the 2003 closure of Defense Nuclear Facilities Safety Board Recommendation 97-2, *Criticality Safety*. Fourteen commitments were effectively addressed for this closure, including the following:

- Revise and reissue Standard 3007-93, *Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear Facilities.*
- Issue a guide for reviewing criticality safety evaluations; survey site-specific programs and obtain commitments from contractors to implement criticality safety training and qualification programs.
- Establish a Web site to make calculations, studies, and data accessible; develop a formal training and qualification program for Federal personnel performing criticality safety oversight.
- Establish line ownership of criticality safety at sites with the use of the Criticality Safety Officer function.

Institutionalizing formal Federal and contractor criticality safety training and qualification serves as an effective way to maintain a cadre of criticality safety professionals. DNFSB suggested 10 improvements DOE also implemented, including providing clearer guidance on using engineered criticality safety controls rather than administrative ones in new designs; decreasing reliance on administrative controls in existing facilities; establishing a robust process for vertically tracing criticality controls; enhancing configuration management over nuclear criticality safety-related design features; and developing a robust method for reporting criticality safety infractions. All associated DOE guidance, standards, and Orders were revised to support contractor adherence to the new changes. The newly enhanced criticality safety program is funded and managed by the National Nuclear Security Administration (NNSA).

DOE, in addition to the successful closure of the DNFSB recommendation 97-3 in 2003, conducted criticality safety assessments at Los Alamos National Laboratory, British Nuclear Fuels Limited in Oak Ridge, Tennessee, and the Hanford Plutonium Finishing Plant, to verify the programs are being conducted in compliance with applicable DOE Orders and standards for criticality safety (see Annex F-7).

F.7.1.3 Removal of Residual Heat

HLW and spent fuel storage systems are required to have reliable passive heat removal capability. NRC regulations and DOE Orders require the decay heat removal system of the spent fuel storage system be capable of reliable operation so the temperatures of materials used for systems, structures, and components (SSCs) important to safety, e.g., fuel assembly cladding material, and solidified high-level waste packages, remain within the allowable limits under normal, off-normal, and accident conditions. Wet and dry fuel assembly transfer systems must have adequate decay heat removal under normal, off-normal, and accident conditions.

Decay heat removal systems may be passive (natural convection and thermal radiation) for dry storage or may include active cooling systems (motors, pumps, heat exchangers, valve actuators, and switchgear) for wet or dry storage. The design must function within the original design basis thermal limits 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. The following is an example of a technical specification for thermal evaluation:

> "Performance of the heat removal system will be verified by tests conducted upon placing the first full storage container in its storage position. These tests determine heat removal by measurement of air flow and temperatures and will be used to confirm the adequacy of the thermal analysis by comparison of the actual conditions of heat generation by the stored fuel assembly and ambient conditions."

F.7.2 Waste Minimization

Waste minimization programs in the U.S. are mandated by law, regulations, and order of the President (Executive Order). The Pollution Prevention Act of 1990, 42 U.S.C. § 13101 and 13102, focused industry, government, and public attention on reducing the amount of pollution through cost-effective changes in production, operation, and raw materials use. Opportunities are often not realized because existing regulations and the industrial resources required for compliance focus on treatment and disposal. Source reduction is fundamentally different and more desirable than waste management or pollution control. Pollution prevention also includes other practices that increase efficiency in the use of energy, water, or other natural resources, and protect our resource base through conservation. Practices include, but are not limited to, recycling and source reduction. The EPA Waste Minimization Program works with industrial organizations, government agencies, and communities to voluntarily find ways to help individual companies reduce the amount of waste they generate, particularly if the wastes contain one or more waste minimization priority chemicals.

Federal agencies, such as DOE, are subject to Executive Orders mandating waste minimization and pollution prevention programs, e.g., 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 within the Office of Environment, Safety, and Health designed to reduce environmental releases and reduce the amount of waste eventually requiring treatment, storage, and disposal at DOE sites. Such activities include site-wide coordination, planning, reporting, employee awareness, assessments, incentives, cost-savings initiatives, recycling, and affirmative procurement programs. DOE produces an annual report[57] titled: *The 2002 Annual Report of Waste Generation and Pollution Prevention Progress*.

DOE established pollution prevention goals for routine generation of transuranic, low-level radioactive, low-level mixed, hazardous, and sanitary wastes in 1999. Goals to be achieved in 2005 were established using 1993 as the baseline year. Excellent progress toward the 2005

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[57]Executive Order (EO) 13148, *Greening the Government Through Leadership in Environmental Management, March 2003. See* http://tis.eh.doe.gov/p2/wastemin/EO13148_DOE02_Rpt.pdf.

goal has been achieved. Some changes from year to year can be attributed to programmatic needs such as the initiation or termination of research projects or site stockpiling of wastes until an opportunity arises for cost-effective recycling, reuse, or disposal. As compared to the baseline at the end of 2004[58],

- Transuranic waste generation dropped 81 percent
- Low-level radioactive generation waste dropped 74 percent, and
- Low-level mixed (hazardous and radioactive waste) dropped 91 percent, exceeding the 80 percent reduction goal.

NRC has established waste minimization as a policy. NRC licensees are encouraged to manage their activities to limit the amount of radioactive waste they produce; those activities would be reviewed in any license application to ensure waste minimization and volume reduction practices are included. NRC has requested organizations provide information on volume reduction techniques and shared the information with licensees. Techniques include avoiding the spread of radioactive contamination, surveying items to ensure they are radioactive before placing them in a radioactive waste container, using care to avoid mixing contaminated waste with other trash, using radioactive materials whose radioactivity diminishes quickly, and limiting radioactive material usage to the minimum necessary to establish the objective.

Licensees as a practical matter take steps to reduce the volume of radioactive waste after it has been produced due to the cost of disposal at licensed commercial burial sites. Common means are compaction and incineration. About 59 NRC licensees are authorized to incinerate certain LLW, although most incineration is performed by a small number of commercial incinerators.

NRC also uses orders, notices and directives which focus on specific practices and operations that either address a point of clarification or unforeseen issues which may not merit the resources and broad needs associated with a full rulemaking. An example of NRC guidance on minimization of waste volumes is *Guidance to Hazardous, Radioactive, and Mixed Waste Generators on the Elements of a Waste Minimization Program*, Information Notice No. 94-23, March 25, 1994. Descriptions of waste volume reduction methods, including some discussion of advantages and disadvantages are provided in a DOE report titled, *Commercially Available Low-Level Radioactive and Mixed Waste Treatment Technologies*, DOE/LLW-240, October 1996.

F.7.3 Interdependencies Among Different Steps in Spent Fuel and Radioactive Waste Management Processes

Successful management of spent fuel and radioactive waste requires careful integration among power or research reactors, waste generators, storage facilities, treatment facilities, disposal sites, the geologic repository project, and their transportation interfaces. Integration is achieved through interface management, such as specified waste acceptance criteria, so generators and disposers have a common understanding of the waste. Acceptance requirements define the interfaces. 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, quality assurance, testing and record keeping ensuring such interdependencies between these steps remain relatively seamless.   Legal manifests are used for transportation of radioactive material,

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[58] *Executive Order 13148, Greening the Government Through Leadership in Environmental Management Annual Progress Report: 2004,* U.S. Department of Energy Office of Environment, Safety, and Health, April 2005.

including radioactive waste and spent fuel. Portal monitors and other 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. The results obtained are used by disposal facilities to verify and to review the validity of assumptions made and to update the assessments as specified in Article 15 for the period after closure. There is no single system to trace all radioactive waste, however, 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 Providing Protection and Taking Into Account 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 (Section E) is responsible for developing national standards on radiation protection. The U.S. Government works with international organizations, e.g., IAEA, and ICRP, to ensure U.S. standards are in general harmony with recommendations from these organizations. Several agencies are now using or allowing the use of the updated dose coefficients found in ICRP Publications 68 and 72. However, the U.S. has not adopted the annual dose limits in ICRP 60. New recommendations are expected from the ICRP soon and most U.S. agencies are awaiting 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.

U.S. Government agencies have interacted with their counterparts in other countries on pertinent areas of radioactive and spent fuel management. An example is the bi-annual exchange with the French nuclear safety authority, the Direction de la Sûreté des Installations Nucléaires (DSIN), which usually covers decommissioning topics, such as DSIN's extension of regulatory authority over "polluted sites," which refers to a class of waste legacy sites. NRC shared its experiences with the West Valley Demonstration Project and other complex decommissioning site experiences. Another example is the decommissioning workshop that NRC conducted in June 2005 for the Federal Environmental, Industrial and Nuclear Supervision Service of the Russian Federation (Rostekhnadzor). The purpose of this meeting was to present a workshop to Russian regulators addressing the processes that NRC uses for decommissioning material sites.

F.7.5 Biological, Chemical and Other Hazards

The U.S. has major environmental laws taking into account biological, chemical, and other hazards. Operators of facilities must abide by these laws to protect workers, the public and the environment. Laws are enforced through the implementation of EPA regulations. EPA in turn delegates some regulatory authority to states meeting the minimum Federal requirements. One such law is the Resource Conservation and Recovery Act (RCRA), which grants EPA the authority to control hazardous waste from the "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 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 the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund), 42 U.S.C. 9601. The Federal Hazardous and Solid Waste Amendments are 1984 amendments to RCRA requiring phasing out land disposal of hazardous waste. Some of the other mandates of this strict law include increased enforcement authority for EPA, more stringent hazardous waste management standards, and a comprehensive underground storage tank program.

Impacts from chemical hazards are assessed as part of the environmental assessment process. These assessments are required prior to constructing spent fuel and radioactive waste management facilities. The Environmental Impact Statement for Yucca Mountain,[59] for example, examined the consequences for chemically toxic materials, which were found to be lower than identified Maximum Contaminant Level Goals. Heavy metal elements were of particular interest, including chromium, molybdenum, nickel, and vanadium contained in the metals proposed to package the waste and support the packages. DOE concluded there are no impacts to water quality or human health from toxic materials exceeding EPA standards for the planned repository.

F.7.6 Avoidance of Undue Burden/Impacts on Future Generations

U.S. policy to dispose of spent fuel and radioactive waste is aimed at not placing undue burdens on future generations. Performance requirements on disposal sites mandate the level of isolation to ensure that there are no undue burdens on future generations. The WIPP geologic repository for TRU waste and the planned Yucca Mountain repository demonstrate the U.S. is addressing the burden/impacts on future generations as national policy.

Our experts maintain contacts with international organizations engaged on such issues. Members of the NCRP work directly with their counterparts in the international community. A panel of the National Academy of Public Administration has studied the issues involved and issued a report[60] addressing these issues. The NAS Board of Radioactive Waste Management considers the public policy, sociological, and ethical aspects of radioactive waste management, for example, long-term societal commitments, societal acceptability of waste management practices, and institutional capabilities to effectively and efficiently manage radioactive wastes.

F.8 Existing Facilities (Articles 5 and 12)

Article 5 and Article 12 of the Joint Convention specify each Contracting Party must take steps to review safety of any spent fuel and radioactive waste management facility existing at the time the Convention enters into force and to ensure, if necessary, all reasonably practicable upgrades are made.

The U.S. is fully compliant with the provisions of Article 5 and Article 12 of the Joint Convention. The U.S. conducts safety reviews of both commercial and governmental spent fuel and radioactive waste management facilities under its existing regulations. No additional reviews of existing facilities are required to comply with the Joint Convention because existing facilities are already subject to periodic safety reviews. The frequency and type of assessments and inspections depend on the type of facility and results of previous safety reviews.
DOE performs safety reviews of its nuclear facilities, including spent fuel and radioactive waste management facilities, under its safety regulations. Previous subsections in this section have detailed safety activities of DOE. Section F.1.2 also discusses the important Integrated Safety Management System used by DOE to provide annual declarations describing how safety is maintained, the effectiveness of the program, and changes and improvements.

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[59]DOE, Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, DOE/EIS-0250, Washington DC, February 2002.
[60]*Deciding for the Future: Balancing Risks, Costs, and Benefits Fairly across Generations, National Academy of Public Administration*, June 1997. See http://www.eh.doe.gov/oepa/data/ under "miscellaneous".

DOE also has a Voluntary Protection Program (VPP) promoting safety and health excellence through cooperative efforts among labor, management, and government at DOE contractor sites. DOE has also formed partnerships with other Federal agencies and the private sector for both advancing and sharing its VPP experiences and preparing for program challenges. DOE initiated its VPP in January 1994 to promote improved safety and health performance through public recognition of outstanding programs. The VPP is applied to a site or contractor, so it can cover multiple complex facilities and activities. It includes coverage of radiation protection/nuclear safety and emergency management. Similar to the U.S. Department of Labor (DOL) Occupational Safety and Health Administration program for general industry, DOE VPP provides several proven benefits to participating contractors, including improved labor/management relations, reduced workplace injuries and illnesses, increased employee involvement, improved morale, reduced absenteeism, and public recognition. Contractors perform annual assessments and their VPP status is certified by DOE. Contractors at DOE sites go through this annual voluntary review process, and are certified under the DOE VPP program.

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

The U.S. is fully compliant with Article 6 and Article 13 of the Joint Convention. The U.S. has legal and regulatory structures described in Section E to site proposed new facilities. The process provides for evaluation of all relevant site related factors, safety impacts to workers, the public, and the environment, and socio-economic impacts.

F.9.1 Environmental Assessment (NEPA Process)

The National Environmental Policy Act of 1969 (NEPA), 42 U.S.C. 4321-4347 is the basic National charter for protection of the environment. It establishes policy, sets goals, and provides means for carrying out the policy. Federal agencies have implementing regulations, e.g., Council for Environmental Quality (40 CFR 1500), DOE (10 CFR Part 1021), NRC (10 CFR Part 51), and EPA (40 CFR Part 6). NEPA requires Federal agencies to integrate environmental values into their decision-making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. NEPA requirements are invoked when airports, buildings, military complexes, highways, parkland purchases, and other Federal activities, such as spent fuel and radioactive management facilities, are proposed. This NEPA process is employed for any significant changes in the facility during the operating period, e.g., additional waste types are disposed or new facilities are added.

The EIS is prepared consistent with 40 CFR 1500-1508 requirements, and addresses impacts of a nuclear waste repository in 12 resource areas including: land use, air quality, hydrology, cultural resources, biological resources, human health and safety, socioeconomics, noise, consumption of resources, waste management, aesthetics, and environmental justice. Applicable occupational and mine safety regulations must also be satisfied.

F.9.2 Site Selection

NRC regulations prescribe site characterization activities required and pre-license application reviews by NRC, the license application requirements, licensing, and construction authorization. The regulations also provide for participation in the pre-licensing (site) review and licensing review by states, affected Indian tribes, and interested stakeholders. Information is publicly available through the formal licensing docket maintained in public reading rooms by NRC.

Site selection for a new spent fuel or waste management facility is embodied in the environmental assessment process (implementation of NEPA), evaluating relevant site safety factors, safety of workers and the public, impacts to the environment, and socio-economic impacts. Licensees select a site based on consideration of many factors. These factors include the geography, demography, meteorology, hydrology, seismology, and the geology characteristics of the site and the surrounding area. Nearby industrial, transportation and military facilities are also a consideration in the selection process. The licensee uses site characteristics to determine the influence on the facility design. The licensee will then evaluate the site characteristics from a safety viewpoint.

NRC from the information supplied in response to the regulations can determine if (1) the applicant has properly identified the external natural and man-induced phenomena for inclusion in the design basis and whether the design basis levels are adequate; (2) the applicant has adequately characterized local land and water use and population so that important individuals and populations likely to be affected can be identified; and (3) the applicant has adequately characterized the transport process which could move any released contamination from the facility to the maximally exposed individuals and populations.

Specific requirements for geological and seismological characteristics are in 10 CFR 72.102. An applicant as an alternative to these requirements may determine the design earthquake by using the criteria and level of investigations required by Appendix A of 10 CFR Part 100. NRC then determines the acceptability of the site-derived design bases and design basis events that were incorporated into the proposed design analysis. NRC also evaluates the applicant's determination of the maximally exposed individuals and populations and the dispersion parameters result in compliance with NRC radiation protection requirements.

F.9.3 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 is open, ongoing, two-way communication - both formal and informal - between government officials and stakeholders. Public participation provides a means for 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. Public participation benefits stakeholders by creating an opportunity to provide input and influence decisions. See the sidebar for information on the Yucca Mountain outreach program.

Yucca Mountain Outreach

The Yucca Mountain Project has a robust public and stakeholder involvement program offering a variety of educational and outreach opportunities. DOE has information centers in Las Vegas, Pahrump and Beatty, Nevada. The information centers feature exhibits, video displays, interactive computer programs, educational programs, and other educational resources that address what is taking place at Yucca Mountain. Las Vegas information center visitors can take a simulated elevator ride down to the Climax Mine Spent Fuel Test and take a "virtual" tour of Yucca Mountain with the help of a computer. The information centers provide a wide range of educational programs including open house tours at Yucca Mountain, "Discovery Day" events providing interactive learning experiences, and school programs to inform students and teachers about scientific and environmental issues. The public can obtain information on the Project and find other educational resources, such as scientific literature and video presentations. A speakers' bureau ensures presentations are available as a public service to any school, group, or organization interested in learning more about the Yucca Mountain Project. The project also has a toll-free phone number staffed with information specialists. Free tours of Yucca Mountain facility are available to the public. In Fiscal Year 2004 (between October 1, 2003 and September 30, 2004), 216 tours were given to Yucca Mountain, during which a total of 4,440 individuals visited the Mountain.

Many DOE sites have formed formal panels made up of interested citizens to advise the government on planned ongoing activities under the Federal Advisory Committee Act. Site-Specific Advisory Boards (SSABs) provide consensus advice and recommendations to DOE spent fuel and waste management activities at most locations where spent fuel and radioactive waste is stored. The boards, which are voluntary and not required by law, provide advice and offer recommendations on DOE activities. When established (as one is at Hanford for example), the SSABs are subject to the Federal Advisory Committee Act of 1972. In addition, there are other panels formed to advice DOE at the program and secretarial office level, e.g. the Environmental Management Advisory Board and the Secretary of Energy Advisory Board. These groups review broader agency actions and policies, providing advice and guidance to senior governmental officials.

DOE has multilateral agreements with national waste management organizations and international organizations, e.g., IAEA and Nuclear Energy Agency (NEA). EPA and NRC conduct public hearings and public meetings, accept written and electronic comment on proposed actions, participate in stakeholder meetings, and provide internet sites.[61] The NRC internet website provides a full description of the agency's public information process and meeting calendar.

The EPA Office of International Affairs and NRC Office of International Programs participate in international organizations (NEA, IAEA, ICRP, etc.) and bilateral activities with our neighbors, such as Canada.

NRC views nuclear regulation as the public's business, and as such, identifies openness in its regulatory process as an explicit goal of the Agency. NRC recognizes it must inform the public about the regulatory process, and offer a reasonable opportunity for meaningful participation in that process. NRC long ago established mechanisms and procedures to afford the public access to major regulatory decisions. NRC has recently examined ways to enhance public involvement and foster confidence in NRC's actions as an effective and independent regulator. NRC is seeking to expand opportunities for public access to clear and understandable process and risk information. NRC has developed fact sheets and brochures as part of its public outreach strategy. These documents provide information to members of the public about different topics, including decommissioning, spent fuel, and radioactive waste.[62] NRC sought to improve its efforts to inform and involve the public in NRC's decision-making process on rulemaking when developing new, site-specific regulations for the planned geologic repository at Yucca Mountain. Major changes were made to the way technical staff members prepare for speaking to general audiences. The format used for public meetings was modified to encourage dialogue with participants. Handout and presentation materials explaining NRC's role and technical topics of concern, in plain language, were developed and are regularly updated. NRC successfully applied these and other institutional changes as it completed final regulations for Yucca Mountain, when introducing a draft license review plan for public comment, and when responding to public requests for information on NRC's licensing and hearing process.

Stakeholders can and do participate in NRC's licensing process. The Atomic Energy Act of 1954, as amended, and NRC regulations contain provisions for public hearings and other means, such as petitions and rulemaking requests for the public to challenge NRC decisions and licensing actions.

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[61] http://www.epa.gov/radiation/index.html and www.nrc.gov
[62] http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/

Congress enacted the Waste Isolation Pilot Plant (WIPP) Land Withdrawal Act in October 1992, giving EPA significant new responsibilities for overseeing DOE activities at WIPP. EPA determined in May 1998 the WIPP will safely contain defense TRU waste because DOE demonstrated that the facility will comply with EPA disposal standards. EPA's decision allowed DOE to begin disposing TRU waste in WIPP. EPA, in implementing its responsibilities, committed to conducting an open public process including interaction with all interested parties. A successful communications and consultation program facilitates the regulatory oversight process and promotes sound public policy decisions. EPA conducted a public consultation and communication "needs assessment" as a first step in meeting its commitment to an open public process. This assessment was designed to obtain input from citizen and environmental groups and the public on their key concerns about EPA's role and responsibilities at the WIPP, and the best methods for communicating with them. EPA provided opportunities throughout the WIPP certification process, for public involvement beyond those required in typical U.S. regulatory programs. This increased the public's understanding of EPA's role and responsibilities for the WIPP project, enabled the public to make informed decisions about the project by increasing their knowledge about radiation and it's risks, and enhanced the overall decision-making process. Additional information on these efforts is found in Annex F-8. The final step in the public consultation and communications process was to evaluate the effectiveness of our WIPP public outreach program.

Example of Total System Performance Assessment on Yucca Mountain

The Total System Performance Assessment Model for the License Application (TSPA-LA) is being developed to analyze the ability of the engineered and natural systems of the Yucca Mountain repository to limit radionuclide releases for the regulatory period specified in 10 CFR Part 63. The conceptual structure of the TSPA-LA Model and analysis of the repository is based on those regulatory requirements, which in turn adopts the EPA Final Rule at 40 CFR Part 197, Subpart B regarding public health and safety standards for radioactive material for the Yucca Mountain repository. The core requirement in 10 CFR Part 63 giving rise to the conceptual structure of the TSPA-LA is the individual protection standard 10 CFR 63.311 specifying the dose standard for the reasonably maximally exposed individual (RMEI) as discussed in Section E.2.2.2.

Per NRC requirements, the License Application (LA) must include a Performance Assessment (PA) analysis that:

(1) Identifies the features, events, processes (except human intrusion), and sequences of events and processes (except human intrusion) that might affect the Yucca Mountain disposal system and their probabilities of occurring during the regulatory period after disposal;
(2) Examines the effects of those features, events, processes, and sequences of events and processes upon the performance of the Yucca Mountain disposal system; and
(3) Estimates the dose incurred by the RMEI, including the associated uncertainties, as a result of releases caused by all significant features, events, processes, and sequences of events and processes, weighted by their probability of occurrence.

The TSPA Model is built on the foundation of the earlier performance assessments (PAs) and is enhanced by updated analyses of the processes affecting Yucca Mountain and the design elements of the repository including a comprehensive consideration of the features, events, and processes (FEPs) relevant to repository system performance. The previous comprehensive TSPA-LA Model used for simulating repository performance was the TSPA-Site Recommendation (SR)/FEIS Model, which has been updated for the License Application (LA).

At the request of DOE, the TSPA-SR was comprehensively reviewed by a Joint International Review Team organized by the IAEA and the Nuclear Energy Agency of the Organization for Economic Co-operation and Development (OECD/NEA). Their final report was issued in December 2001, and concluded that the TSPA methodology was soundly based and implemented in a competent manner.

F.10 Design and Construction of Facilities (Articles 7 and 14)

Articles 7 and 14 of the Joint Convention require parties to take appropriate steps to ensure design and construction of spent fuel and radioactive waste management facilities have measures to limit possible radiological impacts and discharges or uncontrolled releases, provisions are taken into account at the design stage for decommissioning, and technologies are supported by experience, testing and analysis. The U.S. is fully compliant with Articles 7 and 14 of the Joint Convention.

DOE has a series of Orders establishing requirements for protection of the public and the environment. DOE requires all new facilities in excess of $5 million (U.S. dollars) be evaluated on a "life cycle" basis, explicitly including decommissioning. DOE has amassed considerable experience in decommissioning. Safety and environmental protection have been maintained and costs have been steadily declining. Most DOE work is accomplished through contracts with the private sector, so competitive market forces have been effective in driving the contractors to implement efficient and safe techniques to continue to win DOE contracts. NRC also evaluates the licensee's or responsible party's proposed decommissioning plan, including the licensee's justification for using a particular remediation methodology, to determine if it is appropriate for the specific decommissioning project.

General design criteria in NRC regulations set the minimum requirements for the applicant's principal design criteria. These in turn establish the necessary design, fabrication, construction, testing, and performance requirements for structures, systems and components important to safety.

Quality assurance programs, described in Section F.3, are an integral part of NRC and DOE safety programs. Quality assurance programs are applied to design, purchase, fabrication, handling, shipping, storing, cleaning, assembly, inspection, testing, operation, maintenance, repair, modification of structures, systems and components important to safety.

DOE has provisions in 10 CFR Part 830 requiring design of DOE nuclear facilities to include nuclear safety, explosives safety, fire protection, and nuclear criticality safety. DOE Order 420.1A, *Facility Safety* also requires all facilities during operation must be designed for protection from natural phenomena, such as earthquakes and tornadoes and designs facilitate safe deactivation, decommissioning, and decontamination at end of their operating life.

F.11 Assessment of Safety of Facilities (Articles 8 and 15)

The Joint Convention requires a systematic safety assessment and an environmental assessment appropriate to the hazards present at the facility be prepared to cover the entire life cycle. Updated and detailed assessments are required before operations. Safety assessment may be a stand alone process or part of the NEPA process. NRC employs a risk-informed 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

Example of Risk-Informed Decision Making

A risk-informed approach to decision-making was used in developing changes to 10 CFR Part 72 seismological and geological requirements. The Final Rule to 10 CFR Part 72, modifying the seismological and geological requirements of the dry cask Independent Spent Fuel Storage Installations (ISFSIs) and DOE Monitored Retrievable Storage (MRS) facilities, became effective on October 16, 2003. The Final Rule requires the applicants with the proposed dry cask ISFSI or MRS facilities in the area west of the Rocky Mountain Front and other areas of known seismicity, to use the probabilistic seismic hazard analysis methods (PSHA) in evaluating the earthquake hazards, instead of the current 10 CFR Part 72 provisions of requiring deterministic methods of 10 CFR 100 Appendix A. The rule removes the requirement that a design earthquake (DE) of a dry cask ISFSI or MRS facility be equivalent to the Safe Shutdown Earthquake for a nuclear power plant, and allows the DE to be determined based on the lower risk at a dry cask ISFSI or MRS facility compared to a nuclear power plant. The Final Rule makes the 10 CFR Part 72 earthquake regulations risk-informed, and performance-based.

outcomes, sensitivities, areas of importance, system interactions, and areas of uncertainty. This is applied agency-wide in the decision making process.

F.12 Operation of Facilities (Articles 9 and 16)

The U.S. uses results of inspection, monitoring, and testing to verify and review safety assessment assumptions (Article 16(iii)). NRC regulations require licensees to update safety assessments whenever significant new information becomes available possibly reducing a margin of safety or require a change to license conditions.

NRC regulations require operations under a safety envelope. NRC has regulations in 10 CFR Part 61 and internally developed licensing and inspection programs governing the authorization to operate low-level radioactive waste disposal facilities. NRC regulations for issuing licenses for the operation of Independent Spent Fuel Storage Facilities are in 10 CFR Part 72. The performance-based ISFSI regulations in 10 CFR Part 72 incorporate a graded approach and are in addition to the requirements of 10 CFR Part 50 for the domestic licensing of a nuclear power plant. Applicants for such licenses must provide sufficient information about their organization to demonstrate a capability to operate their facility safely. NRC (or Agreement State) issues licenses to each of the companies managing or disposing of radioactive waste, either exclusively or as part of other activities such as energy production to assure "continuity of safe operation". The license defines the terms and conditions ensuring safety from the handling, processing, transporting, transferring and/or disposing of materials.

Operations 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 operation 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.

Examples of investigated operational issues include loose/leaking pressure switches, loose lid bolts, corrosion of outer metallic lid seals, vent and drain port cap installation problems, crane and rigging issues, pad issues, and unapproved fuel loading issues. Specific examples in the area of radioactive waste management include violation of possession limits, improper disposal of radioactive material generated from cleanup operations, and the failure to prevent radiation levels from exceeding the U.S. Department of Transportation and NRC limits on the external surface of a radioactive waste shipment package.

NRC's safety oversight program is designed to limit exposures to acceptable limits and maintain them to 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 periodically inspects the design, fabrication, and use of dry cask storage systems by sending inspectors to licensee and cask vendor and fabricator facilities. The inspectors examine whether licensees and vendors are performing activities in accordance with radiation safety requirements, licensing and certificate of compliance requirements, and quality assurance program commitments. Inspectors follow guidance in the NRC Inspection Manual[63], containing objectives and procedures to use for each type of inspection. See Annex F-1.

[63] http://www.nrc.gov/reading-rm/doc-collections/insp-manual/

NRC issues reports to document inspection findings. These inspection reports may contain enforcement actions and follow-up inspection items. NRC makes the inspection reports available for public review electronically.   Spent fuel storage inspection reports for example can be located by searching for documents with a cask designer's name or docket number, or an ISFSI name or docket number.

NRC issues sanctions called enforcement actions to licensees who violate regulations as part of the oversight process. These sanctions may include notices of violation, monetary fines, or orders to modify, suspend, or revoke a license or require specific actions because of a public health issue.

F.12.1 NRC Inspection of Commercial Licensed Facilities and Activities

NRC inspects licensed commercial nuclear power plants, research reactors, fuel cycle facilities, and radioactive materials activities and operations. Inspectors follow guidance in the NRC Inspection Manual. This manual contains objectives and procedures to use for each type of inspection. If an inspection shows that a licensee is not safely conducting an activity or safely operating a facility, NRC informs the licensee of any problems found and ensures they are addressed. NRC continues to inspect that activity or facility until the problems are corrected.

NRC in addition to region-based inspections stations inspectors, called "resident inspectors," at each of the nations' operating nuclear plants, major fuel cycle facilities, and the Paducah gaseous diffusion plant to carry out the inspection program on a day-to-day basis. Criticality safety and materials control and accounting inspections of fuel cycle facilities are conducted by inspectors based at NRC headquarters.

NRC conducts about 2,000 inspections of nuclear material licensees a year. These inspections cover areas such as training of personnel who use materials, radiation protection programs, radiation patient dose records, and security of nuclear materials. Specific inspection procedures relating to radioactive waste or spent fuel management are described in Annex F-1. Certain inspection activities and responsibilities for radioactive waste and/or spent fuel management overlap with operational considerations. Such cases are addressed in operational inspection manual chapters.[64]

When license conditions are violated, NRC initiates enforcement procedures, based on the investigation of results from inspection, testing or other violation identification mechanisms, including regulatory allegations. Apparent identified violations are assessed in accordance with NRC Enforcement Policy. The policy is published as NUREG-1600, *General Statement of Policy and Procedure for NRC Enforcement Actions*, to foster its widespread dissemination to NRC licensees and members of the public.

F.12.2 NRC Enforcement and Civil Penalties

The Office of Enforcement exercises oversight of 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 actions:

[64] A full list is presented at http://www.nrc.gov/reading-rm/doc-collections/insp-manual/manual-chapter/index.html#page-content

1. *Notices of Violation*: A Notice of Violation (NOV) identifies a requirement, how it was violated, and formalizes a violation pursuant to 10 CFR 2.201. It normally requires a written response.
2. *Civil Penalties*: A civil penalty is a monetary fine issued under authority of Section 234 of the AEA or Section 206 of the ERA. Section 234 of the AEA provides for penalties of up to $100,000 per violation per day; but that amount has been adjusted by the Debt Collection Improvement Act of 1996 to be $120,000.
3. *Orders*: An order may modify, suspend, or revoke a license or require or confirm specific actions by a licensee or a person.[65]

NRC order issuing authority under Section 161 of the AEA extends to any area of licensed activity affecting the public health and safety. NOVs and civil penalties are issued based on violations. Orders may be issued for violations, or in the absence of a violation, to address a public health or safety issue.

NRC assesses significance of identified violations by considering actual safety consequences, potential safety consequences, potential for impacting NRC's ability to perform its regulatory function, and any willful aspects of the violation. Violations are either assigned a severity level ranging from Severity Level IV, more than minor concern, to Severity Level I, the most significant; or are associated with findings assessed through the reactor oversight process Significance Determination Process (SDP) and are assigned a color of Green, White, Yellow, or Red based on increasing risk significance.

NRC response to violations reflects the seriousness of the violation and the circumstances involved. Minor violations are not subject to enforcement action and are not normally described in inspection reports. Minor violations, like all violations, must be corrected. This approach for violations having low risk significance is consistent with the agency's performance goals. More significant violations are candidates for escalated enforcement. Escalated enforcement action is reserved for Severity Level I, II, or III violations; violations associated with White, Yellow, or Red SDP findings; civil penalties; or orders. A graphical representation of NRC graded approach for dispositioning violations is included on the NRC website.[66]

A predecisional enforcement conference may be conducted with a licensee. The purpose of the conference is to obtain information to assist NRC in determining the appropriate enforcement action. Conferences are normally open to public observation. If NRC concludes that a conference is not necessary, it may provide a licensee with an opportunity to respond to the apparent violations before it makes an enforcement decision. Conferences open to public observation are included in the listing of public meetings on the NRC web site.

Fiscal Year 2004 NRC Enforcement Summary

- The Enforcement Policy was revised three times.
- NRC issued 103 escalated enforcement actions including:
- 67 escalated Notices of Violation without civil penalties;
- 28 proposed civil penalties ($660,700)
- 5 orders, and
- 3 impositions (i.e., orders imposing civil penalties).

NRC may issue orders to modify, suspend, or revoke a license; to cease and desist from a given practice or activity; or take such other action as may be proper. Orders may be issued in lieu of, or in addition to civil penalties. NRC may also issue an order to impose a civil penalty

[65]The term *order* within this context is distinguished from a DOE Order, which is which is a directive and/or policy for radiation protection of the public and environment applies to DOE sites and contractors.
[66] http://www.nrc.gov/what-we-do/regulatory/enforcement/enforce-pro.htm

where a licensee refuses to pay a civil penalty. It also may issue an order to an unlicensed person (including vendors) where the agency has identified deliberate misconduct.

A licensee or individual may by statute request a hearing upon receiving an order. Orders are normally effective after a licensee or individual has had an opportunity to request a hearing (30 days). Orders can be made immediately effective without prior opportunity for a hearing, however, when it is determined the public health, safety, or interest so requires. A licensee or individual may appeal the administrative hearing decision to the court of appeals after the hearing.

Civil penalties are normally assessed for Severity Level I and II violations, as well as knowing and conscious violations of the reporting requirements of Section 206 of the Energy Reorganization Act. Civil penalties are considered for Severity Level III violations. Civil penalties (and the use of severity levels) will be considered for willful issues having the potential for impacting the regulatory process, or having actual consequences.

NRC imposes different levels of civil penalties based on several factors, such as severity level of the violation, history of past violations, and promptness and comprehensiveness of corrective actions. The assessment process for each violation or problem (absent the exercise of discretion) results in one of the following three outcomes: no civil penalty, a base civil penalty, or twice the base civil penalty. If a civil penalty is proposed, a written Notice of Violation and Proposed Imposition of Civil Penalty is issued and the licensee has 30 days to respond in writing. It can do so by either paying the penalty or contesting it. NRC considers the response, and if the penalty is contested, may either mitigate it or impose it by order. The licensee may then pay the civil penalty or request a hearing.

NRC issues a press release for each proposed civil penalty or order. All orders 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 the NRC web site.

F.12.3 Operation of DOE Facilities

DOE facilities fall under numerous regulations and Orders mandating similar operational safety requirements as NRC. The DOE safety regulation, 10 CFR Part 830, requires a comprehensive nuclear safety program at all DOE nuclear facilities, including spent fuel management facilities. The regulation requires a safety basis be developed including a documented safety analysis and technical safety requirements placing appropriate limits on operations. A facility safety basis is a set of documented controls providing reasonable assurance DOE facilities can be operated safely and protects workers, the public, and the environment. 2003 marked a significant milestone in improving the safety bases for DOE nuclear facilities. With the implementation of 10 CFR Part 830, Subpart B, *Safety Basis Requirements*, DOE required contractors operating DOE nuclear facilities to submit safety basis documents that meet the requirements of that Rule by an April 10, 2003, deadline. DOE contractors had to document the work to be performed, analyze the hazards, and implement controls to protect workers, the public, and the environment from nuclear or radiological hazards. (The content of the safety documents is further dictated by DOE Standards identified in Appendix A of the Rule.) DOE then applies its own formal review and a performance-based formal enforcement program to ensure contractors adhere to their documented safety controls. Integrated Safety Management requirements, invoked through DOE acquisition regulations, produce a sound, enforceable system to ensure adequate protection from nuclear and radiological work hazards. Additional guidance on the implementation of 10 CFR Part 830 is found in DOE G 421.1-1, *Criticality*

Safety Good Practices Guide for DOE Nonreactor Nuclear Facilities, DOE G 421.1-2, *Implementation Guide For Use in Developing Documented Safety Analyses To Meet Subpart B Of 10 CFR 830*, and DOE G 423.1-1, *Implementation Guide For Use In Developing Technical Safety Requirements*.

Detailed safety analysis reports are developed, including analysis of credible accident scenarios. Additional guidance on safety analysis is found in DOE G 421.1-2, *Implementation Guide For Use in Developing Documented Safety Analyses To Meet Subpart B Of 10 CFR 830*. The safety basis is reviewed and approved by DOE management and documented in a Safety Evaluation Report. Safety analysis reports are updated and approved as necessary. Safety issues may arise during operations. Part 830 mandates an "unreviewed safety question" process that formally resolves these issues. Additional guidance on this process is found in DOE G 424.1-1, *Implementation Guide For Use In Addressing Unreviewed Safety Question Requirements*. These regulations, orders and guidance ensure safety assessments are appropriate and maintained up to date during facility operations per the Joint Convention.

Operational safety incidents at DOE facilities fall into three principal areas, not nuclear safety related, but are important to worker safety:

- **Suspect/Counterfeit Items.** Suspect/counterfeit items (S/CI) are quickly identified to ensure installed items and components meet their intended functional and operability requirements. A suspect item is a part not conforming to established Government-or industry-accepted specifications or national consensus standards. A counterfeit item is one not meeting QA standards, but is knowingly represented as meeting those standards. Such parts may be introduced into safety or mission-sensitive systems. Forty-six separate suspect/counterfeit item discoveries were reported at DOE facilities in 2003, many involving multiple parts or fasteners. There have been no injuries or known accidents associated with these parts and most of them have been discovered and removed prior to being placed into service, but the potential exists for worker injury, particularly when such parts are in lifting devices and container sealing systems. DOE instituted a new DOE-wide process in 2003 to identify, notify, and investigate S/CI; established a website; and issued two Safety Alerts on S/CI. A major training effort on S/CI was undertaken in 2004.

- **Electrical Safety.** The number of reported electrical near-miss events in DOE facilities has recently been increasing. These near-miss events involved contact with energized electrical sources or potential contact when only one or no barrier remained. Injuries that did occur were mitigated by personal protective equipment, separation from the source by distance (e.g., using excavating equipment), or protection by insulated tools. Electrical safety events are an ongoing safety concern. There continue to be near misses, primarily resulting from inattention to detail and failure to follow procedures. Many disturbing events involved experienced electricians. DOE has taken steps to raise awareness of electrical safety, including a nation-wide Electrical Safety Campaign. DOE will continue to track and resolve electrical issues until the trend is significantly reversed.

- **Hoisting and Rigging Events**. Safety challenges remain at DOE facilities as hoisting and rigging incidents continue to occur in all types of DOE operations. The level of rigor applied to planning and controlling hoisting and rigging tasks to ensure they are performed safely was sometimes insufficient and subsequently responsible for many reported events. Performing hoisting and rigging tasks without sufficiently thinking through the entire activity has resulted in an accident in where two people were injured by a falling steel beam. Other hoisting and rigging accidents resulted from the use of insufficient or damaged rigging equipment that failed, dropping the load that in some cases narrowly missed workers below.

A special report was published entitled *DOE Hoisting and Rigging Events.*[67] There have been few injuries as a result of these events, but the increasing level of cleanup and decommissioning activities at DOE facilities means more people will be performing potentially dangerous work.

Fiscal Year 2003 DOE Contractor Enforcement Summary

- 10 Notices of Violation
- $1.3 million in proposed civil penalties
- $800,000 assessed
- $500,000 waived

Fiscal Year 2004 DOE Contractor Enforcement Summary

- Nine Notices of Violation
- $3.0 million in proposed civil penalties
- $1.9 million in assessed
- $1.1 million waived

During 2003, DOE's Office of Environment, Safety and Health reviewed 63 Safety Evaluation Reports from 11 DOE sites. The status of DOE nuclear facility safety documentation is formally tracked in DOE's Safety Basis Information System.[68] The data cover 260 DOE nuclear facilities, excluding facilities with extremely low hazard potential and safety basis documentation requirements do not apply. Annex F-9 provides additional information from DOE Orders covering the requirements for commissioning, conduct-of-operations, maintenance, asset management, reporting, and emergency management.

DOE Office of Price-Anderson Enforcement issued ten Notices of Violation (NOVs) during 2003 totaling $1,305,000 in civil penalties against contractors at its sites. Seven of the ten NOVs were mitigated for contractor self-reporting and prompt corrective action. Contractor-identified corrective actions will be monitored to ensure effectiveness. DOE also conducted six program reviews during 2003 to assist contractors in identifying, reporting, and correcting non-compliances to reduce the risk of enforcement action. During 2004, the Enforcement Program continued to address safety violations. Nine NOVs were issued. Several were mitigated and included $3,025,000 in civil penalties.

[67] http://www.eh.doe.gov/paa/reports/HR_INPO_Style_FinalDraft_01-20-04.pdf
[68] http://www.eh.doe.gov/nsps/basisinfo.html

G. SAFETY OF SPENT FUEL MANAGEMENT

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

G.1 General Safety Requirements (Article 4)

The need for general safety requirements are found in the Atomic Energy Act and the Nuclear Waste Policy Act, as amended. The licensing requirements for the independent storage of spent fuel, HLW, and reactor related Greater Than Class C LLW waste are contained in 10 CFR Part 72. The licensing requirements for disposal of high-level waste, including spent fuel at a permanent geologic repository are contained in 10 CFR Parts 60, and in Part 63 for disposal in a geological repository at Yucca Mountain, Nevada. Other applicable regulations include 10 CFR Part 71, *Packaging and Transportation of Radioactive Material*; Part 73, *Physical Protection of Plants and Materials*; Part 75, *Safeguards on Nuclear Material-Implementation of US/IAEA Agreement*. Table E-2 lists key NRC regulations.

Both pool storage and dry storage are safe methods for spent fuel management, there are significant differences. Pool storage requires a greater and more consistent operational vigilance by utilities or other licensees and the satisfactory performance of many mechanical systems using pumps, piping and instrumentation.

NRC approves dry cask spent fuel storage systems by evaluating each design for resistance to normal conditions of use and accident conditions such as floods, earthquakes, tornados, and temperature extremes. The heat generated from the fuel assemblies stored in each cask is different for each design. The maximum heat generated by the fuel in the highest capacity thermal cask is approximately equal to 320 100-watt light bulbs. The temperature of the fuel in the casks does continuously decrease over time. The first spent fuel dry storage cask was placed in service in July 1986. No releases of spent fuel storage cask contents or other significant safety problems from the dry cask storage systems in use today have been reported.

NRC authorizes storage of spent fuel at an Independent Spent Fuel Storage Installation (ISFSI) under two licensing options: site-specific licensing and general licensing. Under a site-specific license, an applicant submits a license application to NRC and NRC performs a technical review of all the safety aspects of the proposed ISFSI. NRC issues a license valid for 20 years if the application is approved. NRC regulations also include provisions for renewal of an ISFSI license. A spent fuel storage license contains technical requirements and operating conditions (fuel specifications, cask leak testing, surveillance, and other requirements) for the ISFSI and specifies what the licensee is authorized to store at site.

A general license under 10 CFR Part 72, authorizes a nuclear power plant licensee to store spent fuel in NRC-approved dry storage casks at a site licensed to operate a power reactor under 10 CFR Part 50. Licensees are required to perform evaluations of their site to demonstrate the site is adequate for storing spent fuel in dry casks. These evaluations must show the cask Certificate of Compliance conditions and technical specifications can be met; including analyses of earthquake intensity and tornados. The licensee must also review their security program, emergency plan, quality assurance program, training program and radiation protection program, and make any necessary changes to incorporate the ISFSI at its reactor site.

An NRC-approved cask is technically reviewed for its safety aspects and been found adequate to store spent fuel at a site evaluated by the licensee to meet all of NRC requirements in 10 CFR Part 72. NRC issues a Certificate of Compliance for a cask design to a cask vendor if the review of the design finds it technically adequate. The cask certificate expires 20 years from the date of issuance with a re-approval option.

The Yucca Mountain standards (established in 40 CFR 197.35 and implemented through 10 CFR Part 63) apply to Yucca Mountain only. More information is provided in Section E.2.2.2.

G.1.1 Interdependencies between Different Steps in the Spent Fuel Management Process

NRC integrates the regulatory management of the interim storage and transportation of spent fuel with its future permanent disposal. Such integration addresses licensing, certification, safety inspections of waste packages, and quality assurance. Other considerations include interfacing on topics such as international waste management, decommissioning activities, and research. DOE has responsibility for acceptance of spent fuel from the storage site, transport to, and disposal at the planned geologic repository.

DOE has also developed acceptance criteria for DOE spent fuel and high level waste at the planned Yucca Mountain repository. These criteria define the acceptability of waste at the planned repository and provide requirements for treatment and conditioning of spent fuel and HLW for storage at DOE sites in preparation for acceptance at the planned geologic repository.

G.1.2 Avoidance of Undue Burden/Impacts on Future Generations

The U.S. policy is to dispose of spent fuel in geologic repositories and not place undue burdens on future generations. Leading scientists in the U.S. have advocated deep geologic repository disposal to safely and permanently manage spent fuel over the past five decades.

EPA stated in its 2001 Yucca Mountain standards, and has reaffirmed in its 2005 draft revised standards, that future generations should be protected for a very significant time period (i.e., 10,000 years) so that impacts to those generations are no greater than those judged acceptable today. In draft standards proposed to apply for up to 1 million years past closure, EPA acknowledged that the disposal system must provide reasonable protection and security for the very far future (i.e., beyond 10,000 years). However, in view of the technical challenges of regulation for hundreds of thousands of years, standards applicable to these very long times should reflect the relative confidence that can be placed in dose projections as a basis for meaningful decision-making. Thus, for extremely long time frames, EPA has proposed to establish a dose limit based on levels of natural background radiation. In terms of burdens on future generations, EPA believes that exposures of this magnitude that are projected to occur several hundred thousand years into the future can assure a comparable quality of life at that time and should not be considered to pose a realistic threat of irreversible harm.

The planned repository may not be closed for some time after completion of emplacement to further ensure that future generations have flexibility. Repository closure, with proper maintenance, for example, could begin 50 years after the completion of emplacement of spent fuel disposal packages. The repository will be monitored during this time to ensure it is performing as expected.

G.2 Existing Facilities (Article 5)

ISFSIs in the U.S. use about 20 different storage cask system designs. The designs encompass the entire range of multi-purpose canisters, vault storage systems, and metal casks. These storage casks are made by several vendors and have been approved or certified by NRC. Almost all ISFSIs are owned and operated by 10 CFR Part 50 power reactor license holders. See Annex D-1 for additional information.

DOE operates an ISFSI at Idaho National Laboratory (INL) which stores core debris and spent fuel from the Three-Mile Island Unit-2 (TMI-2) 1979 reactor accident in Pennsylvania. The debris and spent fuel were taken to INL in the mid-1980s for investigation of the accident and resulting fuel damage. The core debris and spent fuel canisters were first stored in a pool at INL. DOE received a license from NRC allowing stored canisters to be removed from the aging pool facility, dried in a heated vacuum furnace, repackaged in welded steel containers, transported, and stored in an ISFSI constructed specifically for the TMI-2 fuel debris. The TMI-2 spent fuel and debris were repackaged and moved to the ISFSI between 1999 and 2001.

G.3 Siting of Proposed Facilities (Article 6)

The siting process for a geologic repository has a long history predating the NWPA. Several sites and geologic media were considered and screened; ultimately identifying the Yucca Mountain site for characterization for a potential geologic repository. Any such repository would be licensed by NRC. The Secretary of Energy, the President, and the U.S. Congress designated Yucca Mountain as the site of the planned repository pursuant to the NWPA, as amended. DOE is preparing a license application for submission to NRC to receive authorization to begin construction of the repository.

Standards in 10 CFR Part 60 for HLW and spent fuel were developed for any disposal site and implemented EPA standards in 40 CFR Part 191. Congress required EPA and NRC in 1992 to issue new regulations (10 CFR Part 63) specifically for the Yucca Mountain site. Those regulations became final in 2001. DOE regulations (siting guidelines) were finalized after those of EPA and NRC, to ensure their consistency. In July 2004, the Court of Appeals for the D.C. Circuit vacated the 10,000-year compliance period that was established in EPA standards and incorporated in NRC regulations. Because of the Court's decision, EPA proposed revised standards in August 2005 that retain and add to EPA's original Yucca Mountain standards issued in 2001 and are consistent with the Court ruling. The proposed revised standards provide added protection of public health for one million years after disposal from radioactive materials at the Yucca Mountain facility. When the EPA standard is finalized, NRC will revise their requirements accordingly.

Future repositories for HLW and spent fuel disposal would still be governed by NRC regulations published in 10 CFR Part 60. These regulations prescribe required site characterization activities and pre-license application reviews by NRC. The regulations also allow states and affected Indian tribes to participate in the pre-licensing (site) review and licensing review. Information will be publicly available through the formal licensing docket maintained in public reading rooms by NRC.

The U.S. Government is not currently planning to site or construct a monitored retrievable storage (MRS) installation. A private initiative, however, Privatized Fuel Storage, has submitted an application to NRC to construct an ISFSI designed to accept fuel from multiple utilities.

Private Fuel Storage, Limited Liability Company (PFS) submitted an application in June 1997 to NRC, pursuant to 10 CFR Part 72, to construct and operate an away-from-reactor ISFSI. This was only the second application submitted to NRC for an away-from-reactor ISFSI and the first for storage of spent fuel from more than one utility. PFS is a consortium of nuclear utilities proposing to lease land for the proposed ISFSI from the Skull Valley Band of Goshute Indians (the Skull Valley Band). The PFS application seeks approval for the storage of a maximum of 40,000 MTU of spent fuel at the site. The Skull Valley Band is an Indian tribe whose reservation is located in Utah. PFS plans to transport and store the spent fuel in dual-purpose cask systems, approved by NRC pursuant to the storage cask requirements in 10 CFR Part 72 and the transportation cask requirements in 10 CFR Part 71 for use specifically at the PFS site.

Several parties sought standing to intervene in the proceedings after the PFS application was received. An Atomic Safety Licensing Board (ASLB), an independent judicial arm of NRC, was empaneled and several groups were granted standing. There were 45 admitted contentions or modifications of contentions, some of which were merged. These were eventually accepted by the ASLB and adjudicated. On February 25, 2005, the ASLB issued a decision on the last issue before it on the spent fuel storage facility proposed by PFS. The Board ruled in favor of PFS. The State of Utah filed a motion for reconsideration of that decision, which is pending before the ASLB. Upon issuance of a decision on that motion, the determination whether to issue the requested license will be considered by NRC Commissioners, who may hear appeals. This process is continuing.

G.4 Design and Construction of Spent Fuel Storage Facilities (Article 7)

NRC has 3 primary regulations (Section G.3) for spent fuel management facilities, 10 CFR Part 60 and 10 CFR Part 63 for geologic disposal facilities, and 10 CFR 72 for storage facilities and storage casks. 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 in 10 CFR 72.3. These are minimum requirements for the design criteria for an ISFSI or MRS installation.

NRC’s 10 CFR Part 72 Subpart L, set requirements for spent fuel storage cask design approval and fabrication for use by general licensees. This subpart also contains requirements/ conditions for re-approval of designs having a NRC Certificate of Compliance, record keeping and report requirements, process for amending a certificate of compliance, and for periodic updating of safety analysis reports. Quality assurance requirements apply to both the facility and certificate of compliance holder. These requirements can be found in 10 CFR Part 72, Subpart G.

NRC reviews applications (safety analysis reports) using NUREG-1536, *Standard Review Plan for Dry Cask Storage Systems*, and NUREG-1567, *Standard Review Plan for Spent Fuel Dry Storage Facilities*. These plans assure the quality and uniformity of NRC application reviews.

G.5 Assessment of Safety of Facilities (Article 8)

Technical evaluations of the safety of ISFSIs are performed in six major areas: 1) site evaluation, 2) operations systems evaluations, 3) criteria and technical design evaluation, 4) evaluation of proposed programs that support protection of worker and public health and safety, 5) evaluation of accidents, and 6) evaluation of proposed technical specifications. Additional details and specific requirements can be found in NUREG-1567 *Standard Review Plan for Spent Fuel Dry Storage Facilities*.[69]

DOE is preparing a license application for submission to NRC for authorization to begin construction of a planned repository at Yucca Mountain containing "General Information" and a "*Safety Analysis Report*." This will be accompanied by an environmental impact statement. "General Information" includes a general description of the repository system; proposed schedules for construction, receipt, and emplacement of waste; a physical protection plan; a material control and accounting program plan; and a description of site characterization work.

The "*Safety Analysis Report*" will include discussion of preclosure repository safety analyses; postclosure repository safety analyses; a research and development program to resolve safety questions; a performance confirmation program; and administrative and programmatic requirements. The report must include a specific description of the Yucca Mountain site and the location of the reasonably maximally exposed individual. The report also must include information regarding the site's geologic repository operations area (GROA) with respect to the boundary of the site, geology, hydrology, geochemistry, climatology; a description and discussion of the design of the engineered barrier system, field tests, in-situ tests, laboratory tests representative of field conditions, monitoring data, natural analog studies; and a description of the quality assurance program to be applied to the structures, systems, and components important to safety and to the engineered and natural barriers important to waste isolation. Additional details of the composition of the Safety Analysis Report can be found in 10 CFR 63.21(c).

DOE must prepare a Total System Performance Assessment to demonstrate the postclosure performance objectives specified at § 63.113(b) of NRC regulations in 10 CFR Part 63 are met. The performance assessment quantitatively estimates the expected annual dose to the reasonably maximally exposed individual (RMEI) will not exceed the annual dose limit of 0.15 mSv (15 mrem) from releases from the Yucca Mountain disposal system over the compliance period, as specified in § 63.311. Demonstrating compliance with long-term performance requirements, by necessity, will involve the use of complex predictive models (TSPA) supported by limited data from field and laboratory tests, site-specific monitoring, and natural analog studies that may be supplemented with prevalent expert judgment.

G.6 Operation of Facilities (Article 9)

NRC relies on regulations and internally developed licensing and inspection programs to grant the authorization to store spent fuel or reactor related GTCC waste at an ISFSI, to approve storage cask design, and ensuring safe operation of the ISFSI. No releases from any cask leakage or radiation safety problems have occurred since the first ISFSI became operational in 1985.

10 CFR 72.48 was revised on April 5, 2001 to better define changes in cask design or procedures allowable without a license amendment request. Some control of the operational

[69]NUREG-1567 can be accessed at www.nrc.gov/reading-rm/doc-collections/nuregs/staff/.

limits was shifted from the technical specifications to the Final Safety Analysis Report in implementing this rule change. The objective of this effort was to replace the current detailed technical specifications with more general standard technical specifications concentrating on controlling the parameters most important to safety. The remaining parameters/conditions of lesser importance can be considered under the 10 CFR 72.48 process. The licensee or certificate holder notifies NRC of the safety analysis report updates, but no review or approval by NRC is required. This analysis is then audited during routine NRC inspections.

NRC working closely with industry, 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*. The important parameters are those influencing criticality safety and radiation shielding doses. The parameters are fuel type (array size, number of fuel rods, and cladding type, and number and material of guide and instrument tubes), enrichment (maximum for criticality safety, minimum for radiation shielding) maximum burnup, minimum cooling time, maximum uranium mass, and maximum Co-60 level. The ultimate determination of parameters is based on those the applicant uses in its modeling to demonstrate safety of the package design.

Requirements for incident reporting are specified 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 per INES requirements if the event is classified a level 2 or above. Section F.12.3 provides additional information on operation of facilities.

G.7 Examples of Improvements to Existing Spent Fuel Management Facilities

DOE has significant projects to improve safety at DOE spent fuel storage facilities, including:

Spent Fuel Dry Storage Privatization Project at INL. This project includes packaging and upgraded storage (from pool storage to dry storage) of selected spent fuel at INL. The four-phased project includes design, licensing by NRC, construction of the facility, spent fuel packaging, and spent fuel storage. NRC issued a license in December 2004 to construct and operate the ISFSI, and construction is underway. The dry storage project is designed to accommodate spent fuel elements from the Peach Bottom and Shippingport nuclear power plants and various training and research reactors.

Hanford Spent Nuclear Fuel Project. The Hanford Spent Nuclear Fuel Project started in 1994 to move metallic spent fuel, from DOE defense production reactors, from degraded pool storage conditions in the 105K East and 105K West Basins along the banks of the Columbia River to safe, dry interim storage in the 200 Area on the Central Plateau at Hanford until the planned Federal repository is available. All spent fuel has been moved to dry storage and the Project is now removing water, sludge and debris from the basins. Other spent fuel stored at various locations on the Hanford Site will also be consolidated in the 200 Area interim storage facility for eventual shipment off site for disposition.

The Receiving Basin for Off-Site Fuels (RBOF) was a spent fuel pool facility used at the Savannah River Site for over 40 years for spent fuel storage. All spent fuel was removed and placed in storage elsewhere on the Savannah River Site (L-Area) so the facility could be closed.

The final shipment of spent fuel out of RBOF occurred in October 2003. The facility deactivation was completed in June 2004.

G.8 Disposal of Spent Fuel (Article 10)

Spent fuel is being stored until a geologic repository is licensed and operational. Storage of spent fuel in an ISFSI is considered an interim action and not a final disposal solution. The U.S. Government has clearly distinguished between permanent disposal and interim storage. Nuclear power plants will continue to operate, produce power and generate more spent fuel while the licensing decision and possible construction of the geological repository for spent fuel and HLW proceeds. Most reactors need to maintain the capability of discharging a full core into the storage pool. Reactor plants have achieved expansion of the storage capacity by reracking spent fuel in storage pools. Increases in spent fuel storage capacity will occur during the time required to license, construct and operate a geologic repository. This will result in a need for continued interim dry storage of spent fuel.

H. SAFETY OF RADIOACTIVE WASTE MANAGEMENT

Section F described common elements of spent fuel and radioactive waste safety per Articles 11-16 of the Joint Convention. This section provides additional information for the same Articles pertaining only to radioactive waste management. This section also addresses Article 17 of the Joint Convention.

The fundamental legal basis for activities and sites associated with the generation, storage and disposal management of radioactive waste is the U.S. Atomic Energy Act (AEA). Under this authority and other subsequent legislation (see Table E-1), EPA has responsibility to establish generally applicable standards for the protection of the general environment from radioactive material. NRC issues regulations for activities and facilities it regulates (nuclear fuel cycle facilities, medical and research activities, etc.). DOE similarly issues Orders and regulations to manage its own activities, operations, and facilities. These Orders and regulations are comparable to the corresponding NRC regulations. This process is discussed in greater detail in Section E.

NRC establishes fundamental radiological protection limits in the 10 CFR Part 20, *Standards for Protection Against Radiation* for the safe management of radioactive waste (or any licensed activity dealing with radioactive materials). The DOE Order applying specifically to radioactive waste management is DOE Order 435.1, *Radioactive Waste Management*. This Order and its implementing guide and manual, ensures all radioactive waste is managed to protect worker and public health and safety, and the environment. DOE Order 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 closure. The Order references other DOE requirements on radiation protection, environmental protection, and occupational safety discussed in Section F.

Commercial radioactive waste is regulated by NRC as HLW, LLW, and uranium mill tailings. The types of radioactive materials are categorized as source, special nuclear and byproduct material. NRC's regulatory framework for disposal and management of commercial spent fuel is addressed in sections F and G. This section will address NRC radioactive waste management safety requirements for LLW and uranium recovery programs. The categorization of different kinds of regulated commercial radioactive waste is addressed in detail in section B.2.3.2.

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

Commercial LLW facilities were discussed in Section D.2.2.2. In addition to the Envirocare facility in Utah, which accepts only Class A LLW, six other commercial LLW disposal facilities have operated in the U.S. These facilities are located in Maxey Flats, Kentucky; Sheffield, Illinois; West Valley, New York; Beatty, Nevada; Barnwell, South Carolina; and Richland, Washington. Only the sites in Richland, Washington and Barnwell, South Carolina are still open. The Beatty, Nevada site closed in 1992, and the three other sites closed between 1975 and 1978. LLW was disposed in all six sites in excavated trenches. Water buildup in the trenches, (commonly called the "bathtub effect"), in large part initiated by slumping and failure of the trench caps, led to site closure at both the Maxey Flats and West Valley sites. The problems encountered at these early disposal sites, and lessons learned, prompted the development of NRC's regulation (10 CFR Part 61), focusing on the need for long-term stability of the disposal site and the waste package, as well as other disposal site suitability requirements.

H.1.1. Review of Formerly Licensed Facilities

The U.S. Congress directed NRC in the early 1990's to review its previously terminated contaminated sites, because of concerns about the criteria and procedures used for the decommissioning of these formerly licensed sites. NRC reviewed terminated materials licenses to assure previously licensed facilities were properly decontaminated and posed no threat to public health and safety. The Oak Ridge National Laboratory (ORNL) then reviewed all terminated materials licenses to identify sites with potential for meaningful residual contamination, based on information in the license documentation, and to identify sealed sources with incomplete or no accounting that could represent a public hazard. ORNL examined more than 37,000 terminated license files. ORNL identified about 675 material licenses and 565 sealed source licenses requiring further review. NRC either performed a follow-up review, or transferred responsibility for the follow-up review to the appropriate Agreement State.

Thirty nine formerly licensed sites (See Annex H-1) were found to have residual contamination levels exceeding NRC's criteria for unrestricted release. About forty percent of these formerly licensed sites have since been re-released after successful remediation.[70] The remaining sites are either in the process of decommissioning, under Regional review, or have been transferred to an Agreement State or other Federal Agency. See the Final Report on Results of Terminated License Reviews, dated September 26, 2001 for further details. This report is available online through NRC's Agency-wide Documents Access and Management Systems (Accession No. ML012710539). The U.S. also began to focus on past practices for disposal of chemicals in the 1970's. See Section F.7.5 for additional information.

H.1.2 Currently-Licensed LLW Facilities

The commercial sector's LLW is typically stored on site by licensees, either until it has decayed away (can be disposed of as ordinary trash) or until amounts are large enough for shipment to a

[70]NRC Source: http://www.nrc.gov/what-we-do/regulatory/decommissioning.html

LLW disposal site in containers approved by the U.S. DOT.[71] LLW disposal occurs at commercially operated LLW disposal facilities licensed by either NRC or Agreement States. Facilities must be designed, constructed, and operated to meet rigorous safety standards. The operator of the facility must also extensively characterize the facility site and analyze how the facility will perform for thousands of years.

The Low-level Radioactive Waste Policy Amendments Act of 1985 gave states responsibility for disposal of LLW generated within their borders. The Act encouraged states to enter into compacts allowing them to dispose of waste at a common disposal facility and exclude waste from states outside the compact. Most states have entered into compacts; however, no new compact disposal facilities have been built since the Act was passed. Figure H-1 shows the makeup of U.S. regional compacts for LLW disposal. There are now 10 compacts, comprising 42 states, and 10 unaffiliated states. The District of Columbia and Puerto Rico are considered States by the Atomic Energy Act and Low-Level Radioactive Waste Policy Amendments Act of 1985.

The Atomic Energy Act of 1954, as amended, provides a statutory basis for NRC to relinquish to the states portions of its authority to license and regulate byproduct materials (radioisotopes); source materials (uranium and thorium); and certain quantities of special nuclear materials. Currently, 33 of the 50 states have entered into Agreements with NRC, and others are being evaluated.

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, workshops; evaluates technical licensing and inspection issues from Agreement States; evaluates state rule changes; participates in activities conducted by the Organization of Agreement States'[72] Conference of Radiation Control Program Directors, Inc.; and provides early and substantive involvement of the states in NRC rule making and other regulatory efforts. NRC also coordinates with Agreement States on event reporting and information and responses to allegations reported to NRC involving Agreement States.

The 3 existing U.S. commercial LLW disposal sites are discussed in Section D. All are in Agreement States.

H.1.3 Management Strategies for Low Activity Waste Sites

Management and disposal of "low-activity waste" (LAW) is receiving increased attention both internationally and domestically. The U.S. has no official legal definition for the term, "low-activity waste," but it is a term frequently used by organizations involved in radioactive waste management.[73] The National Research Council of the National Academies defined it as including all types of conventional low-level radioactive waste produced by generators in the nuclear fuel cycle, discrete sources, slightly contaminated solid materials, uranium and thorium ore processing wastes, and wastes containing technologically enhanced naturally occurring radioactive materials (TENORM).

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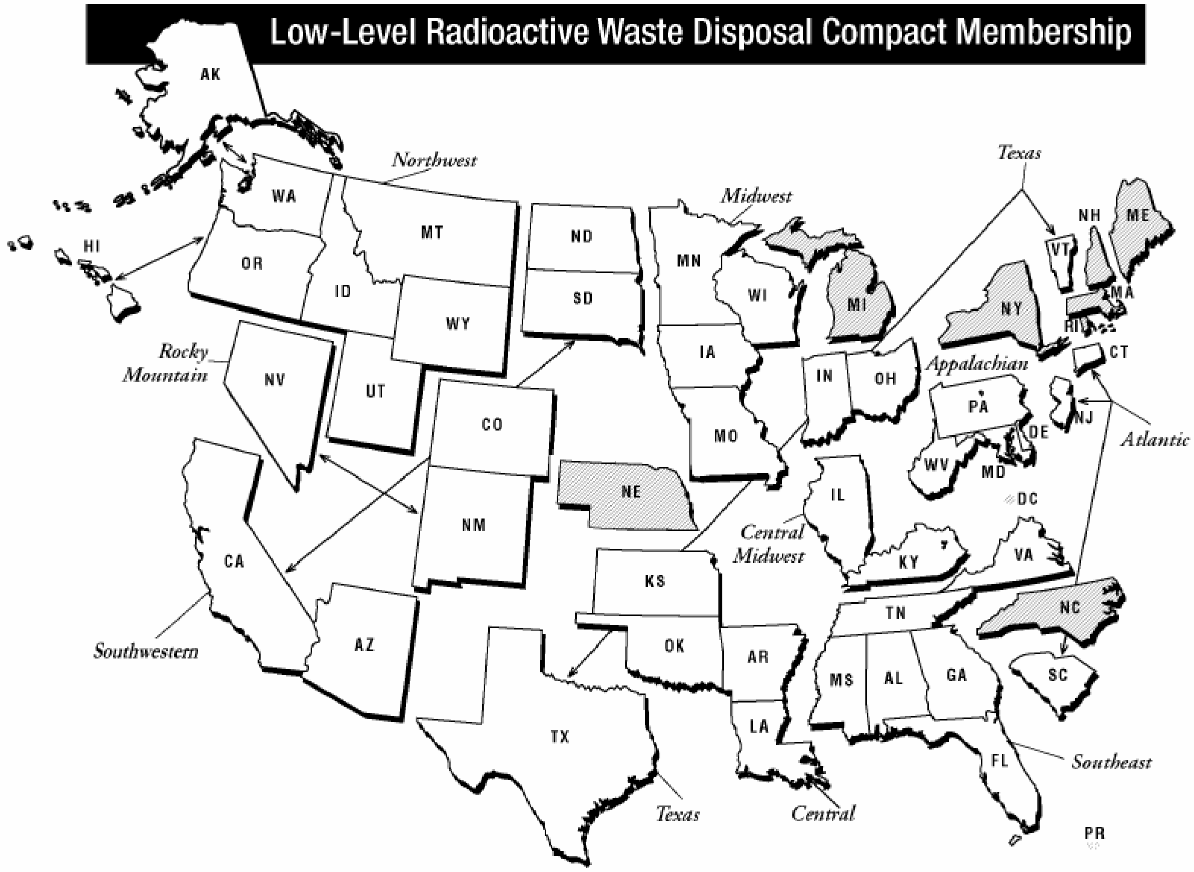
[71]For more detailed information on LLW, see USNRC brochure "Radioactive Waste: Production, Storage, Disposal," (NUREG/BR-0216) and USNRC fact sheet on "Low-Level Radioactive Waste".
[72]See http://www.agreementstates.org/index.html for more information.
[73]Management and Disposal Strategies for Low-Activity Waste in the U.S., M. Federline, NRC, IAEA Symposium On Low-Activity Radioactive Waste Disposal; Cordoba, Spain. December 13-17, 2004



Appalachian Compact
Delaware
Maryland
Pennsylvania
West Virginia

Atlantic Compact
Connecticut
New Jersey
South Carolina

Central Compact
Arkansas
Kansas
Louisiana
Oklahoma

Central Midwest Compact
Illinois
Kentucky

Northwest Compact
Alaska
Hawaii
Idaho
Montana
Oregon
Utah
Washington
Wyoming

Midwest Compact
Indiana
Iowa
Minnesota
Missouri
Ohio
Wisconsin

Rocky Mountain Compact
Colorado
Nevada
New Mexico

Northwest accepts Rocky Mountain waste as agreed between compacts

Southeast Compact
Alabama
Florida
Georgia
Mississippi
Tennessee
Virginia

Southwestern Compact
Arizona
California
North Dakota
South Dakota

Texas Compact
Texas
Vermont

Unaffiliated States
District of Columbia
Maine
Massachusetts
Michigan
Nebraska
New Hampshire
New York
North Carolina
Puerto Rico
Rhode Island

Figure H-1. U.S. Low-Level Waste Compacts[74]

Four Federal agencies implement or oversee cleanup programs producing substantial amounts of LAW. DOE is cleaning up sites previously used for its nuclear weapons program. EPA

[74]Graphic courtesy of Low Level Radioactive Waste Forum, Inc. The District of Columbia and Puerto Rico are considered States for the purpose of low-level radioactive waste disposal.

implements its Superfund program, which includes dozens of sites contaminated with radioactive materials. The Army Corps of Engineers is implementing the FUSRAP, addressing cleanup of sites from the Manhattan Project (See Section D.3.2). NRC established the complex sites decommissioning program in the early 1990's 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.

EPA has been considering a rule that would permit disposal of certain types of "low-activity" wastes in the hazardous waste facilities it regulates. EPA has also discussed LAW in the broad context of radioactive wastes containing radionuclides in small enough concentrations to allow them to be managed in ways that do not require all of the radiation protection measures necessary for higher-activity materials.

One of the primary reasons LAW has become a focus of attention is the unusually large volumes to be managed in comparison to conventional LLW from the ongoing operations of nuclear facilities. DOE's cleanup program includes 75 million cubic meters of contaminated soil, and 20,000 buildings and structures. Many are contaminated and at least half are no longer used. DOE has shipped nearly 7,000 railcar loads to a disposal facility in Utah from the DOE Fernald site in Ohio alone. NRC reports more than a billion metric tons of TENORM waste are produced each year. Some of this waste contains very low levels of radioactivity and may not need special attention. Other TENORM waste streams require measures to manage their risks. No precise numbers are available for NRC's decommissioning and site cleanup program or EPA's Superfund Program. Both programs contain a number of sites that have large quantities (greater than 10,000 cubic meters) of contaminated soil and debris. Some typical examples of LAW present in very large quantities include fly ash from coal combustion [74-359 Bq/kg (2-9.7 pCi/gram)] and scale and sludge from oil and natural gas production (background to approximately 10^6 Bq/kg). Many of the sites undergoing cleanup have concentrations in the range of a few hundred Bq/kg to several thousand Bq/kg of such long-lived radionuclides as uranium, thorium, and/or radium.

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 States authorized by EPA in the case of hazardous waste, and by States alone in the case of solid waste. Neither type of facility was originally designated for radioactive wastes. The same containment and isolation technology used in the design for hazardous and municipal solid waste is relied upon, in certain cases, for radioactive waste. (See Section E.2.2.3 on mixed waste regulation). NRC, in collaboration with the State of Michigan for example, recently permitted some very low-activity wastes from the decommissioning of the Big Rock Point nuclear power plant to be sent to a RCRA Subtitle D (solid waste) landfill. Other States, such as Texas, have also determined these landfills may offer sufficient protection for certain types of radioactive material, such as material with very short half-lives, and have included provisions in their State regulations defining the kinds and amounts of waste that may be disposed of in these facilities. A number of DOE sites, on a case-by-case basis, in coordination with the State regulators, have limited approval 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.

LAW from remediation of sites and decommissioning is also affected by risk management decisions for the release of sites. LAW from contaminated sites may be allowed to remain onsite under certain circumstances, often after the more highly radioactive materials have been removed. DOE plans to leave residual radioactivity in place at many sites, and will require long term management (institutional controls) to ensure future use of the land is safe and barriers are functioning as intended. Several DOE sites (see Section D.2.2.2) have waste disposal onsite in CERCLA disposal cells requiring long-term stewardship. The Superfund program administered by EPA has a long history of permitting residual materials, both chemicals and radioactive materials, to remain on site provided a reliable system of institutional controls is established. CERCLA requires a review every 5 years to ensure the controls are continuing to function.

H.2 DOE Waste Management Facilities

General safety requirements for DOE facilities were discussed in Section F (Article 11). The following subsections contain additional information on the safety of radioactive waste management at DOE facilities.

DOE manages radioactive waste from government-sponsored programs including waste from defense activities and cleanup of former defense waste sites. DOE Order 435.1 is implemented through a manual (Manual 435.1-1) including procedural requirements and existing practices ensuring all waste is managed to protect workers, the public, and the environment. This manual has separate chapters delineating requirements for each class of radioactive waste managed. Chapters have diverse subsections addressing general and specific waste classification requirements. Topics include complex-wide waste management programs, site-wide waste management programs, waste management basis, quality assurance, contingency actions, and corrective actions. It also includes waste acceptance, waste generation planning, waste characterization, waste certification, waste transfer, packaging and transportation, site evaluation and facility design, storage, treatment, disposal, monitoring, and closure. The manual is extensive and is the basis for safe radioactive waste management practices at all DOE facilities.

H.2.1 Past Practices (Article 12)

Environmental restoration activities using the CERCLA (See Section F.7.5) process must demonstrate compliance with the substantive requirements of DOE Order 435.1, including the performance objectives. The CERCLA process can be used for this demonstration if it is adequate. Compliance with all substantive requirements of DOE Order 435.1 not met through the CERCLA process must be separately demonstrated, however.

Some past practices have led to environmental restoration activities or interventions. Former waste disposal techniques, such as soil columns or crib trenches, and decontamination of sites where remaining residual radioactivity does not meet today's standards for unrestricted release are some examples.

Environmental restoration activities resulting in off-site management and disposal of radioactive waste must meet the applicable requirements of DOE Order 435.1. Organizations performing environmental restoration activities, involving development and management of radioactive waste disposal facilities under the CERCLA process, submit a certification of compliance with the substantive requirements of DOE Order 435.1. They also submit the decision document, such as the Record of Decision, or any other document regulating authorization for disposal. Section H.2.4 provides additional requirements for closure of waste management facilities, some of which may be attributed to past practices.
The U.S. is also completing large cleanup programs at Rocky Flats and Fernald sites. Some of this cleanup has been complicated by past practices. Cleanup activities are described further in Section D. Cleanup now reduces and eliminates impacts on future generations.

H.2.2 Siting of Proposed Facilities (Article 13)

New radioactive waste management facilities, operations, and activities are designed and sited in accordance with DOE Order 420.1A, *Facility Safety*, and DOE Order 430.1B, *Real Property Asset Management*.[75] Proposed locations for radioactive waste management facilities are evaluated to identify features to be avoided or must be considered in facility design and analyses. Each site proposed for a new facility or expansion of an existing facility is evaluated considering environmental characteristics, geotechnical characteristics, and human activities. A LLW disposal facility site must additionally demonstrate at a minimum, whether it is:

- Located to accommodate the projected volume of waste to be received;
- Located in a flood plain, a tectonically active area, or in the zone of water table fluctuation; and
- Located where radionuclide migration pathways are predictable and erosion and surface runoff can be controlled.

Proposed sites with environmental characteristics, geotechnical characteristics, and human activities where adequate protection cannot be provided through facility design must be deemed unsuitable. Low-level waste disposal facilities are sited to achieve long-term stability and to minimize, to the extent practicable, the need for active maintenance following final closure.

H.2.3 Design and Construction (Article 14)

Safety structures, systems, and components for high-level waste storage, pretreatment, and treatment facilities are designated and designed consistent with the provisions of DOE Order 420.1A, and nuclear safety regulations (10 CFR 830). The following requirements apply to new or modifications to existing high-level waste systems, ancillary systems, and components:

- Secondary confinement systems are designed to prevent any migration of wastes or accumulated liquid out of the waste system; are capable of detecting, collecting, and retrieving releases into the secondary confinement; and are constructed of, or lined with, materials compatible with the waste(s) to be placed in the waste system; and

- Tank and piping systems used for high-level waste collection, pretreatment, treatment, and storage are welded construction, except where remote configurations or periodic rerouting of high-level waste streams require non-welded construction.

The design of hoisting and rigging devices must comply with specific requirements. Lifting devices, designated as safety class or safety significant, must be designed to prevent free fall of loads. Loading and unloading systems for lifting devices designated as safety class or safety significant must be designed with a reliable system of safety interlocks. Remote maintenance features, and other appropriate techniques to maintain as low as is reasonably achievable (ALARA) personnel exposures, must be incorporated into each HLW facility.

Designs for HLW storage facilities incorporate features to facilitate retrieval. High-level waste receipt and retrieval systems are designed to complement the existing storage facilities for safe storage and transfer of high-level waste. Designs for new tanks incorporate features to avoid critical degradation modes at the proposed site where practicable, or minimize degradation

[75]DOE Orders apply to DOE waste facilities; they do not apply to facilities owned and operated by commercial firms, e.g., commercial LLW facilities subject to licenses issued by NRC or Agreement States.

rates for the critical modes; and incorporate features to facilitate execution of a structural integrity program.

Engineering controls are incorporated in the design and engineering of radioactive waste treatment storage, pretreatment, and treatment facilities to provide volume inventory data and to prevent spills, leaks and overflows from tanks or confinement systems. Monitoring and/or leak detection capabilities are incorporated in the design and engineering of high-level waste storage, pretreatment, and treatment facilities to provide rapid detection of failed confinement or other abnormal conditions.

All radioactive waste management systems and components are designed to maintain waste confinement. Design of pretreatment, treatment, storage, and disposal facilities include ventilation, if needed, through an appropriate filtration system to maintain the release of radioactive material in airborne effluents within requirements and guidelines. Ventilation systems or other measures are provided to keep the gases in a non-flammable and non-explosive condition when conditions exist for generating gases in flammable or explosive concentrations. Measures are taken to prevent deflagration or detonation where concentrations of explosive or flammable gases are expected to approach the lower flammability limit. Areas in new and modifications to existing radioactive waste management facilities subject to contamination with radioactive or other hazardous materials are designed to facilitate decontamination. A proposed decommissioning method or a conversion method leading to reuse must be described for such facilities.

Closure of the WIPP facility will employ both natural and man-made barriers to significantly delay the migration of radionuclides to the natural environment. These barriers will include backfill, panel seals, shaft seals and borehole plugs. Technical provisions for closure may be found for WIPP in Chapter 3 of DOE M 435.1-1 and 40 CFR Part 194 Section VIII(a)1. Technical provisions for closure of the planned Yucca Mountain repository are in 10 CFR Part 63.

Low-level waste disposal facilities are designed to achieve long-term stability, minimize the need for active maintenance following final closure, and minimize the contact of waste with water during and after disposal. DOE M 435.1-1, chapter IV, includes requirements for LLW storage facilities in section M (2) in the areas of confinement, ventilation, instrumentation/control, monitoring, and consideration of decommissioning. Packaging requirements are briefly discussed in section L (1)[76] in the same chapter. Technical provisions for closure of commercial LLW facilities are in 10 CFR 61.52.

DOE M 435.1-1 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 or conversion method leading to reuse must be included in the design.

[76]This information is available on the Internet at http://www.directives.doe.gov/ under the directives, 400 series, and M 435.1-1.

H.2.4 Assessment of Safety of Facilities (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. Specific waste management controls are part of the radioactive waste management basis for:

- Waste generator organizations (the waste certification program);
- Pretreatment and treatment facilities (the waste acceptance criteria and waste certification program);
- Storage facilities (the waste acceptance criteria and the waste certification program); and
- LLW and TRU waste disposal facilities (the performance assessment, composite analysis, disposal authorization statement, closure plan, waste acceptance requirements, and monitoring plan).

A composite analysis must account for all sources of radioactive material contributing to the projected long-term dose to a hypothetical member of the public from an active or planned low-level waste disposal facility. The analysis is a planning tool to provide a reasonable expectation that current low-level waste disposal activities will not result in the need for future corrective or remedial actions. Additional information may be found in the implementation guidance for DOE Order 435.1 (DOE G 435-1). More details on this guidance are available on the internet.[77]

DOE LLW disposal facilities are sited, designed, operated, maintained, and closed so there is a reasonable expectation the following performance objectives are met for waste disposed of after September 26, 1988:

- Dose[78] to representative members of the public does not exceed 0.25 mSv (25 mrem) in a year from all exposure pathways, excluding the dose from radon and its progeny in air;
- Dose to representative members of the public via the air pathway does not exceed 0.10 mSv (10 mrem) in a year total effective dose equivalent, excluding the dose from radon and its progeny; and
- Release of radon is less than an average flux of 0.74 $Bq/m^2/s$ (20 $pCi/m^2/s$) at the surface of the disposal facility; alternatively, a limit of 0.0185 Bq/l (0.5 pCi/l) in air may be applied at the boundary of the facility.

A site-specific radiological performance assessment was prepared and is maintained for DOE LLW disposed of after September 26, 1988. The performance assessment includes calculations for a 1,000-year period after closure of potential doses to representative future members of the public and potential releases from the facility to provide a reasonable expectation the performance objectives above are not exceeded as a result of operation and closure of the facility.

Analyses performed to demonstrate compliance with the performance objectives, and to establish limits on concentrations of radionuclides for disposal based on the performance measures for inadvertent intruders are based on reasonable activities in the critical group of exposed individuals. The assumption of average living habits and exposure conditions in representative critical groups of individuals projected to receive the highest doses is appropriate unless otherwise specified. The likelihood of inadvertent intruder scenarios may be considered

[77] http://www.directives.doe.gov/
[78] Dose is defined here as the total effective dose equivalent, which is defined as the sum of the deep-dose equivalent for external exposures and the committed effective dose equivalent for internal exposures.

in interpreting the results of the analyses and establishing radionuclide concentrations, if adequate justification is provided.

The point of compliance corresponds to the point of highest projected dose or concentration beyond a 100 meter buffer zone surrounding the disposed waste. A larger or smaller buffer zone may be used if adequate justification is provided.

Performance assessments address reasonably foreseeable natural processes disrupting barriers against release and transport of radioactive materials. Performance assessments use DOE-approved dose coefficients (dose conversion factors) for internal and external exposure of reference adults. The performance assessment includes a sensitivity/uncertainty analysis. Performance assessments include demonstrating projected releases of radionuclides to the environment are maintained ALARA. The performance assessment includes an assessment of impacts to water resources to establish limits on radionuclides disposed of near the surface. To establish limits on the concentration of radionuclides that may be disposed of near surface, the performance assessment also includes an assessment of impacts calculated for a hypothetical person assumed to inadvertently intrude for a temporary period into the LLW disposal facility. Institutional controls for intruder analyses are assumed to be effective in deterring intrusion for at least 100 years following closure. The intruder analyses use performance measures for chronic and acute exposure scenarios, respectively, of 1 mSv (100 mrem) in a year and 5 mSv (500 mrem) total effective dose equivalent excluding radon in air.

A site-specific radiological composite analysis was prepared and is maintained for LLW disposal facilities that received waste after September 26, 1988. The composite analysis accounts for all sources of radioactive material left at the DOE site and that may interact with the LLW waste disposal facility, contributing to the dose projected to a hypothetical member of the public from the existing or future disposal facilities. Performance measures are consistent with DOE requirements for protection of the public and environment and evaluated for a 1,000-year period following disposal facility closure. The composite analysis results are used for planning, radiation protection activities, and future use commitments to minimize the likelihood that current LLW disposal activities will result in the need for future corrective or remedial actions.

The performance assessment and composite analysis are maintained to evaluate changes affecting the performance, design, and operating bases for the facility. Performance assessment and composite analysis maintenance includes research, field studies, and monitoring needed to address uncertainties or gaps in existing data. The performance assessment is updated to support the final facility closure. Additional iterations of the performance assessment and composite analysis are conducted as necessary during the post-closure period. Performance assessments and composite analyses are reviewed and revised when significant changes occur that alter the conclusions or the conceptual model(s). A determination of the continued adequacy of the performance assessment and composite analysis is made on an annual basis, and considers the results of data collection and analysis from research, field studies, and monitoring. Annual summaries of LLW disposal operations are prepared on the conclusions and recommendations of the performance assessment and composite analysis and a determination of the need to revise the performance assessment or composite analysis.

A disposal authorization statement is a part of the radioactive waste management basis for a disposal facility and is obtained prior to construction of a new LLW disposal facility. DOE sites with existing LLW disposal facilities obtained a disposal authorization statement in accordance with the schedule in the *Complex-Wide Low-Level Waste Management Program Plan*.[79] The disposal authorization statement is issued based on a review of the facility's performance assessment, composite analysis, preliminary closure plan, and preliminary monitoring plan. The disposal authorization statement specifies the limits and conditions on construction, design, operations, and closure of the LLW facility based on these reviews.

LLW disposal sites develop Disposal Facility Closure Plans. A preliminary closure plan is developed and reviewed with the performance assessment and composite analysis. The closure plan is updated following the disposal authorization statement to incorporate conditions specified in the disposal authorization statement. Closure plans are updated as required during the operational life of the facility. They include a description of how the disposal facility will be closed to achieve long-term stability and minimize the need for active maintenance following closure and to ensure compliance with the requirements of DOE Order 5400.5, *Radiation Protection of the Public and the Environment*. Closure plans also include the total expected inventory of wastes to be disposed of at the facility over the operational life of the facility.

Closure of a DOE LLW disposal facility occurs within a five-year period after it is filled to capacity, or after determining the facility is no longer needed. The final inventory of the LLW disposed in the facility is prepared and incorporated in the performance assessment and composite analysis, which is updated to support the closure of the facility prior to closure. A final closure plan is prepared and implemented based on the final inventory of waste disposed in the facility. An updated performance assessment and composite analysis are prepared in support of the facility closure.

Deactivated DOE HLW facilities/sites are closed in accordance with: (1) the requirements of DOE Order 430.1B, *Real Property Asset Management* and requirements of DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, for free release; (2) the CERCLA process; and/or (3) an approved closure plan. A closure plan is developed under DOE Order 435.1, *Radioactive Waste Management*, for each HLW facility/site being closed defining the approach and plans for closure of each facility within the site. This plan is completed and approved prior to start of physical closure activities, and updated periodically to reflect current analysis and status of individual facility closure actions. The plan includes, at a minimum, the following elements:

- Identification of the closure standards/performance objectives;
- A strategy for allocating waste disposal facility performance objectives from the closure standards identified in the closure plan among the facilities/units to be closed at the site;
- An assessment of the projected performance of each unit to be closed compared to the performance objectives allocated to each unit under the closure plan;
- An assessment of the projected composite performance of all units to be closed at the site compared to the performance objectives and closure standards identified in the closure plan; and
- Any other relevant closure controls including a monitoring plan, institutional controls, and land use limitations to be maintained in the closure activity.

[79]Referenced in DOE Order 435.1.

H.2.5 Operation of Facilities

DOE policy requires that radioactive waste to be treated, stored, and in the case of LLW, disposed of at the site where the waste is generated, if practical, or at another DOE facility. Commercial treatment and storage are allowed if DOE capabilities are not practical or cost effective. The U.S. has no "long-term" LLW storage facilities. Some waste currently without a path to disposal, such as disused sealed sources falling into the GTCC LLW category, remains in storage until a disposal site is available. Disposal of DOE LLW at non-DOE sites requires an exemption showing non-DOE facilities comply with provisions such as:

- Adherence to applicable Federal, State, and local requirements;
- Annual audits by DOE approved personnel;
- Protection of public health and the environment; and
- Demonstration of performance objectives.

TRU waste is disposed of at WIPP in accordance with the requirements of 40 CFR Part 191, *Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes*. Plans for the removal of TRU waste from retrievable earthen-covered storage facilities prior to shipment for disposal are established and maintained. Each waste storage site is evaluated to determine relevant information on types, quantities, and location of radioactive and hazardous chemicals as necessary to protect workers during the retrieval process prior to commencing waste retrieval activities.

The Contact-Handled Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant Waste Acceptance Criteria (DOE-WIPP-02-3122- Rev. 3.0, April 25, 2005)[80] provides details on container, radiological, physical, and chemical properties, as well as data packages and quality assurance. Characterization programs at waste sites are certified by the DOE Carlsbad Field Office. EPA and the State of New Mexico Environmental Department (NMED) have regulatory roles. EPA certifies radioactive waste characterization, while NMED reviews and approves audit reports under their hazardous waste authority. Characterization, certification, and shipping information on individual waste packages and shipments are entered into the WIPP Waste Information System once a site is certified. It is reviewed, approved, and certified prior to each individual shipment by DOE.

Partially buried steel storage tanks for liquid HLW are operated and maintained to preserve the design basis. Secondary confinement systems, where provided, prevent any migration of wastes or accumulated liquid out of the waste confinement systems. A structural integrity program is developed for each HLW storage tank site to verify the structural integrity and service life of each tank to meet operational requirements. The program is capable of verifying and or identifying robustness, chemical and physical integrity, and detecting any failure of tank performance. The structural integrity of other storage components is verified to assure leak tightness and structural strength.

HLW treatment facilities are designed and constructed to comply with DOE/EM 0093, *Waste Acceptance Product Specifications for Vitrified High-Level Waste Forms*, or DOE/RW-0351P, *Waste Acceptance System Requirements Document* for non-vitrified, immobilized HLW.

The requirements of RW-0333P, *Quality Assurance Requirements and Description*, apply to those HLW items and activities important to waste acceptance/product quality. The evaluation and assessment requirements of RW-0333P and associated implementing procedures apply to

[80] http://www.wipp.ws/library/wac/CH-WAC.pdf

HLW acceptance and product quality activities, in addition to the assessment requirements of other DOE directives.

Canisters of immobilized high-level waste awaiting shipment to a repository are:

- Stored in a suitable facility;
- Segregated and clearly identified to avoid commingling with LLW and TRU waste;
- Monitored to ensure that storage conditions are consistent with DOE/EM 0093, *Waste Acceptance Product Specifications for Vitrified High-level Waste Forms*, or DOE/RW-0351, *Waste Acceptance System Requirements Document*, for non-vitrified immobilized high-level waste.

H.2.6 Institutional Measures After Closure

Institutional control measures are integrated into land use and stewardship plans and programs, and continue until the facility can be released pursuant to DOE Order 5400.5, *Radiation Protection of the Public and the Environment*. The location and use of the facility is filed with the local authorities responsible for land use and zoning.

Monitoring ensures radioactive waste management facilities comply with the conditions in their authorization statement. Parameters sampled or monitored, at a minimum, include temperature, pressure (for closed systems), radioactivity in ventilation exhaust and liquid effluent streams, and flammable or explosive mixtures of gases. Facility monitoring programs include verification passive and active control systems have not failed. Liquid level and/or waste volume, and significant waste chemistry parameters are monitored for facilities storing liquid waste. Monitoring programs also include physical inspections.

A preliminary monitoring plan for a LLW disposal facility is prepared and submitted to DOE for review with the performance assessment and composite analysis. The monitoring plan is updated within one year of the disposal authorization statement to incorporate and implement conditions specified in the disposal authorization statement. The site-specific performance assessment and composite analysis are used to determine the media, locations, radionuclides, and other substances to be monitored. Environmental monitoring programs are designed to include measuring and evaluating releases, migration of radionuclides, disposal unit subsidence, and changes in disposal facility and disposal site parameters, which may affect long-term performance. The environmental monitoring programs are capable of detecting changing trends in performance to enable corrective action prior to exceeding the performance objectives.

DOE will use active institutional controls for at least 100 years following closure at the WIPP repository for disposal of TRU waste (see Section B.4.2 and Section D.2.2.1). Active controls, such as fences, roadways, signs, and periodic surveillance, prevent human intrusion during this period. Ground water monitoring will continue for at least 30 years after closure, and subsidence monitoring will continue for at least 100 years. Passive institutional controls are required to inform and warn future generations about the location and purpose of this repository after the active institutional control period.

Regulations require that the TRU waste disposal site use markers and controls. These passive controls are expected to communicate the location, design, and contents of the disposal system for at least 10,000 years. Planned components include: a large earthen berm, perimeter monuments, buried warning markers, magnets and metal radiation symbols, an information center using graphics and various languages, and information storage rooms. Archives will be stored in various locations around the world. A summary report is planned, and will be written in multiple languages on archival-quality paper to preserve it.

H.3 Uranium Recovery Wastes

Uranium milling is any activity resulting in the production of byproduct material. 10 CFR Part 40 defines byproduct material the same as Section 11e.(2) of the Atomic Energy Act, "...the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content," but adds "...including discrete surface wastes resulting from uranium solution extraction processes." This section deals with safety practices, and Section D.2.2.3 provides a description of uranium recovery facilities in the U.S.

H.3.1 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, *Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily for Their Source Material Content*. The criteria in Appendix A cover the siting and design of tailings impoundments, disposal of tailings or wastes, decommissioning of land and structures, ground water protection standards, and testing of the radon emission rate from the impoundment cover. The criteria also include monitoring programs, airborne effluent and off-site exposure limits. The criteria also cover inspection of retention systems, financial surety requirements for decommissioning and long-term surveillance and control of the tailings impoundment, and eventual government ownership of the tailings site under a NRC general license.

A number of non-radiological constituents (e.g., ammonia, arsenic, and heavy metals) contained in tailings present a potential human health and environmental hazard to ground water and surface waters. Table 5C in 10 CFR Part 40, Appendix A contains maximum values for ground water protection. NRC considers all ground water contamination from licensed uranium mill activities to be classified as 11e.(2) byproduct material regulated under the Atomic Energy Act. This includes radiological and non-radiological constituents. Clean-up standards are made on a site-specific basis and licensees can propose as their ground water protection standards: (1) background values, (2) maximum concentration limits per Table 5C, or (3) alternate concentration limits that present no significant hazard and are ALARA after considering practicable corrective actions. Compliance is assessed and assured by review of licensee monitoring and NRC inspections.

EPA regulations provide generally applicable mill standards, which NRC adopted in its regulations for uranium milling. The Office of Surface Mining, U.S. Department of Interior and individual states regulate mining safety as an industrial, non-nuclear activity. EPA also issues regulations and standards to direct the actions of other Federal agencies. NRC regulates milling and the disposal of tailings in non-Agreement States; although state agencies regulate these activities in Agreement States when the agreement specifically includes tailings. NRC requires licensees to meet EPA standards for cleanup of uranium and thorium mill sites after the milling operations have permanently closed. This includes requirements for long-term stability of the mill tailings piles, radon emissions control, water quality protection and cleanup, and cleanup of lands and buildings. The annual occupational dose limit for both mines and mills is 50 mSv (5 rem).

H.3.2 Existing Facilities/Past Practices (Article 12)

Most mills in the United States are in decommissioning, one is in standby, and one is in operation. Most of the conventional uranium mill sites have completed, or are completing, reclamation activities to provide long-term stabilization and closure of the tailings impoundments and the sites. There are about 12 ISL facilities in the United States. Four are licensed by NRC, and the rest are licensed by Texas, an Agreement State.

NRC or the Agreement State inspects these sites at one- to three-year intervals depending on the operational (or stand-by) and reclamation status. Annex D-3 provides the status of each of the uranium recovery facilities.

H.3.3 Uranium Recovery Radioactive Waste Management Facilities: 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.[81] Technical Criterion 1 sets broad objectives for siting and design. The intent is to provide permanent isolation of tailings and associated contaminants by minimizing disturbance and dispersion by natural forces, and to do so without ongoing maintenance. Additional criteria specify period of performance (longevity) and other design considerations. 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 to negligible levels.

H.3.4 Uranium Recovery Radioactive Waste Management Facilities: Safety Assessment (Article 15)

Safety assessment is performed as part of the application review process for a uranium recovery operation. The licensee needs to provide an environmental report with sufficient information for NRC to prepare an environmental assessment (under the provisions of NEPA – See Table E-1) as significant changes occur during the life of the facility, e.g., expansion of the tailings pile or increasing the number of ISL well fields. A more complete EIS is prepared by NRC should the environmental assessment result in potential significant environmental impacts. The licensee may, as a result of such an EIS, have to revise the design and/or increase the financial assurance mechanism, which guarantees there will be adequate funding for closure and disposal.

H.3.5 Uranium Recovery Radioactive Waste Management Facilities: Institutional Measures After Closure (Article 17)

Appendix A, Criterion 12 stipulates final design of the waste impoundment, i.e., the final disposition of tailings, residual radioactive material, or wastes at milling sites, should assure ongoing active maintenance is not necessary to preserve isolation. A monetary mechanism is specified to ensure surveillance and monitoring continue, but active ongoing maintenance should not be needed because of the robust impoundment design required by other criteria.

Licensees are required by license conditions to complete site decontamination, decommissioning, and surface and ground-water remedial actions consistent with decommissioning, reclamation, and ground-water corrective action plans before license

[81]These criteria can be accessed at the URL: http://www.nrc.gov/reading-rm/doc-collections/cfr/part040/part040-appa.html

termination.[82] Licensees must document the completion of these remedial actions in accordance with NRC procedures. This information includes a report documenting completion of tailings disposal cell construction, as well as radiation surveys and other information required under 10 CFR 40.42.

The licensee will work with the custodial agency in preparing the Long Term Surveillance Plan (LTSP) because the LTSP must reflect the remediated condition of the site. This coordination will likely involve supplying the custodial agency with appropriate documentation such as as-built drawings of the remedial actions taken and reaching agreements (formal or informal) with the custodial agency on the necessary surveillance control features of the site (boundary markers, fencing). It is the responsibility of the custodial agency to submit the LTSP to NRC for approval. The licensee may, however, elect to help prepare the LTSP, to whatever degree is agreed upon between the licensee and the custodial agency.

The licensee provides funding to cover long-term surveillance responsibilities in accordance with Criterion 10 of Appendix A. NRC will determine the final amount of this charge based on final conditions at the site. The remaining liability of the licensee after termination of the existing license and transfer of the site and byproduct materials to the custodial agency, extends solely to any fraudulent or negligent acts committed before the transfer to the custodial agency, as provided for in Section 83b(6) of the AEA.

Section 83 of the AEA, as amended, states before termination of the specific license, title to the site and byproduct materials should be transferred to (a) DOE, (b) a Federal agency designated by the President, or (c) the State in which the site is located, at the option of the State. DOE will be the custodial agency for most, if not all, of the sites.

It is the responsibility of the custodial agency to submit the LTSP to NRC for review and acceptance. Provisions and activities identified in the final LTSP will form the bases of the custodial agency long-term surveillance at the site. The NRC general license in 10 CFR 40.28(a) becomes effective when the licensee’s current specific license is terminated and the Commission accepts the LTSP. Custodial agencies are required, under 10 CFR 40.28(c)(1) and (c)(2), to implement the provisions of the LTSP. The license termination process is discussed in more detail in Section E3.0 of NUREG-1620.

H.3.6 Monitoring Releases to the Environment

The Environmental Radiation Ambient Monitoring System (ERAMS) is a national network of more than 200 monitoring stations distributed across all 50 states and the American Territories. Each station regularly samples the nation's air, precipitation, drinking water, or pasteurized milk for a variety of radionuclides (e.g., iodine-131) and radiation types (e.g., gross beta).

The legal basis of ERAMS originated in Executive Order 10831, issued by President Dwight D. Eisenhower in 1959 and was restated as part of the legislative history of the 1959 amendments to the AEA. Radioactive fallout and environmental radiation monitoring became the responsibility of the Department of Health, Education and Welfare (HEW) under these legal mandates. HEW transferred these responsibilities to EPA In 1970.

These responsibilities are described in EPA Order 1110.2, in which EPA …”shall develop programs and systems for monitoring the condition of the environment which are integrated with monitoring activities of other Federal and non-Federal agencies.” EPA established ERAMS in

[82]NUREG-1814 *Status of the Decommissioning Program: 2004 Annual Report*, January 2005.

1973, by consolidating components of the various radiation monitoring networks developed to that point, including the Radiation Alert Network, the Tritium Surveillance System, the Interstate Carrier Drinking Water Network, and the Pasteurized Milk Network. The responsibility for operating ERAMS is now assigned to the Director of the National Air and Radiation Environmental Laboratory, Montgomery, Alabama.

Since its establishment, ERAMS has collected over a half million high quality environmental samples. The current database primarily provides data that have been collected since 1978. Some older "pre-ERAMS" data are included.

ERAMS normally operates in a "routine" mode, sampling radiation in all media on a regularly defined schedule. The ERAMS operates in an "emergency" (or alert) mode in a threat of a significant radiation release, accelerating the frequency of sampling and generating many more data records for a given period of time compared to the ERAMS routine mode. This was done in 1979 following the Three Mile Island-2 nuclear reactor accident, in 1986 following the Chernobyl nuclear reactor accident, in 1999 following the Tokaimura nuclear fuel processing facility criticality accident in Japan, in 2000 following wildfires at Los Alamos National Laboratory and Hanford Reservation, and in 2001 following the terrorist attacks in the U.S.

The air monitoring portion of the ERAMS system is currently being upgraded and expanded to better serve emergency response scenarios. This expansion responds to the recent emphasis on homeland security since, in the early stages of a radiological incident, air is the most likely exposure pathway. As part of the network's redesign, it has also been renamed as RadNet.

By adding new air monitoring stations across the country with the enhanced capability to detect and rapidly report environmental levels of radiation, EPA will provide public officials information to help them determine if and where additional assessments may be needed. EPA has developed a strategy to place the new fixed station monitors in locations that will ensure improved national coverage from both a population and geographic standpoint. The monitors will continue to be operated by volunteers.

The expanded RadNet system will provide information to help evaluate the degree and extent of contamination caused by an accidental release or a terrorist incident.   The upgrades will include:

- Air monitors that automatically transmit near-real-time data;
- The additional placement of monitors to improve national coverage;
  and
- Air monitors that can be deployed in the event of an accident or terrorist event involving radioactive materials.

I. TRANSBOUNDARY MOVEMENT

I.1 Overview of U.S. Legal and Policy Framework Governing the Transboundary Movement of Radioactive Waste and Spent Fuel

The Atomic Energy Act of 1954, as amended, assigns regulatory and oversight responsibility for imports and exports of source, special nuclear and byproduct materials to and from the United States to NRC.[83] NRC's regulations in 1995, governing such imports/exports are set forth in 10 CFR Part 110 (Part 110). NRC amended these regulations in 1955, to conform to the guidelines of the IAEA Code of Practice on the International Transboundary Movement of Radioactive Waste. They remain in force and are consistent with the guidelines of the Joint Convention. NRC amended Part 110 in 2005, to make the regulations consistent with the current version of the IAEA Code of Conduct on the Safety and Security of Radioactive Sources, as well as the Guidance on the Import and Export of Radioactive Sources, approved by the IAEA Board of Governors and endorsed by the General Conference in September 2004. These amendments, which become effective January 1, 2006, establish specific licensing requirements for U.S. imports and exports of all Category 1 and 2 radioactive sources.

I.1.1 Regulatory Issues and Considerations

The U.S. began considering options to establish better domestic controls for exports and imports of radioactive wastes in the mid-to-late 1980s. There was some concern about the potential impacts of unnecessarily restricting transfers of radioactive materials which otherwise were not considered significant for nuclear weapons proliferation or as potentially endangering public health and safety if improperly handled. The process to develop and finalize U.S. regulations for the export and import of radioactive waste involved extensive review, consultation and revision.

The U.S. developed the rationale for and clearly defined what additional exports and imports of nuclear materials should be controlled as radioactive waste to effectively protect public health and safety without unnecessarily curtailing international trade. It was understood a certain amount of flexibility was needed to preserve and facilitate continuation of useful practices. The most difficult part of establishing new regulations governing the U.S. export and import of radioactive wastes was developing appropriate definitions to distinguish what additional materials needed to be controlled from those not needing special controls. The NRC approach was to establish two new categories of materials: radioactive waste and incidental radioactive material.

[83] Although not covered in this report, 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.

I.1.2 Radioactive Waste

A specific license is required under Part 110, to import or export radioactive waste, defined as any waste containing or is contaminated with source, special nuclear and byproduct materials. Such radioactive waste may also contain or be contaminated with hazardous waste.[84] Radioactive waste does not include radioactive material that is:

- Contained in a sealed source, or device containing a sealed source, being returned to any manufacturer qualified to receive and possess the sealed source or the device containing a sealed source;
- A contaminant on service equipment (including service tools) used in nuclear facilities, if the service equipment is being shipped for use in another nuclear facility and not for waste management purposes or disposal; or
- Generated or used in a United States Government waste research and development testing program under international arrangements.

Therefore, a specific NRC license is not required to import or export such material.

Specific NRC licenses will be required beginning January 1, 2006, for all exports and imports of Category 1 and 2 sealed sources including disused sources. Because the Part 110 definition of radioactive waste was not changed, it is unlikely an application for an NRC license to import disused Category 1 or 2 sealed sources would be characterized as involving the import of radioactive waste. Therefore, the application would not be subject to the type of review required to process an application involving such imports. NRC is evaluating the implications of EPACT05 on the import and export of radiation sources.

I.1.3 Incidental Radioactive Material

NRC regulations in 10 CFR Part 110 establish less stringent controls for imports and exports of "incidental radioactive material," which is defined as radioactive material contained in or a contaminant of any non-radioactive material or component not decontaminated before recycling or recovery of the non-radioactive material or component occurs. Export or import of naturally-occurring radioactive material (other than source or byproduct material) under section 11e.(2) of the AEA and accelerator-produced radioactive material lie outside of NRC's regulatory authority and are subject to public health and safety requirements administered by the states and other Federal agencies. EPACT05 implementation will affect NRC's current regulatory responsibilities on import and export of incidental radioactive material.

I.1.4 Spent Fuel

NRC regulations adopted in 1995 did not address spent nuclear fuel since other provisions governing imports and exports of special nuclear and source material already covered it. Most imports of special nuclear and source material are authorized under NRC's general import license provisions to appropriately licensed recipients. A specific NRC license is required however, for imports of irradiated fuel if the shipment exceeds 100 kilograms. This requirement does not apply to DOE, however, because DOE has separate statutory authority to import nuclear material and equipment and is not subject to NRC import licensing.

[84] Defined in Section 1004(5) of the Solid Waste Disposal Act, 42 U.S.C. 6903(5).

I.2 Regulatory Requirements Export or Import Radioactive Waste

The specific provisions of Part 110 regulations governing the export or import of radioactive waste can be found in Annex I-1. A comparison of NRC's regulatory regime with the Radioactive Waste Transboundary Movement provisions of the Joint Convention can be found in Annex I-2. NRC forwards the application to the U.S. Department of State after determining that an applicant seeking a license to import or export radioactive waste has provided the required information. The Department of State is responsible for coordinating review by interested U.S. Federal Government agencies and contacting the foreign government in the nation where the material originated or is destined to either provide notice or obtain consent in accordance with Joint Convention guidelines. The Department of State may also consult with foreign governments of transit countries if necessary to satisfy Joint Convention guidelines.

It must be determined that approving the proposed transaction will not be inimical to the common defense and security of the United States and will not result in unreasonable risks to the public health and safety before an export or import license is issued. A brief description of the process for each is provided below since the reviews for exports and imports involve different considerations.

I.2.1 Exports

The Department of State for proposed exports of radioactive waste, asks the government of the recipient nation if it will accept such an import from the U.S. and requests confirmation the designated consignee is authorized to receive the radioactive waste. (Note the term "nation" is used here instead of "state" to avoid confusion with the "states" making up the U.S.) The State Department will ask the government to provide assurances the material will be maintained in accordance with terms and conditions of the agreement if the material is subject to a peaceful nuclear cooperation agreement between the U.S. and the recipient nation. The U.S. accepts responses and assurances received from the nation of destination as confirmation it has the administrative and technical capacity and regulatory structure to manage and dispose of the waste. NRC regulations do not require specific assessments and findings about the adequacy of the receiving nation's administrative and technical capacity and regulatory structure. NRC does not, however, contemplate any circumstances for where it would issue a license authorizing the export of radioactive waste to a country without a regulated waste disposal program.

Countries 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 under the terms and conditions of U.S. peaceful nuclear cooperation agreements. Requests for U.S. approvals of such retransfers are submitted to and processed by the DOE /National Nuclear Security Administration, which coordinates U.S. interagency review of the proposed transaction. The U.S. is also consulted about the return of materials from reprocessing if a country obtains U.S. approval to transfer spent fuel to a third country for reprocessing.

I.2.2 Imports

The Department of State for proposed imports of radioactive waste, contacts the government of the exporting nation and seeks acknowledgement they are aware of the proposed transaction and any comments they might wish to provide. NRC has exclusive U.S. jurisdiction within the U.S. (the states and U.S. territories) for granting or denying specific licenses to import radioactive waste. NRC, however, does recognize the authority of the host state officials and the relevant LLW compact commission to accept an import of LLW for disposal in the compact region. NRC consults with interested state officials and LLW compact commissions as part of the review of an application for a license to import LLW. NRC will not grant an import license for waste intended for disposal unless it is clear the waste will be accepted by a disposal facility, the host state, and the compact commission (where applicable). These are among the factors considered in determining the appropriateness of the facility agreeing to accept the waste for management or disposal.

I.3 Implementation Experience to Date

NRC received a total of 36 applications for radioactive waste import (22) or export (14) licenses or license amendments since 1995, following the promulgation of specific licensing requirements for imports or exports of radioactive waste, through December 31, 2004. NRC received and processed over 1,000 applications involving proposed exports of the other nuclear materials, (mainly source, special nuclear or byproduct material) and nuclear equipment under its jurisdiction during the same period.

NRC issued a total of 22 licenses or license amendments -- 11 for imports and 11 for exports. As of January 1, 2005, of the 22 licenses or license amendments issued, 7 were active, 9 have been amended, 3 have expired, and 2 are on hold since requests to amend and extend them were received with less than 30 days to their expiration date. One radioactive waste import license was suspended at the request of officials from the Agreement State where the importing facility is located.

Of the remaining 14 applications received for which NRC has not issued licenses or license amendments, 2 were withdrawn, 6 were returned without action, 4 are currently pending, and review of 2 applications has been suspended. Information on radioactive waste import and export license applications received is provided in Annex I-3.

I.4 Megaports Initiative

The U.S. and Spain have begun a joint effort in the war on terrorism by installing special equipment at one of Spain's busiest seaports to detect and stop hidden shipments of nuclear and other radioactive materials. This agreement is part of DOE's National Nuclear Security Administration (NNSA) Megaports Initiative, a program aimed at stopping illicit shipments of nuclear and other radioactive material.

Megaports is the fifth cooperative agreement, and joins efforts currently in place in the Netherlands (Rotterdam), Greece (Piraeus), Sri Lanka, and Belgium. The Megaports Initiative is part of DOE’s "Second Line of Defense" programs, the U.S. Government program designed to work with foreign governments to deter, detect, and interdict illegal shipments of nuclear materials. DOE’s NNSA works with foreign partners under the Megaports Initiative to equip major seaports with radiation detection equipment and to provide training to law enforcement officials. The specialized radiation detection technology deployed under this program is based on technologies originally developed by DOE laboratories as part of overall U.S. Government efforts to guard against weapons proliferation.

J. DISUSED SEALED SOURCES

J.1 General Safety for Sealed Sources

Radiation safety programs for use of byproduct material as a sealed source or device are based on robust containment of radioactive material. Sealed sources or devices are designed to withstand stresses imposed by the environment in which they are possessed and used. Regulations in 10 CFR Parts 30, 31, 32, 34, 35, 36, and 39 provide requirements for both vendors and users of sealed sources and devices. Agreement States issue compatible regulations for the control of sealed sources and devices within their borders.

Current regulations require products used under a specific license issued in accordance with 10 CFR Parts 30-39 be registered with NRC. The specific provisions in 10 CFR 30.32(g) require a license applicant to either make reference to a registered sealed source or device or provide the information necessary to perform a safety evaluation of the sealed source or device. Section 32.210 outlines the NRC safety evaluation and registration criteria and clarifies the regulatory responsibility of registration certificate holders of products for which NRC evaluates and registers radiation safety information. This practice has been used since the 1950s and allows regulatory agencies to ensure designs meet all regulatory requirements, and are expected to maintain their integrity under both normal use and credible accident conditions. This process allows applicants and license reviewers to reference the evaluation when licensing the product for use or distribution without having to perform a complete evaluation of the product for each licensing action. Regulations in 10 CFR Parts 34, 35, 36, and 39, provide additional requirements for specific types of sources and devices. 10 CFR Parts 30, 31, and 32 also allow for use of equipment requiring registration but not requiring a license for use, and for sources and devices requiring neither registration nor licensing if they meet certain requirements.

NRC and the Agreement States perform safety evaluations of the ability of sealed sources and devices to contain radioactivity under the conditions of their possession and use. These evaluations are summarized in registrations maintained by NRC in the National Sealed Source and Device Registry. The Registry is currently unavailable for general public access, however. Information on the regulatory system for sealed sources and devices is available to the public through the NRC website.[85] Agreement States also provide information on their radiation safety evaluations to NRC for the registry. A vendor only needs to provide detailed information about its sealed source or device to a single agency. The results of the radiation safety evaluation are available to NRC during licensing approval to users of the devices throughout the U.S. NRC estimates there are approximately 2,000,000 of these devices in existence.

[85] http://www.nrc.gov/materials/miau/sealed-source.html

The possession, use, packaging, handling, transfer and disposition of radioactive sealed sources are also required to comply with the general occupational and public radiological protection regulations, listed in Table E-2. This includes licensing, financial assurance and record keeping for decommissioning, and expiration and termination of licenses and decommissioning. Annex J-1 identifies additional NRC regulations applicable to sealed sources. Additional measures for high-risk sources are discussed in Section J.2.

J.2 Reentry of Disused Sealed Sources from Abroad

U.S. regulations do not bar the return of disused sealed sources (see Section I.1.2 for more detail). The U.S., recognizing the need to address the threat of radiological terrorism, has led international efforts to strengthen controls over international transfers of radioactive sources and materials, including those sources partially used in a radioactive dispersal device or "dirty bomb." U.S. efforts have yielded significant progress, including the revision of the International Atomic Energy Agency (IAEA) Code of Conduct on the Safety and Security of Radioactive Sources (Code). G-8 Leaders agreed at the Sea Island Summit in June 2004 to import/export controls for radioactive sources. On September 14, 2004, the IAEA Board of Governors approved the import/export guidance for radioactive sources, which had been finalized in July 2004, by an IAEA expert group representing 41 member states. This guidance was endorsed by the IAEA General Conference on September 24, 2004 (see GC(48)/RES/10), and published by the IAEA on March 30, 2005 (IAEA/CODEOC/IMP-EXP/2005).

NRC amended domestic licensing requirements to be consistent with the revised Code and international import/export guidance for imports and exports of Category 1 and 2 radioactive sources and materials. Beginning on January 1, 2006, transfers of these radioactive sources into or out of the U.S. will need to be approved by NRC in a specific import or export license as noted above. The U.S. continues to promote greater harmonization for strengthening controls over international transfers of radioactive sources, and this has been among the key objectives of the G-8 Evian, Sea Island and Glen Eagle Summits.

J.3 Disposition of Sealed Sources

Sealed source retrieval efforts have recently become a priority to reduce the risk from both accidental and intentional dispersal of radioactive materials. Retrieved sources are managed in accordance with the objectives of the Joint Convention found in Article 1. Disused sources are not declared waste until they are accepted for disposal at commercial or governmental facilities. The contribution to total volume disposed is negligible because the volume of disposed disused sealed sources is small in comparison to the larger volumes of commercial and government waste.

The Federal government is responsible for disposal of all GTCC LLW sealed sources. The ultimate disposition path for these materials is not yet determined, but currently DOE provides long term storage of some GTCC sources; see Section J.4.

J.4 U.S. Radiological Threat Reduction Program

Many sealed sources are excess, unwanted, and orphaned in the U.S. industrial, medical, academic, and government sectors. DOE's National Nuclear Security Administration (NNSA) collects these sealed sources from commercial licensees and stores them, pending disposition. Long-lived sealed sources consist mainly of americium neutron sources, other americium-241 sources, plutonium-238 heat sources, plutonium-239 neutron sources, cesium-137 sources, and large strontium-90 sources. Large cesium-137 sources also typically exceed the U.S. regulatory criteria for shallow LLW disposal, but are largely recycled and remanufactured into new sources. The U.S. Government recognizes public health and safety risks are posed by unwanted long-lived sealed sources. Americium-241 is one of the most common isotopes used. Many of these are used in oil and gas well-logging activities. Small firms lacking the physical capability and financial resources to provide safe storage commonly own these neutron sources. This presents a growing problem because while most of these sources are not suitable for disposal in shallow land burial facilities, other appropriate disposal options are not yet available. NNSA is addressing a variety of isotopes presenting a threat for use in radiological dispersal devices, but not having a disposal pathway.

Many heat sources containing plutonium-238 were once used in manufacturing cardiac pacemakers. These pacemakers and plutonium-238 batteries became obsolete in the 1970s with the onset of long-life chemical battery technology. The Radiological Threat Reduction Program's Off-Site Source Recovery Project has recovered approximately 2,000 excess and unwanted pacemakers to date.

The most common use of long-lived sealed sources in the U.S. is in portable and fixed industrial gauges. Approximately 9,000 such sources, chiefly containing americium-241, are found in manufacturing and general commerce. Recovering these sources is particularly important because many are excess and unwanted, and commonly are lost, stolen or inadvertently discarded.

Sealed source handling capacity was greatly expanded beginning in the late 1990s, to accommodate thousands of excess sealed sources from the commercial sector. Neutron sources were initially chemically processed to eliminate neutron generation. This was, later determined unnecessary. Excess and unwanted sealed sources are now simply stored as radioactive waste at government nuclear facilities. This strategy required developing new nuclear material containers specifically for long-lived neutron sources. The first of these is a special-form overpack capsule for individual sources. The second is a multi-function container capable of providing safe storage, transportation, and ultimately disposal.

The special-form capsule has been designed, tested, and certified in several configurations. It is made of thick-walled stainless steel and is used to safely store and ship damaged sealed sources, or sources for other reasons cannot be certified for transportation. These capsules are available for both government and commercial radioactive waste management activities.

The multi-function container evolved from containers used by NNSA for transportation and disposal of TRU waste. This container incorporates neutron shielding and accommodates quantities of neutron sources without special handling requirements. The pipe overpack concept was modified to provide a narrow diameter (15 cm.) inner payload container, within a standard 200-liter (55-gallon) drum. The annular space is filled by neutron shielding material. This multi-function container has been evaluated and approved by the government's TRU waste certification program, and is now acceptable for field recovery, transportation, long-term storage, and eventual disposal in a government waste repository.

The Off-Site Source Recovery Project became part of a new NNSA Nuclear and Radiological Threat Reduction Task Force in November 2003, where its scope and mission were realigned to reflect the security threats posed by radiological sources within the United States and to accelerate and expand sealed source recovery efforts.[86] This became the domestic portion of the new Global Threat Reduction Initiative in May 2004. The initiative is very successful. NNSA responded to an emergency request from NRC to recover nearly 500 sources from a bankrupt licensee in Pennsylvania in 2004. Sealed source recovery operations were fully operational for six isotopes, including strontium-90, and recoveries began for two isotopes, cesium-137 and cobalt-60 by the end of March 2005. More than 10,500 sealed sources were recovered before the end of March, 2005.

Sealed source recovery expanded to include plutonium-239 sources when new storage space was made available in 2003. More than 340 plutonium-239 sources were recovered as of March 2005. These sources were loaned and remain the property of DOE. Recovery operations will continue until all these sources are returned when no longer used. Plutonium-239 sources, addressed by the U.S. Radiological Threat Reduction Program, are eligible for disposal as TRU waste at the Waste Isolation Pilot Plant in New Mexico.

Four large strontium-90 sources, totaling over 2,200 TBq. (60,000 curies) in the form of radioisotope thermoelectric generators, were recovered in February 2004 in Texas. The capability to recover and recycle cesium-137 sealed sources was demonstrated when two large cesium-137 sources were removed from high schools in New York and New Jersey and recycled by private industry in August 2004. Plans call for continuing to use this approach, and implementing new storage capacity for recovered cesium-137 sources, when recycling or disposal is not possible. Some cesium-137 and cobalt-60 sources meet disposal acceptance criteria at commercial low-level radioactive waste disposal facilities. Recovered sealed sources not meeting the waste acceptance requirements for existing disposal facilities (the Waste Isolation Pilot Plant or low-level waste disposal facilities), are stored pending a future disposition path for greater-than-Class C low-level waste. Studies are underway to evaluate disposition of such waste.

[86] See Section B.2.1 for information on foreign research reactor spent fuel acceptance program also managed by DOE.

K. PLANNED ACTIVITIES TO IMPROVE SAFETY

This report has described many existing and ongoing U.S. activities ensuring the safe management of spent fuel and radioactive waste. The U.S. is already in compliance with the conditions set forth in the Joint Convention. There are, however, several key areas important to safety continuing to receive much attention.

K.1 Spent Fuel and High-Level Waste Storage and Disposal

Developing disposal capability for spent fuel and high-level waste remains a key activity for long-term safety of spent fuel and HLW management. This is manifest in DOE site characterization and licensing efforts for a repository at Yucca Mountain.

DOE is preparing a license application for submission to NRC to receive authorization to begin construction of a repository at Yucca Mountain. NRC will review this license application pursuant to 10 CFR Part 63. The license application review by NRC is expected to take about three to four years. DOE will then begin construction of the repository and then apply to NRC for a license amendment to allow receipt and possession of waste (given adequate funding by the U.S. Congress and successful completion of the licensing process). Spent fuel shipments could then begin arriving at the repository.

NRC continues to authorize licensees to store spent fuel in dry casks using NRC approved dry cask designs. Even when a geological repository becomes available, using ISFSIs for interim storage of spent fuel in the U.S will continue.

K.2 Commercial Low-Level Waste Disposal

The commercial low-level waste management system in the U.S. provides adequate disposal capacity to waste generators. There remains uncertainty in the availability of disposal for Class B and C LLW after 2008, when the Atlantic Compact (South Carolina, New Jersey and Connecticut) plans to limit access to the Barnwell, South Carolina, site to generators outside the compact. Efforts by regional compacts to site new disposal facilities have been unsuccessful. The State of Texas received an application from Waste Control Specialists in 2004 for a new LLW disposal facility, near Andrews, Texas, for the Texas Compact (Texas and Vermont). Review of the application for this facility is continuing with the issuance of a license or denial projected for December 2007. Plans call for disposal of Class A, B, and C LLW in one cell, and possible disposal of DOE LLW in another cell. The U.S. Congress and government agencies continue to monitor the availability of commercial LLW disposal facilities to meet future needs, although opposition to new disposal sites for LLW waste makes it difficult to site new facilities.

K.3 Disused Sealed Sources and Greater Than Class C LLW Disposal

The U.S. Government has an aggressive program to collect thousands of disused sealed sources from the commercial sector for safe storage and eventual disposal as described in Section J. This activity decreases the likelihood for accidents or misuse of this material across the nation. Many of these sources fall into the GTCC LLW classification (see Table B-1). GTCC LLW is being stored, e.g., at nuclear power plants and other facilities until an adequate disposition policy is determined. GTCC LLW must be disposed of in an NRC-licensed facility under Federal law (LLRWPAA). The U.S. Government is analyzing the environmental impacts of various options for GTCC disposal.

NRC is proposing regulatory changes strengthening domestic licensing requirements for the import and export of high-risk radioactive sources and materials. These revisions to 10 CFR Part 110 will bring U.S. import/export controls in line with the revised IAEA Code of Conduct on the Safety and Security of Radioactive Sources and international import/export guidance.

New requirements in EPACT05 related to management and disposal of disused sealed sources and GTCC LLW are being evaluated by the appropriate Federal agencies.

K.4 Cleanup of the Former Nuclear Weapons Complex

The U.S. Government is spending billions of dollars per year on DOE activities to clean-up government sites and facilities throughout the nation. DOE is making progress at sites like the Rocky Flats Environmental Technology Site, Colorado, expected to be complete in 2006 and converted to a wildlife refuge. The Waste Isolation Pilot Plant, an operating geologic repository, continues to dispose of transuranic waste at record levels. Most of this waste was in storage for decades. The Waste Treatment Plant project for HLW at the Hanford site is one of the largest construction projects now underway in the U.S. It is designed to process and package waste now in storage tanks for disposal.

Other Federal agencies and the private sector are similarly cleaning up sites and facilities, as described in Section D.3. The U.S. will continue to reduce risks, increase safety and eliminate the liability from past practices by the commitment to cleanup of the remaining contaminated facilities and sites across the nation.

K.5 Accelerated Return of Weapons-Usable Uranium from Other Countries to the United States and Russia

The United States in partnership with the IAEA, Russian Federation, and other nations established the Global Threat Reduction Initiative (GTRI) in May 2004 to remove and/or secure high-risk nuclear and radiological materials and equipment around the world posing a threat to the United States and to the international community. This initiative under the strategy a more secure world is a safer world is designed to comprehensively address all vulnerable nuclear and radiological materials and secure and/or remove these materials and equipment as quickly as possible.

DOE's NNSA, with the cooperation of other agencies such as the Department of State and NRC, has established both domestic and foreign programs to implement GTRI. Some of the activities include nuclear materials removal efforts and development of a comprehensive inventory of research reactors and vulnerable nuclear materials worldwide to rapidly identify and address any gaps in current security coverage and recovery or removal efforts. Material and source recovery activities are organized within several programs:

- Russian Research Reactor Fuel Return Program to eliminate stockpiles of Russian-origin HEU by assisting eligible countries to convert their research reactors from HEU to low-enriched uranium (LEU) fuel upon availability and qualification;
- Reduced Enrichment for Research and Test Reactors Program to target research reactors and medical isotope production processes worldwide for conversion to suitable LEU fuels and targets;
- Foreign Research Reactor Spent Nuclear Fuel Acceptance Program to eliminate stockpiles of U.S.-origin spent nuclear fuel from foreign research reactors through repatriation to the United States; and
- Radiological Threat Reduction Program to identify, recover, and store, on an interim-basis, certain domestic radioactive sealed sources as well as other radiological materials that pose a security risk to the United States and/or world community, and to reduce the international threat posed by radiological materials that could be used in a radiological dispersal device or 'dirty bomb.'

The GTRI is establishing a comprehensive global database to identify and prioritize nuclear materials and equipment of proliferation concern not being addressed by existing threat reduction efforts. Global Materials Recovery Team was established to pre-position equipment and designate personnel for urgent nuclear materials recovery operations to better address removal efforts. The initiative combines radioactive source security and recovery efforts with nuclear materials security and removal efforts to maximize synergies among programs. The Offsite Source Recovery Program (Section J.4) provides source security and recovery efforts within the U.S.

The Secretary of Energy soon after the establishment of GTRI announced a change in policy extending the deadlines for Foreign Research Reactor spent fuel of U.S. origin from 2009 until 2019. The ten year extension in the irradiation deadline, now 2016, and acceptance deadline, now 2019, provide additional time for research reactors to convert from HEU to LEU fuel. Some nations have experienced technical difficulties in conversion of research reactors to LEU and the extension avoids impact to their ongoing research programs while solutions are found. The policy change responded to questions raised during the first Joint Convention review meeting in November 2003. Eliminating the use of HEU in civil applications and securing, returning, or recovering the nuclear material is an important part. The Acceptance Program had completed 31 shipments of U.S.-origin SF from foreign research reactors in 27 countries since inception of the return policy in May 1996 through December 2004. The Savannah River and Idaho sites have received 25 and 6 shipments, respectively. Eleven of 34 possible countries have returned all of their U.S.-origin HEU to the U.S., while 23 countries still possess U.S.-origin HEU fuel.

The Russian Research Reactor Fuel Return Program is facilitating the return of HEU to Russia, whereby operators of foreign research reactors with Russian-origin HEU fuel agree to shut down or convert their reactors to LEU. This Program has identified research reactors in 17 countries (mostly in the former Soviet Union and Eastern Europe) having Russian-origin fuel. The U.S. Government through DOE/NNSA is supporting transporting and disposing of HEU fuel in Russia from these research reactors. An estimated 4,000 kilograms of Russian-origin research reactor fuel resides in the 17 countries. The U.S., by 2004, provided assistance to return about 105 kilograms of fresh (unused) HEU fuel from 6 countries (Czech Republic, Bulgaria, Libya, Romania, Serbia, and Uzbekistan) for storage at two nuclear facilities in Russia—Dmitrovgrad and Novosibirsk. The U.S. also plans to pay Russia to "blend down" the HEU returned to Dmitrovgrad to LEU.

ANNEXES

Annex D-1. Spent Fuel Management Facilities

State	Installation	Facility	Function	Licensee	Regulator	SF Source [87]	Inventory	Estimated Activity (Bq)
Government Facilities (Inventory as of December 2003, per INL NSNFP database version 5.0.1)								
California	General Atomic	Hot Cell Facility	Dry Storage	DOE	DOE	1	0.005 MTHM	2.43E+14
Colorado	U.S. Geological Survey (Denver)	Research/Test Reactor	Wet Storage	U.S. Geological Survey	NRC		41.47 kgU	
Idaho	Idaho National Lab	CPP-666	Wet Storage	DOE	DOE	1	21.76 MTHM	
		Multiple INL facilities	Dry Storage	DOE	DOE/NRC	1	268.69 MTHM	1.52E+18
Illinois	Argonne National Lab - East	ANL-E SF Storage	Dry Storage	DOE	DOE	1	114.62 kgU	3.22E+15
Maryland	National Institute of Standards and Technology (Gaithersburg)	Research/Test Reactor	Wet Storage	National Institute of Standards and Technology	NRC		4.89 kgU	
	Armed Forces Radiobiology Research Institute (Bethesda)	Research/Test Reactor	Wet Storage	Armed Forces Radiobiology Research Institute	NRC		18.27 kgU	
Nevada	Yucca Mountain Site	Planned Geologic Repository	SF and HLW Disposal	DOE	NRC	1,2	0	0
New Mexico	Sandia National Lab – NM	Tech Area 5 Kirkland AFB - Manzano Storage Facility	Dry Storage	DOE	DOE	1	0.29 MTHM	9.73E+15
New York	Brookhaven National Lab	Research/Test Reactor		DOE	NRC		5.12 kgU	
Rhode Island	Rhode Island Atomic Energy Commission (Narragansett)	Research/Test Reactor	Wet Storage	Rhode Island Atomic Energy Commission	NRC		24.71 kgU	
South Carolina	Savannah River Site	L-Basin	Wet Storage	DOE	DOE	1,2	27.67 MTHM	6.54E+17
		K-Reactor	Dry Storage	DOE	DOE	1,2	0.5 MTHM	
Tennessee	Oak Ridge Reservation	Oak Ridge Reservation	Dry Storage	DOE	DOE	1	0.92 MTHM	2.15E+16
Washington	Hanford Site	Multiple Hanford facilities	Dry Storage	DOE	DOE	1	2128.95 MTHM	6.33E+18
University Research Facilities (Inventory as of Dec 2003, per INL NSNFP database version 5.0.1)								
Arizona	University of Arizona (Tucson)	Research Reactor	Wet Storage	University of Arizona	NRC	2	18.27 kgU	

[87] **SF Sources:** 1-Defense applications; 2-Commercial NPPs and Test/Research Reactors

Annex D-1. Spent Fuel Management Facilities								
State	**Installation**	**Facility**	**Function**	**Licensee**	**Regulator**	**SF Source** [87]	**Inventory**	**Estimated Activity (Bq)**
California	University of California (Irvine)	Research Reactor	Wet Storage	University of California	NRC	2	21.42 kgU	
	University of California (Davis)[88]	Research Reactor	Wet Storage	University of California	NRC	2	72.31 kgU	
Florida	University of Florida (Gainesville)	Research Reactor	Wet Storage	University of Florida	NRC	2	5.00 kgU	
Idaho	Idaho State University (Pocatello)	Research Reactor	Wet Storage	Idaho State University	NRC	2	0	
Illinois	University of Illinois (Urbana)	Research Reactor (2)	Wet Storage	University of Illinois	NRC	2	37.42 kgU	
Indiana	Purdue University (West Lafayette)	Research Reactor	Wet Storage	Purdue University	NRC	2	2.22 kgU	
Kansas	Kansas State University (Manhattan)	Research Reactor	Wet Storage	Kansas State University	NRC	2	21.08 kgU	
Maryland	University of Maryland (College Park)	Research Reactor	Wet Storage	University of Maryland	NRC	2	16.35 kgU	
Massachusetts	University of Lowell (Lowell)	Research Reactor	Wet Storage	University of Lowell	NRC	2	14.63 kgU	
	Massachusetts Institute of Technology (Cambridge)	Research Reactor	Wet Storage	Massachusetts Institute of Technology	NRC	2	27.86 kgU	
	Worcester Polytechnic Institute (Worcester)	Research Reactor	Wet Storage	Worcester Polytechnic Institute	NRC	2	22.75 kgU	
Missouri	University of Missouri (Columbia)	Research Reactor	Wet Storage	University of Missouri	NRC	2	35.44 kgU	
	University of Missouri (Rolla)	Research Reactor	Wet Storage	University of Missouri	NRC	2	26.46 kgU	
New Mexico	University of New Mexico (Albuquerque)	Research Reactor	Wet Storage	University of New Mexico	NRC	2	0	
New York	State University of New York (Buffalo)	Research Reactor	Wet Storage	State University of New York	NRC	2	498.2 kgU	
	Rensselaer Polytechnic Institute (Troy)	Research Reactor	Wet Storage	Rensselaer Polytechnic Institute	NRC	2	0	
North Carolina	North Carolina state University (Raleigh)	Research Reactor	Wet Storage	North Carolina state University	NRC	2	315.4 kgU	

[88] Formerly McClellan AFB (Sacramento)

Annex D-1. Spent Fuel Management Facilities

State	Installation	Facility	Function	Licensee	Regulator	SF Source 87	Inventory	Estimated Activity (Bq)
Ohio	Ohio State University (Columbus)	Research Reactor	Wet Storage	Ohio State University	NRC	2	26.15 kgU	
Oregon	Oregon State University (Corvallis)	Research Reactor	Wet Storage	Oregon State University	NRC	2	17.42 kgU	
	Reed College (Portland)	Research Reactor	Wet Storage	Reed College	NRC	2	12.59 kgU	
Pennsylvania	Pennsylvania Statue University (University Park)	Research Reactor	Wet Storage	Pennsylvania Statue University	NRC	2	37.57 kgU	
Texas	Texas A&M University (College Station)	Research Reactor (2)	Wet Storage	Texas A&M University	NRC	2	29.48 kgU	
	University of Texas (Austin)	Research Reactor	Wet Storage	University of Texas	NRC	2	30.24 kgU	
Utah	University of Utah (Salt Lake City)	Research Reactor	Wet Storage	University of Utah	NRC	2	26.82 kgU	
Washington	Washington State University (Pullman)	Research Reactor	Wet Storage	Washington State University	NRC	2	36.72 kgU	
Wisconsin	University of Wisconsin (Madison)	Research Reactor	Wet Storage	University of Wisconsin	NRC	2	39.29 kgU	
Commercial Facilities (Inventory as of December 31, 2002, per DOE/EIA RW-859 data)								
Alabama	Browns Ferry 1&2	Nuclear Power Plant Pool	Wet Storage	Tennessee Valley Authority	NRC	2	836.5 MTU	
	Browns Ferry 3	Nuclear Power Plant Pool	Wet Storage				393.7 MTU	
	Farley 1	Nuclear Power Plant Pool	Wet Storage	Southern Nuclear Operating Company	NRC	2	473.6 MTU	
	Farley 2	Nuclear Power Plant Pool	Wet Storage				430.1 MTU	
Arkansas	Arkansas Nuclear One	ISFSI	Dry Storage	Entergy Nuclear South	NRC	2	241.4 MTU	
	Arkansas Nuclear 1	Nuclear Power Plant Pool	Wet Storage				360.5 MTU	
	Arkansas Nuclear 2	Nuclear Power Plant Pool	Wet Storage				306.7 MTU	
Arizona	Palo Verde	ISFSI	Dry Storage	Arizona Public Service Company	NRC	2	0	
	Palo Verde 1	Nuclear Power Plant Pool	Wet Storage				399.5 MTU	
	Palo Verde 2	Nuclear Power Plant Pool	Wet Storage				399.3 MTU	
	Palo Verde 3	Nuclear Power Plant Pool	Wet Storage				359.0 MTU	
California	Aerotest Research (San Ramon)	Research/Test Reactor	Wet Storage	Aerotest Research	NRC		17.43 kgU	
	Diablo Canyon	ISFSI	Dry Storage	Pacific Gas & Electric Company	NRC	2	0	
	Diablo Canyon 1	Nuclear Power Plant Pool	Wet Storage				397.2 MTU	

Annex D-1. Spent Fuel Management Facilities

State	Installation	Facility	Function	Licensee	Regulator	SF Source 87	Inventory	Estimated Activity (Bq)
	Diablo Canyon 2	Nuclear Power Plant Pool	Wet Storage				363.6 MTU	
	General Atomics (San Diego)	Research/Test Reactor (2)	Wet Storage	General Atomics	NRC		56.68 kgU	
	General Electric (Pleasanton)	Research/Test Reactor	Wet Storage	General Electric	NRC		3.86 kgU	
	Humboldt Bay	Nuclear Power Plant Pool	Wet Storage	Pacific Gas & Electric Company	NRC	2	28.9 MTU	
	Rancho Seco	ISFSI	Dry Storage	Sacramento Municipal Utility District	NRC	2	228.4 MTU	
	Rancho Seco	Nuclear Power Plant Pool	Wet Storage				0	
	San Onofre	ISFSI	Dry Storage	Southern California Edison	NRC	2	0	
	San Onofre 1	Nuclear Power Plant Pool	Wet Storage				76.6 MTU	
	San Onofre 2	Nuclear Power Plant Pool	Wet Storage				480.8 MTU	
	San Onofre 3	Nuclear Power Plant Pool	Wet Storage				455.9 MTU	
Colorado	Fort St. Vrain	ISFSI (Storage Well)	Dry Storage	DOE	NRC	2	14.7 MTU	1.07E+17
Connecticut	Haddam Neck	ISFSI	Dry Storage	Connecticut Yankee Atomic Power Company	NRC	2	0	
	Haddam Neck	Nuclear Power Plant Pool	Wet Storage				412.3 MTU	
	Millstone	ISFSI	Dry Storage	Dominion Resources	NRC	2	0	
	Millstone 1	Nuclear Power Plant Pool	Wet Storage				525.6 MTU	
	Millstone 2	Nuclear Power Plant Pool	Wet Storage				401.4 MTU	
	Millstone 3	Nuclear Power Plant Pool	Wet Storage				300.8 MTU	
Florida	Crystal River 3	Nuclear Power Plant Pool	Wet Storage	Florida Power & Light Company	NRC	2	382.3 MTU	
	St. Lucie 1	Nuclear Power Plant Pool	Wet Storage	Florida Power & Light Company	NRC	2	524.4 MTU	
	St. Lucie 2	Nuclear Power Plant Pool	Wet Storage				346.3 MTU	
	Turkey Point 3	Nuclear Power Plant Pool	Wet Storage	Florida Power & Light Company	NRC	2	422.6 MTU	
	Turkey Point 4	Nuclear Power Plant Pool	Wet Storage				429.1 MTU	
Georgia	Hatch	ISFSI	Dry Storage	Southern Nuclear Operating Company	NRC	2	151.2 MTU	
	Hatch 1 & 2	Nuclear Power Plant Pool	Wet Storage				909.3 MTU	
	Vogtle 1 & 2	Nuclear Power Plant Pool	Wet Storage	Southern Nuclear Operating Company	NRC	2	720.8 MTU	
Idaho	Idaho National Lab	ISFSI (TMI-2)	Dry Storage	DOE	NRC	2	81.6 MTU	

Annex D-1. Spent Fuel Management Facilities

State	Installation	Facility	Function	Licensee	Regulator	SF Source [87]	Inventory	Estimated Activity (Bq)
	Privatized ISF at INL (Under Construction)	ISFSI	Dry Storage	Foster Wheeler Environmental Corporation	NRC		0	
Illinois	Braidwood 1&2	Nuclear Power Plant Pool	Wet Storage	Exelon Generation Company	NRC	2	628.7 MTU	
	Byron 1&2	Nuclear Power Plant Pool	Wet Storage	Exelon Generation Company	NRC	2	756.4 MTU	
	Clinton 1	Nuclear Power Plant Pool	Wet Storage	Exelon Generation Company	NRC	2	288.8 MTU	
	Dresden	ISFSI	Dry Storage	Exelon Generation Company	NRC	2	146.9 MTU	
	Dresden 1	Nuclear Power Plant Pool	Wet Storage				0	
	Dresden 2	Nuclear Power Plant Pool	Wet Storage				527.0 MTU	
	Dresden 3	Nuclear Power Plant Pool	Wet Storage				482.2 MTU	
	GE Morris	ISFSI	Wet Storage	General Electric Co.	NRC	2	674.3 MTU	
	LaSalle County 1&2	Nuclear Power Plant Pool	Wet Storage	Exelon Generation Company	NRC	2	744.5 MTU	
	Quad Cities 1&2	Nuclear Power Plant Pool	Wet Storage	Exelon Generation Company	NRC	2	1106.5 MTU	
	Zion 1&2	Nuclear Power Plant Pool	Wet Storage	Exelon Generation Company	NRC	2	1019.4 MTU	
Iowa	Duane Arnold	ISFSI	Dry Storage	Nuclear Management Company	NRC	2	0	
	Duane Arnold	Nuclear Power Plant Pool	Wet Storage				347.9 MTU	
Kansas	Wolf Creek 1	Nuclear Power Plant Pool	Wet Storage	Wolf Creek Nuclear Operating Corporation	NRC	2	427.3 MTU	
Louisiana	River Bend 1	Nuclear Power Plant Pool	Wet Storage	Entergy Nuclear South	NRC	2	383.9 MTU	
	Waterford 3	Nuclear Power Plant Pool	Wet Storage	Entergy Nuclear South	NRC	2	396.3 MTU	
Maine	Maine Yankee	ISFSI	Dry Storage	Maine Yankee Atomic Power Company	NRC	2	99.3 MTU	
	Maine Yankee	Nuclear Power Plant Pool	Wet Storage				443.0 MTU	
Maryland	Calvert Cliffs	ISFSI	Dry Storage	Constellation Energy Group	NRC	2	368.1 MTU	
	Calvert Cliffs 1&2	Nuclear Power Plant Pool	Wet Storage				518.0 MTU	
Massachusetts	Pilgrim 1	Nuclear Power Plant Pool	Wet Storage	Entergy Nuclear Northeast	NRC	2	413.9 MTU	

Annex D-1. Spent Fuel Management Facilities

State	Installation	Facility	Function	Licensee	Regulator	SF Source[87]	Inventory	Estimated Activity (Bq)
	Yankee Rowe	ISFSI	Dry Storage	Yankee Atomic Electric Company	NRC	2	84.7 MTU	
	Yankee Rowe	Nuclear Power Plant Pool	Wet Storage				42.4 MTU	
Michigan	Big Rock Point	ISFSI	Dry Storage	Consumers Power Company	NRC	2	57.9 MTU	
	Big Rock Point	Nuclear Power Plant Pool	Wet Storage				0	
	Cook 1&2	Nuclear Power Plant Pool	Wet Storage	Indiana/Michigan Power company	NRC	2	969.0 MTU	
	Dow Chemical Company (Midland)	Research/Test Reactor	Wet Storage	Dow Chemical Company	NRC		14.81 kgU	
	Enrico Fermi 2	Nuclear Power Plant Pool	Wet Storage	Detroit Edison Company	NRC	2	304.6 MTU	
	Palisades	ISFSI	Dry Storage	Nuclear Management Company	NRC	2	172.4 MTU	
	Palisades	Nuclear Power Plant Pool	Wet Storage				260.7 MTU	
Minnesota	Monticello	Nuclear Power Plant Pool	Wet Storage	Nuclear Management Company	NRC	2	236.1 MTU	
	Prairie Island	ISFSI	Dry Storage	Northern States Power	NRC	2	262.3 MTU	
	Prairie Island 1&2	Nuclear Power Plant Pool	Wet Storage				410.3 MTU	
Mississippi	Grand Gulf 1	Nuclear Power Plant Pool	Wet Storage	Entergy Nuclear South	NRC	2	560.2 MTU	
Missouri	Callaway 1	Nuclear Power Plant Pool	Wet Storage	Ameren	NRC	2	479.0 MTU	
Nebraska	Cooper Station	Nuclear Power Plant Pool	Wet Storage	Nebraska Public Power District	NRC	2	278.6 MTU	
	Fort Calhoun	Nuclear Power Plant Pool	Wet Storage	Omaha Public Power District	NRC	2	304.9 MTU	
New Hampshire	Seabrook 1	Nuclear Power Plant Pool	Wet Storage	Florida Power & Light Company	NRC	2	287.2 MTU	
New Jersey	Hope Creek 1	Nuclear Power Plant Pool	Wet Storage	Public Service Electric & Gas Company	NRC	2	431.5 MTU	
	Oyster Creek	ISFSI	Dry Storage	Exelon Generation Company	NRC	2	47.6 MTU	
	Oyster Creek	Nuclear Power Plant Pool	Wet Storage				455.9 MTU	
	Salem 1	Nuclear Power Plant Pool	Wet Storage	Public Service Electric & Gas Company	NRC	2	457.8 MTU	
	Salem 2	Nuclear Power Plant Pool	Wet Storage				374.8 MTU	
New York	Fitzpatrick	ISFSI	Dry Storage	Entergy Nuclear Northeast	NRC	2	37.2 MTU	
	Fitzpatrick	Nuclear Power Plant Pool	Wet Storage				446.5 MTU	

Annex D-1. Spent Fuel Management Facilities

State	Installation	Facility	Function	Licensee	Regulator	SF Source [87]	Inventory	Estimated Activity (Bq)
	Ginna	Nuclear Power Plant Pool	Wet Storage	Constellation Energy Group	NRC	2	357.4 MTU	
	Indian Point 1	Nuclear Power Plant Pool	Wet Storage	Energy Nuclear Northeast	NRC	2	30.6 MTU	
	Indian Point 2	Nuclear Power Plant Pool	Wet Storage				491.2 MTU	
	Indian Point 3	Nuclear Power Plant Pool	Wet Storage				381.9 MTU	
	Nine Mile Point 1	Nuclear Power Plant Pool	Wet Storage	Constellation Energy Group	NRC	2	458.4 MTU	
	Nine Mile Point 2	Nuclear Power Plant Pool	Wet Storage				343.2 MTU	
North Carolina	Brunswick 1	Nuclear Power Plant Pool	Wet Storage	Progress Energy	NRC	2	243.8 MTU *	
	Brunswick 2	Nuclear Power Plant Pool	Wet Storage				233.5 MTU *	
	Harris 1	Nuclear Power Plant Pool	Wet Storage	Progress Energy	NRC	2	964.5 MTU *	
	McGuire	ISFSI	Dry Storage	Duke Power Company	NRC	2	68.6 MTU	
	McGuire 1	Nuclear Power Plant Pool	Wet Storage				493.2 MTU *	
	McGuire 2	Nuclear Power Plant Pool	Wet Storage				507.9 MTU *	
Ohio	Davis-Besse	ISFSI	Dry Storage	First Energy Nuclear Operating Company	NRC	2	33.9 MTU	
	Davis-Besse 1	Nuclear Power Plant Pool	Wet Storage				351.2 MTU	
	Perry 1	Nuclear Power Plant Pool	Wet Storage	First Energy Nuclear Operating Company	NRC	2	378.4 MTU	
Oregon	Trojan	ISFSI	Dry Storage	Portland General Electric	NRC	2	0	
	Trojan	Nuclear Power Plant Pool	Wet Storage				358.9 MTU	
Pennsylvania	Beaver Valley 1	Nuclear Power Plant Pool	Wet Storage	First Energy Nuclear Operating Company	NRC	2	404.7 MTU	
	Beaver Valley 2	Nuclear Power Plant Pool	Wet Storage				268.2 MTU	
	Limerick 1&2	Nuclear Power Plant Pool	Wet Storage	Exelon Generation Company	NRC	2	824.0 MTU	
	Peach Bottom	ISFSI	Dry Storage	Exelon Generation Company	NRC	2	190.2 MTU	
	Peach Bottom 2	Nuclear Power Plant Pool	Wet Storage				520.0 MTU	
	Peach Bottom 3	Nuclear Power Plant Pool	Wet Storage				542.7 MTU	
	Susquehanna	ISFSI	Dry Storage	Pennsylvania Power & Light	NRC	2	238.5 MTU	
	Susquehanna 1&2	Nuclear Power Plant Pool	Wet Storage				738.4 MTU	
	Three Mile Island 1	Nuclear Power Plant Pool	Wet Storage	Exelon Generation Company	NRC	2	416.5 MTU	
South Carolina	Catawba 1	Nuclear Power Plant Pool	Wet Storage	Duke Power Company	NRC	2	416.3 MTU	
	Catawba 2	Nuclear Power Plant Pool	Wet Storage				366.2 MTU	

Annex D-1. Spent Fuel Management Facilities

State	Installation	Facility	Function	Licensee	Regulator	SF Source [87]	Inventory	Estimated Activity (Bq)
	Oconee	ISFSI	Dry Storage	Duke Power Company	NRC	2	800.4 MTU	
	Oconee 1&2	Nuclear Power Plant Pool	Wet Storage				437.3 MTU *	
	Oconee 3	Nuclear Power Plant Pool	Wet Storage				228.4 MTU *	
	Robinson	ISFSI	Dry Storage	Progress Energy - Carolina	NRC	2	24.1 MTU	
	Robinson 2	Nuclear Power Plant Pool	Wet Storage				147.9 MTU *	
	Summer	Nuclear Power Plant Pool	Wet Storage	South Carolina Electric & Gas Company	NRC	2	353.9 MTU	
Tennessee	Sequoyah	ISFSI	Dry Storage	Tennessee Valley Authority	NRC	2	0	
	Sequoyah 1&2	Nuclear Power Plant Pool	Wet Storage				782.6 MTU	
	Watts Bar 1	Nuclear Power Plant Pool	Wet Storage	Tennessee Valley Authority	NRC	2	136.6 MTU	
Texas	Comanche Peak 1&2	Nuclear Power Plant Pool	Wet Storage	Texas Utilities Electric Company	NRC	2	540.7 MTU	
	South Texas 1	Nuclear Power Plant Pool	Wet Storage	STP Nuclear Operating Company	NRC	2	339.2 MTU	
	South Texas 2	Nuclear Power Plant Pool	Wet Storage				338.6 MTU	
Vermont	Vermont Yankee	Nuclear Power Plant Pool	Wet Storage	Energy Nuclear Northeast	NRC	2	488.4 MTU	
Virginia	BWX Technology, Inc.	Fuel Facility	Dry storage	BWX Technology, Inc.	NRC		43.5 kgU	
	North Anna	ISFSI	Dry Storage	Dominion Virginia Power	NRC	2	220.8 MTU	
	North Anna 1&2	Nuclear Power Plant Pool	Wet Storage				652.7 MTU	
	Surry	ISFSI	Dry Storage	Dominion Virginia Power	NRC	2	524.2 MTU	
	Surry 1&2	Nuclear Power Plant Pool	Wet Storage				365.4 MTU	
Washington	Columbia Gen. Station	ISFSI	Dry Storage	Energy Northwest	NRC	2	61.0 MTU	
	Columbia	Nuclear Power Plant Pool	Wet Storage				333.7 MTU	
Wisconsin	Kewaunee	Nuclear Power Plant Pool	Wet Storage	Nuclear Management Company	NRC	2	347.6 MTU	
	LaCrosse	Nuclear Power Plant Pool	Wet Storage	Dairyland Power Cooperative	NRC	2	38.0 MTU	
	Point Beach	ISFSI	Dry Storage	Nuclear Management Company	NRC	2	144.1 MTU	
	Point Beach 1&2	Nuclear Power Plant Pool	Wet Storage				507.4 MTU	

*Shared pools

Annex D-2. Radioactive Waste Management Facilities[89]

State	Installation	Licensee	Regulator	Facility	Function	Waste Source	Inventory (m3)	Estimated Activity (Bq)	Rad Cat
Government Facilities									
California	Lawrence Berkeley National Lab	DOE	DOE	M/LLW Waste Facilities	M/LLW Storage	2			6
		DOE	DOE	TRU Waste Facilities[90]	TRU Storage	2	2		6
	Lawrence Livermore National Lab	DOE	DOE	Various Waste Facilities	Mixed Low-Level Waste (MLLW) Storage		3		1,2,3,4,5
					TRU Storage		350		3
Colorado	Rocky Flats Environmental Technology Site	DOE	DOE/CO	M/LLW Facilities	M/LLW Storage, characterization, treatment, packaging	1	2,700		3,4
		DOE	DOE	TRU Waste Facilities	TRU Storage, characterization, packaging	1	353		3,4
Idaho	Idaho National Laboratory	DOE	DOE	HLW Calciner	HLW Treatment (evaporation and calcination)	1	0		
		DOE	DOE	Calcined Solids Storage Facility	Calcined HLW Storage in underground tanks/bins	1	4,400	1.11E+18	
		DOE	DOE	HLW Tank Farm	HLW Liquid Storage in underground tanks	1	3,400		
		DOE	DOE	Radioactive Waste Management Complex	LLW Disposal in shallow land disposal facility	1	29,758	1.22E+17	1,2,3,4,5
		DOE	DOE	Idaho CERCLA Disposal Facility	LLW Disposal in engineered surface disposal cell for D&D wastes	1	41,300[91]		
		DOE	DOE	TRU Waste Storage Facilities	TRU Storage	1	61,500		3
		DOE	DOE	Advanced Mixed Waste Treatment Plant	TRU characterization, treatment, and packaging	1	0		
		DOE	DOE/ID	MLLW Facilities	M/LLW Storage, characterization, treatment, packaging	1	508	1.27E+10	1,2,3,4,5
Kentucky	Paducah Gaseous Diffusion Plant	DOE	DOE/KY	MLLW Facilities	MLLW Storage, characterization, treatment, packaging	1	1,000		3,4
		DOE	DOE/KY	LLW Facilities	LLW Storage, characterization, treatment, packaging		9,500		3,4
		DOE	DOE	TRU Waste Facilities	TRU Storage	1	5		3,4
Missouri	Weldon Spring Site Rem. Action	DOE	DOE	On-Site Disposal Cell	11e.(2) Disposal in engineered, surface disposal cell	1	1,120,000		4

[89] See Key to Annex D-2 on last page of this table.
[90] This TRU inventory transferred to Hanford Site since the time of data collection.
[91] As of 1/31/2005

Annex D-2. Radioactive Waste Management Facilities[89]

State	Installation	Licensee	Regulator	Facility	Function	Waste Source	Inventory (m3)	Estimated Activity (Bq)	Rad Cat
Multiple States[92]	Other DOE	DOE	DOE/ Other states	LLW Facilities (small)	LLW Storage, characterization, treatment, packaging	1	10		6
			DOE	TRU Waste Facilities (small)	TRU Storage	1	334		6
Nevada	Nevada Test Site	DOE	DOE	Greater Confinement Disposal	TRU Disposal in boreholes	1	200	2.11E+15	1,2,3,4,5
		DOE	DOE/NV	MW Disposal Unit	MLLW Disposal in shallow trenches	1	8,500	3.92E+13	1,2,3,4,5
		DOE	DOE	Area 3/Area 5 RWMS	LLW Disposal in trenches and subsidence craters	1	771,900	3.70E+17	1,2,3,4,5
		DOE	DOE	TRU Waste Facilities	TRU Storage, characterization, packaging	1	615		
	Yucca Mountain Site	DOE	NRC	Geologic Repository (planned at Yucca Mountain, Nevada)	SF/HLW Disposal	1,3	0	0	
New Mexico	Los Alamos National Laboratory	DOE	DOE/NM	MLLW Facilities	MLLW Storage, characterization, treatment, packaging	1	216		2,3,4,5
		DOE	DOE	TRU Waste Facilities	TRU Storage, characterization, packaging	1	12,500		3
		DOE	DOE	Technical Area 54/Area G	LLW Disposal in shallow land disposal facility	1	215,000	7.30E+16	1,2,3,4,5
		DOE	DOE	Technical Area 54	Disused Sealed Source Storage	1	Not Reported		
		DOE	DOE	Chemical and Metallurgy Research Bldg.	Disused Sealed Source Consolidation	1			
	Sandia National Laboratory - NM	DOE	DOE	TRU Waste Facilities	TRU Storage, characterization, packaging	1	30		6
		DOE	DOE/NM	MLLW Facilities	MLLW Storage, characterization, treatment, packaging	1	6	4.44E+10	2,3,5
	Waste Isolation Pilot Plant	DOE	NMED/ EPA	WIPP Disposal	TRU Disposal in deep salt formation	1	24,000	1.65E+16	1,2,3,4,5
New York	Brookhaven National Lab	DOE	DOE	Waste Management Facilities	LLW Storage		58		1,2,3,4,5
	Niagara Falls Storage Site (FUSRAP)	COE	NY	Niagara Falls Storage Facility	11e.(2) Restoration Waste Storage		195,000		4

[92] There are multiple sites with labs with processing facilities or waste generated from D&D, e.g., Argonne National Laboratory, Ames Laboratory, Columbus Environmental, Energy Technology Engineering Center, Laboratory for Energy-Related Health Research, Inhalation Toxicology Research Institute, and Princeton Plasma Physics Laboratory.

Annex D-2. Radioactive Waste Management Facilities[89]

State	Installation	Licensee	Regulator	Facility	Function	Waste Source	Inventory (m3)	Estimated Activity (Bq)	Rad Cat
	West Valley Demonstration Project	DOE	DOE	TRU Waste Facilities	TRU Storage	3	850		1,2,3,4
		DOE	DOE	HLW Glass Storage Cell	Interim storage of Vitrified HLW in a former process cell	3	229		2,3
		DOE	DOE/NY	MLLW Facilities	MLLW Storage, characterization, treatment, packaging	3	5		1,2,3,4,5
		DOE	DOE/NY	LLW Facilities	LLW Storage, characterization, treatment, packaging	3	16,290		
Ohio	Ashtabula Environ. Management Project	DOE	DOE/OH	MLLW Facilities	MLLW Storage, characterization, treatment, packaging	1	285		4
		DOE	DOE/OH	LLW Facilities	LLW Storage, characterization, treatment, packaging	1	3,064		4
	Fernald Environmental Management Project	DOE	DOE	On-Site Disposal Facility	MLLW (from D&D) Disposal in engineered surface disposal cell	1	90		4
					LLW (from D&D) Disposal in engineered surface disposal cell	1	1,683,162		4
		DOE	DOE/OH	LLW Facilities	LLW Storage, characterization, treatment, packaging		14,800	8.98E+11	4
		DOE	DOE/OH	11e.(2) Facilities	11e.(2) Storage, characterization, treatment, packaging	1	10,700		4
	Miamisburg Environmental Management Project	DOE	DOE	LLW Waste Facilities	LLW Storage, characterization, packaging	1			3,4
		DOE	DOE	TRU Waste Facilities[93]	TRU Storage, characterization, packaging	1	247		3,4
	Portsmouth Gaseous Diffusion Plant	DOE	DOE/OH	MLLW Facilities	MLLW Storage, treatment, packaging	1	300		4
		DOE	DOE/OH	LLW Facilities	LLW Storage, treatment, packaging	1	15,200		4
South Carolina	Savannah River Site	DOE	DOE	TRU Waste Facilities	TRU Storage, characterization, packaging	1	13,000		3
		DOE	DOE	Glass Waste Storage Building	Interim Storage of Vitrified HLW	1	1,070		1,2,3,4,5
		DOE	DOE	HLW Tank Farm	HLW Liquid Storage in underground double-shell, stainless steel tanks	1	140,000		1,2,3,4,5
		DOE	DOE	Defense Waste Processing Fac.	HLW Liquid Treatment (Vitrification)	1	0		
		DOE	DOE/SC	MLLW Facilities	MLLW Storage, characterization, treatment, packaging	1	598	7.31E+12	1,2,3,4,5
		DOE	DOE/SC	LLW Facilities	LLW Storage, characterization, treatment, packaging	1	2,333		1,2,3,4,5

[93] This inventory transferred to Savannah River Site since the time of data collection

Annex D-2. Radioactive Waste Management Facilities[89]

State	Installation	Licensee	Regulator	Facility	Function	Waste Source	Inventory (m3)	Estimated Activity (Bq)	Rad Cat
		DOE	DOE	E-Area Disposal	Disposal of LLW in underground vaults and trenches	1	70,700	1.08E+16	1,2,3,4,5
		DOE	DOE	Old Burial Ground	Historic disposal of LLW	1	677,000		1,2,3,4,5
		DOE	DOE	Saltstone Vaults	Disposal of low-activity fraction of HLW	1	19,300		1,2,3,4,5
Tennessee	Oak Ridge Reservation	DOE	DOE	TRU Waste Facilities	TRU Storage, characterization, packaging	1	2,438		1,2,3,4
		DOE	DOE/TN	Toxic Substances Control Act Incinerator	MLLW treatment	1			1,2,3,4,5
		DOE	DOE/TN	MLLW Facilities	MLLW Storage (in building and on concrete pad), characterization, treatment, packaging	1	8,877		1,2,3,4,5
		DOE	DOE/TN	LLW Facilities	LLW Storage (in building and on concrete pad), characterization, treatment, packaging	1	22,500		1,2,3,4,5
		DOE	DOE	Environmental Management Waste Management Facility	LLW Disposal in engineered surface disposal cell for D&D wastes	1	140,000		
		Foster-Wheeler Corp.	DOE	Oak Ridge TRU Waste Treatment Facility	Private facility for DOE TRU waste treatment; also for liquid LLW supernate treatment and packaging	1	0		
		DOE	DOE	Interim Waste Management Fac.	LLW Disposal in engineered aboveground facility	1	3,700	1.18E+13	1,2,3,4,5
		DOE	DOE	Hydrofracture	Historic disposal of LLW		17,300		
		DOE	DOE	Old Burial Ground	Historic disposal of LLW		441,000		
Utah	Monticello Remedial Action Project	DOE	DOE	Monticello Disposal Cell	11e.(2) Disposal in engineered, surface disposal cell	1	2,000,000		4
Washington	Hanford Site	DOE	DOE	Decommissioned Submarine Hulls Disposal Area	LLW Navy submarine hulls disposal in trenches	1	110 reactor compartments		
		DOE	DOE	HLW Tank Farm	HLW Liquid Storage in underground single- and double-shell tanks	1	207,000		1,2,3,4,5
		DOE	DOE	Waste Encapsulation and Storage Facility	Cs-Sr Storage in hot cells and storage pool	1	1,929 sources	2.85E+18	
		DOE	DOE	TRU Waste Facilities	TRU Storage, characterization, packaging	1	43,600		1,2,3,4,5
		DOE	DOE/WA	RMW Trenches	MLLW Disposal in lined trenches	1	1,888	1.01E+15	1,2,3,4,5
		DOE	DOE	Environmental Restoration Disposal Facility	LLW (from D&D) Disposal in engineered surface disposal unit	1	2,000,000		1,2,3,4,5

Annex D-2. Radioactive Waste Management Facilities[89]

State	Installation	Licensee	Regulator	Facility	Function	Waste Source	Inventory (m3)	Estimated Activity (Bq)	Rad Cat
		DOE	DOE	200 Area Burial Grounds	LLW Disposal in trenches	1	311,480	1.68E+17	1,2,3,4,5
		DOE	DOE	Integrated Disposal Facility (under construction)	M/LLW Disposal	1			1,2,3,4,5
		DOE	DOE/WA	MLLW Facilities	MLLW Storage, characterization, treatment, packaging	1	5,280		1,2,3,4,5
		DOE	DOE/WA	LLW Facilities	LLW Storage, characterization, treatment, packaging	1	360		1,2,3,4,5
Commercial Facilities									
California	New World Technology	New World Technology	NRC	New World Technology	Broker – Waste Treatment Service (Other than compactio3333n)	3	NA		
	Thomas Grey Associates	Thomas Grey Associates	NRC	Thomas Grey Associates	Broker – Processing of liquids and radium	3	NA		
Connecticut	Cabrera Services, Inc.	Cabrera Services, Inc.	NRC	Cabrera Services, Inc.	Broker – Decontamination Services	3	NA		
	Radiation Safety Associates	Radiation Safety Associates	NRC	Radiation Safety Associates	Broker	3	NA		
	Yale Univ. Radiation Safety Section	Yale University	NRC	Yale Univ. Radiation Safety Section	Broker – Academic Type A Broad	3	NA		
Illinois	ADCO Services Inc.	ADCO Services Inc.	NRC	ADCO Services Inc.	Broker – Processing of uranium and thorium	3	NA		
	Dept. Of The Army Rock Island Arsenal	Dept. Of The Army	NRC	Dept. Of The Army	Broker – Waste Disposal Service Processing and/or Repackaging.	3	NA		
Maryland	Dept. Of The Army Ft. Detrick	Dept. Of The Army	NRC	Dept. Of The Army	Broker – Waste Disposal Service Processing and/or Repackaging.	3	NA		
	Ecology Services	Ecology Services	MD	Ecology Services	Broker – Mixed waste processing	3	NA		
	RSO, Inc.	RSO, Inc.	MD	RSO, Inc.	Broker – Organics processing	3	NA		
Michigan	Pharmacia & Upjohn Company	Pharmacia & Upjohn Company	NRC	Pharmacia & Upjohn Company	Broker – Manufacturing and Distribution Type A Broad	3	NA		
Minnesota	University of Minnesota	University of Minnesota	NRC	University of Minnesota	Broker – Waste Disposal Service Processing and/or Repackaging.	3	NA		
Missouri	Pharmacia Corporation	Pharmacia Corporation	NRC	Pharmacia Corporation	Broker – Waste Disposal Service Processing and/or Repackaging.	3	NA		
	R.M. Wester	R.M. Wester	NRC	R.M. Wester	Broker	3	NA		

Annex D-2. Radioactive Waste Management Facilities[89]

State	Installation	Licensee	Regulator	Facility	Function	Waste Source	Inventory (m3)	Estimated Activity (Bq)	Rad Cat
	Westinghouse Electric Company, LLC	Westinghouse Electric Company, LLC	NRC	Westinghouse Electric Company, LLC	Broker – Decommissioning of Uranium Fuel Fabrication Plants	3	NA		
Montana	HHS, Dept. Of USPHS, NIH, Rocky Mountain Laboratories	Dept. of Health & Human Services	NRC	HHS, Dept. Of USPHS, NIH, NIAID	Broker – Research and Development Type A Broad	3	NA		
New Jersey	BASF Corporation	BASF Corporation	NRC	BASF Corporation	Broker – Research and Development Type A Broad	3	NA		
	Radiation Science, Inc.	Radiation Science, Inc.	NRC	Radiation Science, Inc.	Broker – Waste Disposal Service Prepackaged only.	3	NA		
	Teledyne Brown Engineering, Inc.	Teledyne Brown Engineering, Inc.	NRC	Teledyne Brown Engineering, Inc.	Broker – Waste Disposal Service Prepackaged only.	3	NA		
New York	Radiac Research Corp.	Radiac Research Corp.	NRC	Radiac Research Corp.	Broker – Waste Disposal Service Prepackaged only.	3	NA		
North Carolina	HHS, Dept. Of Public Health Service	Dept. of Health & Human Services	NRC	HHS, Dept. Of Public Health Service	Broker – Research and Development Type A Broad	3	NA		
	V.A. Medical Center	Dept. of Veterans Affairs	NRC	V.A. Medical Center	Broker – Medical Institution Broad	3	NA		
Ohio	Solutient Technologies	Solutient Technologies	NRC	Solutient Technologies	Broker – Processing	3	NA		
Pennsylvania	Alaron Corporation	Alaron Corporation	NRC	Alaron Corporation	Broker – Waste Disposal Service Processing and/or Repackaging.	3	NA		
	Applied Health Physics, Inc.	Applied Health Physics, Inc.	NRC	Applied Health Physics, Inc.	Broker – Waste Disposal Service Prepackaged only.	3	NA		
	BWX Technologies, Inc. B&W Nuclear Environmental Services	BWX Technologies	NRC	BWX Technologies, Inc. B&W Nuclear Environmental Services	Broker – Decommissioning of Advanced Fuel R&D and Pilot Plants	3	NA		
	Fox Chase Cancer Center	Fox Chase Cancer Center	NRC	Fox Chase Cancer Center	Broker – Medical Institution Broad	3	NA		
South Carolina	GTS-Duratek/Chem-Nuclear Systems, Inc.	GTS-Duratek, Inc	NRC	GTS-Duratek/ Chem-Nuclear Systems, Inc.	Broker – Decommissioning of Byproduct Material Facilities	3	NA		

Annex D-2. Radioactive Waste Management Facilities[89]

State	Installation	Licensee	Regulator	Facility	Function	Waste Source	Inventory (m3)	Estimated Activity (Bq)	Rad Cat
	Chem-Nuclear Systems	GTS-Duratek, Inc	SC	Barnwell Commercial Disposal	LLW Disposal Class A	3	701,999	7.17E+17	1,2,3,4,5
					LLW Disposal Class B	3	46,286		
					LLW Disposal Class C	3	23,143		
Tennessee	Bionomics	Bionomics	TN	Bionomics	Broker	3	NA		
	Chase Environmental	Chase Environmental	TN	Chase Environmental	Broker	3	NA		
	Diversified Technologies	Diversified Technologies	TN	Diversified Technologies	Processing of resins, sludges, and liquids	3	NA		
	Duratek	Duratek	TN	Duratek	Broker – Processing of uranium, thorium, other	3	NA		
	Permafix	Permafix	TN	Permafix	Processing/treatment of mixed wastes	3	NA		
	Philotechnics	Philotechnics	TN	Philotechnics	Broker -- Processing of uranium and thorium salts	3	NA		
	Radiological and Consulting Services	RACE	TN	RACE	Broker – Processing of large equipment	3	NA		
	V.A. Medical Center	Dept. of Veterans Affairs	NRC	V.A. Medical Center	Broker – High Dose Rate Remote Afterloader	3	NA		
Texas	MKM Engineers, Inc.	MKM Engineers, Inc.	NRC	MKM Engineers, Inc.	Broker – Waste Disposal Service Processing and/or Repackaging.	3	NA		
	NSSI	NSSI	TX	NSSI	MLLW processing	3	NA		
	Specpro, Inc.	Specpro, Inc.	NRC	Specpro, Inc.	Broker – Waste Disposal Service Processing and/or Repackaging.	3	NA		
	Waste Control Specialists (WCS)	WCS	TX	Waste Control Specialists	GTCC Storage		45.8		
					MLLW Treatment	3	NA		
Utah	Envirocare of Utah	Envirocare of Utah	UT/NRC	Envirocare	MLLW Treatment and Disposal	3	63,420		1,2,3,4,5
					LLW --Class A Disposal	3	1,439,159	2.09E+14	1,2,3,4,5
					11e.(2) Disposal	3	1,096,866		1,2,3,4,5
Washington	Pacific EcoSolutions	PECOS	WA	Allied Technology Group	MLLW treatment and processing	3	NA		
	U.S. Ecology - Richland	U.S. Ecology	WA	U.S. Ecology	LLW--Class A Disposal	3	380,303	2.70E+17	1,2,3,4,5
					LLW--Class B Disposal	3	3,881		
					LLW--Class C Disposal	3	3,881		
Wisconsin	Covance Laboratories	Covance Laboratories	NRC	Covance Laboratories	Broker – Research and Development Other	3	NA		
	William S. Middleton Memorial V.A. Hospital	Dept. of Veterans Affairs	NRC	William S. Middleton Memorial Veterans Hospital	Broker – Medical Institution Broad	3	NA		

Annex D-2. Radioactive Waste Management Facilities[89]

State	Installation	Licensee	Regulator	Facility	Function	Waste Source	Inventory (m3)	Estimated Activity (Bq)	Rad Cat
Multiple States	Beatty, NV; Maxey Flats, KY; Sheffield, IL; West Valley, NY	None	NV, KY, IL, NY	Closed Commercial Disposal	LLW—All Classes	3	438,450	7.81E+16	1,2,3,4,5
	Multiple ISFSIs	Various utilities	NRC	NPPs	GTCC Storage		139		
Past Practices									
Ocean Disposal				Atlantic	LLW		8,600	2.94E+15	
				Pacific	LLW		14,000	5.54E+14	

Annex D-2 Key

Waste Source		Radionuclide Category (Rad Cat)		
		Category		Key Isotopes
1	Defense applications	1	Activation Products	Primarily Cl-36, Fe-55, Mn-54, Zn-65, Co-58, Co-60, Ni-63,
2	Nuclear applications	2	Mixed Fission Products	Radioactive isotopes and daughters from Zn-72 to Gd-158; primary loner-lived isotopes are Kr-85, Sr-89, Sr-90/Y-90,Y-91, Zr-95, Nb-95, Ru-103/Rh103, Ru-106/Rh-106, Sb-125/Te-125, Cs-137/Ba-137, Ce-141, Ce-144/Pr-144, Pm-147, S-m151,and Eu-155
3	Commercial	3	Transuranic Isotopes	Isotopes of Cf, Bk, Cm, Am, Pu, and Np, and their respective decay products.
		4	Naturally-Occurring Isotopes	U-238 , U-235, U-234, Th-232, and their respective decay products (*Pa-231, Th-227, Th-228, Th-230, Th-231, Th-234, Ac-227, Ac-228, Ra-223, Ra-224, Ra-226, Ra-228, Fr-223, Rn-219, Rn-220, Rn-222, At-215, At-218, At-219, Po-210, Po-211, Po-212, Po-214, Po-215, Po-216, Po-218, Bi-210, Bi-211, Bi-212, Bi-214, Pb-210, Pb-211, Pb-212, Pb-214, Tl-206, Tl-207, Tl-208, and Tl-210*), C-14, K-40, V-40, Rb-87, In-115, Te-123, La-138, Ce-142, Nd-144, Sm-147, Sm-148, Sm-149, Gd-152,Dy-156, Lu-176, Hf-174, Ta-180, Re-187, Pt-190, Pb-204, Bi-215
		5	Tritium	H-3
		6	Various	Radioactivity from various sources and categories

Annex D-3. Uranium Mill Tailings and Related Sites[94]

State	Site Name/ Location	Licensee	Type	Status	Regulator	Regulatory Program	Quantity of Contaminated Material (dry metric tonnes except as noted)	Total Ra-226 Activity (TBq)
Arizona	Tuba City	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program; property owned by Navajo Indian Nation.	NRC	UMTRCA Title I	2,250,000	35
Colorado	Cheney Disposal Cell (residual radioactive material removed from the former Grand Junction Climax site)	DOE	Surface residual radioactive material disposal cell	Active until 2023 to accept residual radioactive material from other sites.	NRC	UMTRCA Title I	3,590,800 m^3	TBD
	Cotter	Cotter Corp. USA	Conventional mill	Standby/periodic limited operations	Colorado	UMTRCA Title II	2,000,000	N/A
	Durango (Bodo Canyon disposal site)	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program	NRC	UMTRCA Title I	3,460,000	52
	Durita,	Hecla Mining Company	Heap Leach Site	Reclamation/Stability monitoring	Colorado	UMTRCA Title II	540,000	N/A
	Gunnison	DOE	Conventional mill and surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program	NRC	UMTRCA Title I	1,140,000	6.5
	Maybell	DOE	Conventional mill and surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program; annual groundwater monitoring inspections.	NRC	UMTRCA Title I	4,291,928	17
	Maybell	EPA Superfund	Heap Leach Site	Reclamation/Stability monitoring	Colorado	UMTRCA Title II	NA	N/A

[94]Source: DOE Grand Junction web site
Note: Blanks in the Licensee column indicate Licensee and Installation name are the same.
NA: Not applicable

Annex D-3. Uranium Mill Tailings and Related Sites[94]

State	Site Name/ Location	Licensee	Type	Status	Regulator	Regulatory Program	Quantity of Contaminated Material (dry metric tonnes except as noted)	Total Ra-226 Activity (TBq)
	Naturita	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	971,762	2.9
	Rifle	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program	NRC	UMTRCA Title I	4,967,451	101
	Slick Rock	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program	NRC	UMTRCA Title I	1,140,000	6.5
	Sweeney	EPA Superfund	Conventional mill	No activity. Colorado is trying to get it on the FUSRAP list.	Colorado	UMTRCA Title II	N/A	N/A
	Uravan	EPA Superfund	Conventional mill	Reclamation/decommissioning	Colorado	UMTRCA Title II	9,500,000	N/A
Idaho	Lowman	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program	NRC	UMTRCA Title I	222,230	0.4
Illinois	West Chicago	Kerr-McGee	Conventional mill	Decommissioning. The West Chicago site is being decommissioned for unrestricted use.	Illinois	UMTRCA Title II	77,000 remaining to be excavated; previous materials removed to Utah disposal site.	N/A
New Mexico	Ambrosia Lake	DOE	Conventional mill and surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program	NRC	UMTRCA Title I	6,931,000	69
	Ambrosia Lake	Rio Algom Mining LLC	Conventional mill	Not yet on LTSP. DP approved 2003 (mill), 2004 (soil projected 2005)	NRC	UMTRCA Title II	30,100,000	N/A
	Bluewater	DOE	Conventional mill and surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program	NRC	UMTRCA Title II	24,000,000	457

Annex D-3. Uranium Mill Tailings and Related Sites[94]

State	Site Name/ Location	Licensee	Type	Status	Regulator	Regulatory Program	Quantity of Contaminated Material (dry metric tonnes except as noted)	Total Ra-226 Activity (TBq)
	Church Rock	United Nuclear Corporation Mining and Milling	Conventional mill; groundwater restoration program	Not yet on LTSP. DP[95] approved 3/1991, projected revision approval in 2005	NRC	UMTRCA Title II	3,200,000	N/A
	Grants	Homestake Mining Co	Conventional mill; groundwater restoration program	Not yet on LTSP. Revised DP approved 3/1995	NRC	UMTRCA Title II	20,300,000	N/A
	L-Bar (Sohio Western Mining)	DOE	Conventional mill and surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program October 2004. DP approved 1989	NRC	UMTRCA Title II	1,900,000	N/A
	Shiprock	DOE	Conventional mill and surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program	NRC	UMTRCA Title I	2,520,000 wet metric tonnes	28
Oklahoma	Sequoyah Fuels Corporation	Sequoyah Fuels Corp.	UF_6 Facility	DP projected approval 2006; only 77% of total may be treated as Title II tailings	NRC	UMTCA Title II	248,318 cubic meters	0.11
Oregon	Lakeview	DOE	Conventional mill and surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program	NRC	UMTRCA Title I	736,000	1.6
Pennsylvania	Burrell	DOE	Surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program; groundwater monitoring and maintenance program to maintain site integrity.	NRC	UMTRCA Title I	86,000	0.15
	Canonsburg	DOE	Conventional mill and surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program; surface and groundwater under monitoring regime.	NRC	UMTRCA Title I	226,000	4
South Dakota	Edgemont	DOE	Conventional mill	Under general NRC	NRC	UMTRCA	4,000,000	19

[95]DP= Decommissioning Plan

Annex D-3. Uranium Mill Tailings and Related Sites[94]

State	Site Name/ Location	Licensee	Type	Status	Regulator	Regulatory Program	Quantity of Contaminated Material (dry metric tonnes except as noted)	Total Ra-226 Activity (TBq)
			and surface mill tailings disposal cell	license, in DOE LTSP program		Title II		
Texas	Cogema	Cogema	In Situ Site	Restoration/Closure	Texas	UMTRCA Title II	NA	N/A
	Conoco Conquista	Conoco Conquista	Conventional mill	Reclamation/Stability monitoring	Texas	UMTRCA Title II		N/A
	Hobson	Everest Minerals	In Situ Site	Restoration/Closure	Texas	UMTRCA Title II	NA	N/A
	Exxon Felder		Conventional mill	Reclamation/Stability monitoring	Texas	UMTRCA Title II	400,000	N/A
	Falls City	DOE	Conventional mill and surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	7,143,000	47
	IEC		In Situ Site	Restoration/Closure	Texas	UMTRCA Title II	NA	N/A
	Allta Mesa	Mestena	In Situ Site	New license, pre-operational work only.	Texas	UMTRCA Title II	NA	N/A
	RGR/Chevron (aka Pana Maria)		Conventional mill	Reclamation/Stability monitoring	Texas	UMTRCA Title II	5,900,000	N/A
	Kingsville Dome	URI	In Situ Site	Standby, Restoration of some satellite well fields	Texas	UMTRCA Title II	NA	N/A
	USX		In Situ Site	License has been terminated.	Texas	UMTRCA Title II	NA	N/A
Utah	Green River	DOE	Conventional mill and surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program; groundwater monitoring regime.	NRC	UMTRCA Title I	501,000	1.1
	Lisbon	Rio Algom Mining Corp	Conventional mill	Not yet on LTSP	Utah	UMTRCA Title II	3,500,000	
	Mexican Hat	DOE	Conventional mill and surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program; groundwater monitoring regime.	NRC	UMTRCA Title I	4,400,000	67

Annex D-3. Uranium Mill Tailings and Related Sites[94]

State	Site Name/ Location	Licensee	Type	Status	Regulator	Regulatory Program	Quantity of Contaminated Material (dry metric tonnes except as noted)	Total Ra-226 Activity (TBq)
	Moab	DOE	Mill & Tailings Disposal	DOE assumed ownership of site in 2001	DOE	UMTRCA Title II	10,800,000	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	2,798,000	57
	Salt Lake City Processing Site Central Valley Water Reclamation Facility	DOE	Currently a sewage treatment facility	Institutional controls maintained by DOE	DOE	UMTRCA Title I	Residual Ra-226- and Th-230-contaminated material.	N/A
	Shootaring Canyon	Plateau Resources Ltd	Conventional uranium mill	Proposal to use mill as a disposal site for uranium mill tailings and other similar byproduct material.	Utah	UMTRCA Title II	15,300 cubic meters – only operated for 3 months.	N/A
	White Mesa	International Uranium Corporation	Conventional uranium mill	Operating	Utah	UMTRCA Title II	3,200,000	N/A
Washington	Dawn Mining	Dawn Mining Company	Conventional uranium mill	Reclamation/Residue Disposal	WA	UMTRCA Title II	2,800,000	N/A
	WNI Sherwood	DOE Custody	Conventional uranium mill	State License Terminated (April 2001); Disposal area is under 40.28 General License by NRC	WA/NRC	UMTRCA Title II	2,600,000	17
Wyoming	ANC	American Nuclear Corp	Conventional uranium mill	Not yet on LTSP	NRC	UMTRCA Title II	5,300,000	N/A
	Bear Creek	Bear Creek Uranium Co	Conventional uranium mill	Not yet on LTSP. DP approved 5/1989	NRC	UMTRCA Title II	4,300,000	N/A
	Gas Hills	American Nuclear Corporation	Conventional uranium mill	Not yet on LTSP. DP approved 10/1998, projected revision approval in 2005	NRC	UMTRCA Title II	7,300,000	N/A

Annex D-3. Uranium Mill Tailings and Related Sites[94]

State	Site Name/ Location	Licensee	Type	Status	Regulator	Regulatory Program	Quantity of Contaminated Material (dry metric tonnes except as noted)	Total Ra-226 Activity (TBq)
	Gas Hills	Pathfinder Mines Corp -- Lucky MC	Conventional uranium mill	Not yet on LTSP. Revised DP approved 6/1996	NRC	UMTRCA Title II	10,600,000	N/A
	East Gas Hills	Umetco Minerals Corp	Conventional uranium mill	Not yet on LTSP. Revised DP approved 4/2001(soil)	NRC	UMTRCA Title II	7,300,000	N/A
	Highlands	Exxon Mobil Corp	Conventional uranium mill	Not yet on LTSP. DP approved 1990	NRC	UMTRCA Title II	10,300,000	N/A
	Johnson & Campbell Counties	COGEMA Mining, Inc.	In Situ Site	DP approved 12/2001	NRC	UMTRCA Title II		N/A
	Shirley Basin	Pathfinder Mines Corp	Conventional uranium mill	Not yet on LTSP. Revised DP approved 12/1997	NRC	UMTRCA Title II	7,400,000	N/A
	Shirley Basin	Petrotomics Co	Conventional uranium mill	Not yet on LTSP. DP approved 1989	NRC	UMTRCA Title II		N/A
	Split Rock	Western Nuclear Inc.	Conventional uranium mill	Not yet on LTSP. DP approved 1997	NRC	UMTRCA Title II	7,000,000	N/A
	Spook	DOE	Conventional mill and surface residual radioactive material disposal cell	Under general NRC license, in DOE LTSP program.	NRC	UMTRCA Title I	1,500,000 m3	N/A
	Sweetwater	Kennecott Uranium Co	Conventional uranium mill	Not yet on LTSP	NRC	UMTRCA Title II	2,100,000	N/A

Annex D-4. DOE Decommissioning and Remediation Projects[96]

State	Site	Historic Mission	Nuclear/Radioactive Facility Decommissioning		Release Site Remediation	
			Pending	Completed	Pending	Completed
California	Energy Technology Engineering Center	Research, Development & Testing	3	3	6	4
	Lab. for Energy-Related Health Research	Research, Development & Testing			1	16
	Lawrence Berkeley National La/Oakland Ops	Research, Development & Testing			20	164
	Lawrence Livermore National Lab - Main Site	Defense, Research, Development & Testing			25	168
	Lawrence Livermore National Lab - Site 300	Defense, Research, Development & Testing				
	Stanford Linear Accelerator Center	Research, Development & Testing			4	16
	General Atomics	Research, Development & Testing			0	2
Colorado	Rocky Flats Environmental Technology Site	Defense	45	15	43	197
Idaho	Idaho National Laboratory/Idaho Operations	Defense, Research, Development & Testing	105	18	128	412
Illinois	Argonne National Lab – East/Chicago Ops	Research, Development & Testing	15	63	0	473
Kentucky	Paducah Gaseous Diffusion Plant	Enrichment	2	0	151	86
Missouri	Kansas City Plant	Defense			1	42
New Mexico	Inhalation Toxicology Laboratory	Research, Development & Testing			0	9
	Los Alamos National Lab/Albuquerque Ops	Defense, Research, Development & Testing	1	0	799	1481
	Sandia National Laboratories-New Mexico	Defense, Research, Development & Testing	0	1	111	152
Multiple States (NV, AK, NM, CO, MS)	Nevada Test Site and off-site test locations	Defense (Weapons Testing)			1366	716
New York	Brookhaven National Laboratory	Research, Development & Testing	7	3	8	68
	Separations Process Research Unit	Research, Development & Testing	4	0	6	0
	West Valley Demonstration Project	Commercial Reprocessing			1	0
Ohio	Ashtabula Environmental Management Project	Defense	5	20	3	0
	Columbus Environmental Management Project - West Jefferson	Research, Development & Testing	3	12	1	1
	Fernald Environmental Management Project	Defense	1	19	4	2
	Miamisburg Environmental Management Project	Defense	19	0	60	118
	Portsmouth Gaseous Diffusion Plant	Enrichment			14	149
South Carolina	Savannah River Site	Defense	231	4	211	304
Tennessee	Oak Ridge Reservation	Defense, Research, Development, & Testing	68	8	394	260
Texas	Pantex Plant	Defense			161	76
Washington	Hanford Site	Defense	628	5	1670	270

[96]Source: *Office of Environmental Management Closure Planning Guidance*, June 1, 2004 Reflects Decommissioning and remediation completed through 2003.

Annex D-5. Formerly Utilized Sites Remedial Action Program Sites

State	Site	Status
Connecticut	CE Site, Windsor	Ongoing Remediation
Indiana	Joslyn Steel, Fort Wayne	Currently Under Site Investigation
Iowa	Iowa Army Ammunition Plant, Middletown	Ongoing Remediation
Maryland	W.R. Grace & Company, Curtis Bay/Baltimore	Ongoing Remediation
Massachusetts	Shpack Landfill, Norton	Ongoing Remediation
Missouri	Latty Avenue Properties, Hazelwood	Ongoing Remediation
	St. Louis Airport Site, St. Louis	Ongoing Remediation
	St. Louis Airport Site Vicinity Properties, St. Louis	Ongoing Remediation
	St. Louis Downtown Site, St. Louis	Ongoing Remediation
New Jersey	Maywood Site, Maywood	Ongoing Remediation
	Wayne Site, Wayne/Peaquannock	Ongoing Remediation
	Middlesex Sampling Plant, Middlesex	Ongoing Remediation
	DuPont Chamber Works, Deepwater	Ongoing Remediation
New York	Niagara Falls Storage Site, Lewiston	Ongoing Remediation
	Ashland 1, Tonawanda	Ongoing Remediation
	Linde, Tonawanda	Ongoing Remediation
	Guteril Steel, Buffalo	Currently Under Site Investigation
	Seaway Industrial Park, Tonawanda	Ongoing Remediation
	Colonie Site, Colonie	Ongoing Remediation
Ohio	Luckey Site, Luckey	Ongoing Remediation
	Painesville Site, Painesville	Ongoing Remediation
	Dayton Unit I, Dayton	Currently Under Site Investigation
	Dayton Unit III, Dayton	Currently Under Site Investigation
	Dayton Unit IV, Dayton	Currently Under Site Investigation
	Dayton Warehouse, Dayton	Ongoing Remediation
	Harshaw Chemical	Ongoing Remediation
Pennsylvania	Shallow Land Disposal Area, Parks Township	Ongoing Remediation

Annex D-6. Decommissioning Of Complex NRC-Licensed Materials Sites[97]

State	Installation	Location	Decommissioning Status[98]
Alabama	Department of the Army	Fort McClellan, Alabama	Estimated closure in 9/2005, under unrestricted release.
Connecticut	ABB Prospects	Windsor, CT	Estimated closure in 12/2007, under unrestricted release.
	UNC Naval Products (a.k.a. United Nuclear)	New Haven, Connecticut	Estimate closure to be determined. Closure under unrestricted release.
Florida	Eglin Air force Base	Walton County, FL	Estimated closure in 12/2005, under unrestricted release.
Idaho	Salmon River	North Fork, ID	Estimate closure in 5/2012. Closure under unrestricted release.
Illinois	Engelhard Minerals	Great Lakes, IL	Estimated closure to be determined, closure under unrestricted release.
Indiana	Jefferson Proving Ground (Department of the Army)	Madison, Indiana	Estimate closure to be determined. Closure under restricted release.
Michigan	AAR Manufacturing Group, Inc.	Livonia, Michigan	Estimated closure in 1/2007, under restricted release.
	Dow Chemical Company	Bay City, Michigan	Estimated closure in 4/2006, under unrestricted release.
	Michigan Dept. of Natural Resources	Kawkawlin, Michigan	Estimated closure in 10/2006, under unrestricted release.
	NWI Breckenridge	Breckenridge, MI	Estimated closure to be determined. Closure under unrestricted release.
	SCA Services	Kawkawlin, Michigan	Estimated closure in 7/2011, under restricted release.
Missouri	Mallinckrodt Chemical Inc.	St. Louis, Missouri	Estimated closure in 7/2008, under unrestricted release.
	Westinghouse Electric Corp. (Hematite Facility)	Jefferson County, MO	Estimated closure in 3/2010, under unrestricted release.
New Jersey	Heritage Minerals Inc.	Lakehurst, New Jersey	Estimate closure to be determined. Closure under unrestricted release.
	Shieldalloy Metallurgical Corp	Newfield, New Jersey	Estimated closure in 9/2010, under restricted release.
	Stepan Chemical Company	Maywood, NJ	Estimated closure in 9/2009, under unrestricted release.
New Mexico	Kirtland Air Force Base	Albuquerque, NM	Estimated closure in 12/2005, under unrestricted release.
New York	West Valley	West Valley, NY	Estimated closure to be determined.
Ohio	Battelle Columbus Laboratories	West Jefferson, OH	Estimated closure in 12/2005, under unrestricted release.
Oklahoma	FMRI (Fansteel), Inc.	Muskogee, Oklahoma	Estimate closure after 2023, under unrestricted release.
	Kaiser Aluminum Specialty Products	Tulsa, Oklahoma	Estimated closure in 5/2007, under unrestricted release.
	Kerr-McGee – Cimarron	Cimarron, OK	Estimated closure in 5/2007, under unrestricted release.
	Kerr-McGee - Cushing Refinery	Cushing, OK	Estimated closure in 12/2005, under unrestricted release.
	Sequoyah Fuels Corp.[99]	Gore, Oklahoma	NRC decided that the site front-end waste could be classified as 11e.(2) byproduct material, thereby permitting site control and long-term custody to be passed to DOE. Estimated closure 6/2010, under restricted release.
Pennsylvania	Babcock & Wilcox Shallow Land Disposal Area	Parks Township, Pennsylvania	Estimated closure in 10/2009, under restricted release.
	Cabot Performance Materials Inc.	Reading, Pennsylvania	Estimated closure in 5/2006, under unrestricted release.
	Curtis-Wright	Cheswick, PA	Estimated closure in 12/2008, under unrestricted release.
	Molycorp, Inc (Washington)	Washington, Pennsylvania	Estimated closure in 10/2006, under unrestricted release.
	Superbolt (formerly Superior Steel)	Carnegie, PA	Estimate closure to be determined. Closure under unrestricted release.

[97] Source: NUREG 1814
[98] Unspecified closure dates pending resolution of site-specific regulatory provisions; e.g., financial assurance, waste management arrangements, etc.
[99] The Sequoyah Fuels Corporation is listed under the decommissioning program, but the 11(e)2 decision designates the waste as being covered under UMTRCA, Title II.

Annex D-6. Decommissioning Of Complex NRC-Licensed Materials Sites[97]

State	Installation	Location	Decommissioning Status[98]
	Quehanna (formerly Permagrain Products, Inc.)	Karthaus, PA	Estimated closure to be determined. Closure under unrestricted release.
	Royersford Wastewater Treatment Facility	Royersford, PA	Estimate closure to be determined. Closure under unrestricted release.
	Safety Light Corporation	Bloomsburg, PA	Estimate closure to be determined. Closure under restricted release.
	Westinghouse Electric Corp.	Blairsville, PA	Estimated closure in 5/2006, under unrestricted release.
	Westinghouse Electric Corp. (Waltz Mill)	Madison, PA	Estimated closure to be determined. Closure under unrestricted release.
	Whittaker Corporation	Greenville, PA	Estimated closure in 9/2005, under unrestricted release.
South Dakota	Pathfinder	Sioux Falls, SD	Estimated closure in 4/2006, under unrestricted release.
Tennessee	Union Carbide Corporation	Lawrenceburg, Tennessee	Estimated closure in 12/2005, under unrestricted release.
West Virginia	Homer Laughlin[100]	Newell, West Virginia	Estimate closure to be determined. Closure under unrestricted release.

[100] Item is still under NRC Region II review. The license is retired; Lic No. SUB-00081; Docket No. 040-01957.

Annex D-7. NRC-Licensed Reactors Under Decommissioning

Facility	Location	Reactor Type	Power	D&D Status
Commercial Power Reactors				
Humboldt Bay 3	Eureka, CA	Boiling Light-Water Reactor	63 Mwe	SAFSTOR
Rancho Seco	Sacramento, CA	Pressurized Light-Water Reactor	913 Mwe	DECON
San Onofre – Unit 1	San Clemente, CA	Pressurized Light-Water Reactor	436 Mwe	DECON
Haddam Neck- Connecticut Yankee	Meriden, CT	Pressurized Light-Water Reactor	590 Mwe	DECON
Millstone – Unit 1	Waterford, CT	Boiling Light-Water Reactor	660 Mwe	SAFSTOR
Dresden – Unit 1	Dresden, IL	Boiling Light-Water Reactor	200 Mwe	SAFSTOR
Zion – Unit 1	Waukegan, IL	Pressurized Light-Water Reactor	1,040 Mwe	SAFSTOR
Zion – Unit 2	Waukegan, IL	Pressurized Light-Water Reactor	1,040 Mwe	SAFSTOR
Maine Yankee	Wiscasset, ME	Pressurized Light-Water Reactor	860 Mwe	DECON
Yankee Rowe	Greenfield, MA	Pressurized Light-Water Reactor	167 Mwe	DECON
Big Rock Point	Charlevoix, MI	Boiling Light-Water Reactor	67 Mwe	DECON
Fermi – Unit 1	Newport, MI	Liquid Metal Fast Breeder Reactor	61 Mwe	SAFSTOR
Indian Point – Unit 1	Buchanan, NY	Pressurized Light-Water Reactor	257 Mwe	SAFSTOR
Peach Bottom – Unit 1	Delta, PA	High Temperature Gas Reactor	40 Mwe	SAFSTOR
Three Mile Island – Unit 2	Harrisburg, PA	Pressurized Light-Water Reactor	792 Mwe	Monitored SAFSTOR
La Crosse	La Crosse, WI	Boiling Light-Water Reactor	50 Mwe	SAFSTOR
Research and Test Reactors				
General Atomics	San Diego, CA	TRIGA Mark F	1,500 kW	DECON
General Atomics	San Diego, CA	TRIGA Mark I	250 kW	DECON
Manhattan College	Bronx, NY	ZPR	0.0001 kW	DECON
University of Illinois	Urbana, IL	TRIGA	1,500 kW	DECON
University of Washington	Seattle, WA	Argonaut	100 kW	DECON
University of Virginia-Cavalier	Charlottesville, VA	Pool	Not applicable	DECON
University of Virginia	Charlottesville, VA	Pool	2 MW	DECON
National Aeronautics and Space Administration	Cleveland, OH	Tank	60 MW	DECON
National Aeronautics and Space Administration	Cleveland, OH	Mockup	100 kW	DECON
Nuclear Ship Savannah	Newport News, VA	Pressurized Light-Water Reactor	80 MW	SAFSTOR
Cornell University	Ithaca, NY	Tank (ZPR)	0.1 kW	DECON
Cornell University	Ithaca, NY	TRIGA	500 kW	DECON
Ford Nuclear Reactor	Ann Arbor, MI	Pool	2 MW	DECON
General Electric Co.	Sunol, CA	GETR (Tank)	50 MW	SAFSTOR
General Electric Co.	Alameda, CA	VESR	2 MW	SAFSTOR
Vallecitos BWR	Sunol, CA	Boiling Light-Water Reactor	5 MW	SAFSTOR
Veterans Administration	Omaha, NE	TRIGA-Mark I	20 kW	DECON
Westinghouse	New Stanton, PA	Tank	60 MW	DECON
Saxton	Saxton, PA	Pressurized Light-Water Reactor	35 MW	DECON
University of Buffalo	Buffalo, NY	Pool	2 MW	SAFSTOR until fuel is removed from the site

Annex E-1. NRC Guidance

NRC provides guidance on acceptable methods for meeting its regulatory requirements. Guidance documents, such as regulatory guides or staff technical positions, are not a substitute for regulations. Compliance with guidance is not required. Methods, analysis, and solutions different from guidance are also acceptable if they demonstrate meeting actual regulatory requirements. Some examples of guidance include:
HLW Management
NUREG-1804, Revision 2, *Yucca Mountain Review Plan (Draft Report for Comment)*. March 2002
NUREG-1494 *Staff Technical Position on Consideration of Fault Displacement Hazards in Geologic Repository Design*, March 1994
NUREG-1563, *Branch Technical Position on the Use of Expert Elicitation in the HLW Program*, issued November 1996
LLW Management
Regulatory Guide 4.20, *Constraint on Releases of Airborne Radioactive Materials to The Environment For Licensees Other Than Power Reactors*
Regulatory Guide 4.18, *Standard Format and Content of Environmental Reports for Near-Surface Disposal of Radioactive Waste*, June 1983
NUREG-1200, *Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility*, Revision 3, April 1994.
NUREG-1300, *Environmental Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility*
NUREG-1199, *Standard Format and Content of a License Application for a Low-Level Radioactive Waste Disposal Facility,* Revision 2. January 1991.
NUREG-1241, *Licensing of Alternative Methods of Disposal of Low-Level Radioactive Waste*
NUREG-1573, *A Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities*
Regulatory Guide 4.19, *Guidance for Selecting Sites for Near-Surface Disposal of Low-Level Radioactive Waste,* August 1988
Uranium Recovery
NUREG-1724, *Standard Review Plan for the Review of DOE Plans for Achieving Regulatory Compliance at Sites with Contaminated Ground Water Under Title I of the Uranium Mill Tailings Radiation Control Act: Draft Report for Comment*, June 2000
NUREG- 1623, *Design of Erosion Protection for Long-Term Stabilization,* September 2002
NUREG-1620, Rev. 1. *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*, June 2003
NUREG-1569, *Standard Review Plan for In Situ Leach Uranium Extraction License Applications*, June 2003
Uranium Mill In-Situ Leach Uranium Recovery, and 11e.(2) Byproduct Material Disposal Site Decommission Inspection,(Procedure 87654), March 2002
Decommissioning
NUREG/CR-5512, *Residual Radioactive Contamination From Decommissioning Parameter Analysis,* April 1996.
NUREG-1556, *Consolidated Guidance About Nuclear Materials*, Vol 1-20
NUREG-1700, *Standard Review Plan for Evaluating Nuclear Power Reactor License Termination Plans,* April 2003.
Regulatory Guide 1.184, *Decommissioning Of Nuclear Power Reactors*, July 2000.
Regulatory Guide 1.185, *Standard Format and Content for Post-shutdown Decommissioning Activities,* July 2000.
NRC Regulatory Issue Summary 2002-02, *Lessons Learned Related to Recently Submitted Decommissioning Plans and License Termination Plans*, January 2002
NRC Regulatory Issue Summary 2004-08 *Results Of The License Termination Rule Analysis,* May 28, 2004.
NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual,* Revision 1. August 2001.
NUREG-1757, *Consolidated NMSS Decommissioning Guidance*, Volumes 1-3
Action Plan to Ensure Timely Cleanup of Site Decommissioning Management Plan Sites, 57 FR 13389 April 1992.
Regulatory Guide 1.179, *Standard Format and Content of License Termination Plans for Nuclear Power Reactors*, January 1999.
NUREG/CR-6477, *Revised Analyses of Decommissioning Reference - Non-Fuel-Cycle Facilities*, December 2002.

Annex E-1. NRC Guidance

NUREG-1628, *Staff Responses to Frequently Asked Questions Concerning Decommissioning of Nuclear Power Reactors*, June 2000.
NUREG-0586, *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities* (also NUREG-0586 Supplement 1, Vols. 1 & 2)
NUREG-1496, *Generic Environmental Impact Statement in Support of Rulemaking on Radiological Criteria for license Termination of NRC-Licensed Nuclear Facilities*, Vols. 1-3, U.S. Nuclear Regulatory Commission, Washington, D.C.
Spent Fuel Management
NUREG-1536, *Standard Review Plan for Dry Cask Storage Systems*
NUREG-1567, *Standard Review Plan for Spent Fuel Dry Storage Facilities*
Interim Staff Guidance:
ISG-1, *Damaged Fuel*
ISG-2, *Fuel Retrievability*
ISG-3, *Post Accident Recovery and Compliance with 10 CFR 72.122(l)*
ISG-4, *Cask Closure Weld Inspections*
ISG-5, *Confinement Evaluation*
ISG-6, *Establishing Minimum Initial Enrichment for the Bounding Design Basis Fuel Assembly(s)*
ISG-7, *Potential Generic Issue Concerning Cask Heat Transfer in a Transportation Accident*
ISG-8, *Burnup Credit in the Criticality Safety Analyses of PWR Spent Fuel in Transport and Storage Casks*
ISG-9, *Storage of Components Associated with Fuel Assemblies*
ISG-10, *Alternatives to the ASME Code*
ISG-11, *Cladding Considerations for the Transportation and Storage of Spent Fuel*
ISG-12, *Buckling of Irradiated Fuel Under Bottom End Drop Conditions*
ISG-13, *Real Individual*
ISG-14, *Supplemental Shielding*
ISG-15, *Materials Evaluation*
ISG-16, *Emergency Planning*
ISG-17, *Interim Storage of Greater Than Class C Waste*
ISG-18, *The Design/Qualification of Final Closure Welds on Austenitic Stainless Steel Canisters as Confinement Boundary for Spent Fuel Storage and Containment Boundary for Spent Fuel Transportation*
Regulatory Guide 3.44, *Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation (Water-Basin Type)*, Rev.2, January 1989
Regulatory Guide 3.48, *Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation or Monitored Retrievable Storage Installation (Dry Storage)*, Rev. 1, August 1989
Regulatory Guide 3.49, *Design of an Independent Spent Fuel Storage Installation (Water-Basin Type)*, December 1981
Regulatory Guide 3.50, *Standard Format and Content for a License Application To Store Spent Fuel and High-Level Radioactive Waste* (Draft FP 907-4 published 3/1981) Rev. 1. September 1989
Regulatory Guide 3.53, *Applicability of Existing Regulatory Guides to the Design and Operation of an Independent Spent Fuel Storage Installation*, July 1982
Regulatory Guide 3.54, *Spent Fuel Heat Generation in an Independent Spent Fuel Storage Installation*, Rev.1. January 1999
Regulatory Guide 3.60, *Design of an Independent Spent Fuel Storage Installation (Dry Storage)*, March1987
Regulatory Guide 3.61, *Standard Format and Content for a Topical Safety Analysis Report for a Spent Fuel Dry Storage Cask*, February 1989
Regulatory Guide 3.62, *Standard Format and Content for the Safety Analysis Report for Onsite Storage of Spent Fuel Storage Casks*, February 1989

Annex F-1. Qualification Requirements for NRC Staff and Procedures Related to Spent Fuel or Radioactive Waste Inspection

Manual Chapter	Title	Issue Date
1246A08	*Division of Waste Management Inspectors and License Reviewers*	5-Jan-2001
1246A09	*Decommissioning Inspector*	5-Jan-2001
1246A10	*Division of Waste Management Decommissioning Project Managers & Technical Reviewers*	14-Apr-2003
1246A12	*Training Requirements For Uranium Recovery Inspector*	5-Jan-2001
1246A13	*Training Requirements For Uranium Recovery License Reviewer*	5-Jan-2001
1246A14	*Training Requirements For High-Level Waste Repository Inspector*	14-Apr-2003
1246A15	*Training Requirements For High-Level Waste Repository License Technical Reviewers*	14-Apr-2003
1246B08	*Division Of Waste Management Inspectors and License Reviewers*	5-Jan-2001
1246B09	*Decommissioning Inspector*	5-Jan-2001
1246B10	*Division of Waste Management Decommissioning Project Managers & Technical Reviewers*	14-Apr-2003
1246B12	*Uranium Recovery Inspector NRC Inspector Journal*	5-Jan-2001
1246B13	*Uranium Recovery Project Manager/Technical Reviewer NRC Project Manager/Technical Reviewer Qualification Journal*	5-Jan-2001
1246B14	*High-Level Waste Repository Inspector NRC Inspector Qualification Journal*	14-Apr-2003
1246B15	*High-Level Waste Repository License Technical Reviewer NRC Technical Reviewer Qualification Journal*	14-Apr-2003
2300	*Yucca Mountain Pre-Operation Inspection Program*	20-Jun-2001
2401	*Near-Surface Low-Level Radioactive Waste Disposal Facility Inspection Program*	27-Nov-2001
2561	*Decommissioning Power Reactor Inspection Program*	14-Apr-2003
2602	*Decommissioning Inspection Program For Fuel Cycle Facilities And Materials Licensees*	4-Jun-1997
2605	*Decommissioning Procedures For Fuel Cycle And Materials Licensees*	12-Nov-1996
2620	*On-Site Construction Reviews Of Remedial Action At Inactive Uranium Mill Tailing Sites (Title I, Uranium Mill Tailings Radiation Control Act)*	5-Oct-2001
2690	*Inspection Program For Dry Storage Of Spent Reactor Fuel At Independent Spent Fuel Storage Installations*	3-Dec-2001
2690A	*Inspection Program For An ISFSI Located At A Reactor Site*	3-Dec-2001
2690B	*Inspection Program For An ISFSI Located Away From Any Reactor Site*	3-Dec-2001
2801	*Uranium Mill 11e.(2) Byproduct Material Disposal Site And Facility Inspection Program*	25-Aug-2000

Annex F-2. Radiation Protection Guidance	
Federal guidance is a set of guidelines developed by EPA for use by Federal and state agencies responsible for protecting the public from the harmful effects of radiation. Guidance on radiation protection from EPA comes in two forms:	
• Federal Guidance Recommendations, which are signed by the President and usually reflected in Federal regulations for radiation protection of workers or the general public, and	
• Federal Guidance Technical Reports, which help standardize radiation dose and risk assessment methodologies.	
Federal Guidance Recommendations	
Radiation Protection Guidance for Federal Agencies, Federal Radiation Council 25 FR 9057 September 26, 1961.	This guidance provides recommendations for population groups exposed to environmental sources of radiation. It provides Radiation Protection Guides; guidance on general principles of control applicable to all environmental radionuclides; and specific guidance in connection with exposure of population groups to radium-226, iodine-131, strontium-90, and strontium-89.
Radiation Protection Guidance for Federal Agencies, Federal Radiation Council 25 FR 4402 May 18, 1960.	This guidance provides a general framework for radiation protection and general principles of radiation control based on the annual intake of radioactive materials. These recommendations provide the basis for the control and regulation of radiation exposure during normal peacetime operations. Numerical values for the Radiation Protection Guides, designed to limit the exposure of the whole body and certain organs, are provided.
Radiation Protection Guidance to Federal Agencies for Occupational Exposure, U.S. Environmental Protection Agency 52 FR 2822 January 27, 1987.	This guidance provides general principles, and specifies the numerical primary guides for limiting worker exposure. It applies to all workers who are exposed to radiation in the course of their work, either as employees of institutions and companies subject to Federal regulation or as Federal employees.
Radiation Protection Guidance to Federal Agencies for Diagnostic X-rays, U.S. Environmental Protection Agency 43 FR 4377 February 1, 1978.	This guidance provides recommendations to reduce radiation exposure from the use of diagnostic x-rays. These recommendations, transmitted to the President jointly by EPA and the Department of Health, Education and Welfare were based on two guiding principles: avoidance of unnecessary prescription of x-rays, and use of good technique to minimize radiation exposure.
Underground Mining of Uranium Ore, Federal Radiation Council 34 FR 576 January 15, 1969 35 FR 245 December 18, 1970.	This guidance sets forth recommendations for radiation protection activities as they apply to the underground mining of uranium ore. EPA subsequently reviewed these recommendations and concluded no modification was necessary.
Federal Guidance Technical Reports	
Technical reports summarize current scientific and technical information for radiation dose and risk assessments. Examples of technical reports are:	
Background Material for the Development of Radiation Protection Standards, Federal Radiation Council, July 1964.	This guidance provides background material used in the development of guidance for Federal agencies for (1) planning protective actions to reduce potential doses to the population from radioactive fission products which may contaminate food, and (2) doses at which implementation of protective actions may be appropriate.
The Radioactivity Concentration Guides, EPA 520/1-84-010, December 1984.	This guidance provides numerical values for the concentrations of radioactivity in air and water, corresponding to the limiting annual doses recommended for workers in the 1960 *Federal Guidance Document, Radiation Protection Guidance for Federal Agencies*, and
Cancer Risk Coefficients for Environmental Exposure to Radionuclides, EPA 402-R-99-001, September 1999.	This guidance provides methods and data for estimating risks due to both internal and external radionuclide exposures. The information presented in this report is for use in assessing risks from radionuclide exposure in a variety of applications ranging from environmental impact analyses of specific sites to the general analyses that support rulemaking

Annex F-3. Emergency Event Categories

The vast majority of events reported to NRC are routine and do not require activation of its incident response program. See *How We Respond to an Emergency*[101] for information on how NRC responds to threatening public health and safety emergencies. NRC-licensed facilities have various classes of emergencies. Both power and non-power reactor licensees use the following four emergency classes, in order of increasing severity.

Category	Description
Notification of Unusual Event	Under this category events are in process or have occurred which indicate potential degradation in the level of plant safety. No release of radioactive material requiring off-site response or monitoring is expected unless further degradation occurs.
Alert	An alert is declared if events are in process or have occurred involving an actual or potential substantial degradation in the level of safety of the plant. Any releases of radioactive material from the plant are expected to be limited to a small fraction of U.S. Environmental Protection Agency (EPA) protective action guidelines.
Site Area Emergency	A site emergency involves events in process or having occurred resulting in actual or likely major failures of plant functions needed to protect the public. Any releases of radioactive material are not expected to exceed U.S. Environmental Protection Agency (EPA) protective action guidelines except near the site boundary.
General Emergency	A general emergency involves actual or imminent substantial core damage or melting of reactor fuel with the potential for loss of containment integrity. Radioactive releases during a general emergency can reasonably be expected to exceed U.S. Environmental Protection Agency (EPA) protective action guidelines for more than the immediate site area.

Emergencies for nuclear materials licensees and fuel cycle facilities are classified as either **Alert** or a **Site Area Emergency** (roughly equivalent in severity to the reactor event classes above). Some nuclear materials licensees may also use the **Unusual Event** classification to notify officials of events of a lower safety significance, although not required by NRC regulations.

[101] http://www.nrc.gov/what-we-do/emerg-preparedness/respond-to-emergency.html

Annex F-4. NRC Participation in Emergency Exercises During 2004

Date	Facility/Activity/ Exercise Title	State	Participants	Comments
01/30/2004	Senior Officials Exercise #2	District of Columbia	HQ	Federal Sponsored Senior Official Exercise
2/14-21/04	Unified Defense 04 (NORTHCOM)	Texas	HQ and Region IV	Federal Sponsored Full Exercise (NRC participation on 2/19--21/04)
02/18/2004	St. Lucie	Florida	Region II	Region
03/16/2004	Catawba	South Carolina	HQ and Region II	Full Exercise
03/23/2004	Fermi II	Michigan	Region III	Region
5/12-13/04	Forward Challenge 04	N/A	All COOPs	Federal COOP Exercise (NRC full participation)
05/11/2004	Beaver Valley	Pennsylvania	Region I	Ingestion Pathway Exercise (Ingestion Team only)
06/08/2004	Indian Point	New York	HQ and Region I	Full Exercise
06/09/2004	River Bend	Louisiana	IV	Region
06/16/2004	Prairie Island	Minnesota	III	Region
8/4-10/04	Determined Promise (NORTHCOM)	N/A	HQ and Regions II and IV	Federal Sponsored Full Exercise
8/6-7/04	Amalgam Virgo (NORAD)	N/A	HQ and Regions II and IV	Federal Sponsored Full Exercise
8/10-11/04	South Texas	Texas	Region IV	Ingestion Pathway Exercise (Ingestion Team only)
9/13-15/04	Millstone	Connecticut	Region I	Ingestion Pathway Exercise (Ingestion Team only)
09/14/2004	Transportation Event	N/A	II	Tabletop Exercise
09/16/2004	Waterford	Louisiana	Region IV	Ingestion Pathway Exercise (Ingestion Team only)
09/21/2004	Cooper	Nebraska	HQ and Region IV	Full Exercise
09/22/2004	Vogtle	Georgia	Region II	Ingestion Pathway Exercise (Ingestion Team only)
09/29/2004	Paducah GDP	Kentucky	Region II	Region
10/05/2004	Perry	Ohio	HQ and Region III	Full Exercise

Annex F-5. Requirements for Notifying NRC of Emergency and Non-Emergency Events[102]

Specific requirements for NRC-licensed radioactive materials and commercial nuclear facilities[103]
Standards for Protection Against Radiation (10 CFR Part 20):
➢ §20.2201 Reports of theft or loss of licensed material.
➢ §20.2202 Notification of incidents.
➢ §20.2203 Reports of exposures, radiation levels, and concentrations of radioactive material exceeding the constraints or limits.
Domestic Licensing of Byproduct Material (10 CFR 30.50) Reporting requirements.
Domestic Licensing of Source Material (10 CFR 40.60) Reporting requirements.
Domestic Licensing of Production and Utilization Facilities (10 CFR Part 50):
➢ §50.72 Immediate notification requirements for operating nuclear power reactors.
➢ §50.73 Licensee event reporting system.
Domestic Licensing of Special Nuclear Material (10 CFR Part 70):
➢ §70.50 Reporting requirements.
➢ §70.52 Reports of accidental criticality or loss or theft or attempted theft of special nuclear material.
➢ §70.74 Additional reporting requirements (Appendix A - Reportable Safety Events)
Licensing Requirements for Independent Storage of Spent Fuel and High-Level Radioactive Waste (10 CFR Part 72):
➢ §72.74 Reports of accidental criticality or loss of special nuclear material.
➢ §72.75 Reporting requirements for specific events and condition.
Material Control and Accounting of Special Nuclear Material (10 CFR 74.11 Reports of loss or theft or attempted theft or unauthorized production of special nuclear material).
Certification of Gaseous Diffusion Plants (10 CFR 76.120 Reporting requirements.
Examples of non-reactor incident reports
NUREG-1405 *Inadvertent Shipment of a Radiographic Source from Korea to Amersham Corporation, Burlington, Massachusetts* (Publication Date: May 1990)
NUREG-1450 *Potential Criticality Accident at the General Electric Nuclear Fuel and Component Manufacturing Facility, May 29, 1991* (Publication Date: August 1991)
NUREG-1480 *Loss of an Iridium-192 Source and Therapy Misadministration at Indiana Regional Cancer Center Indiana, Pennsylvania on November 16, 1992* (Publication Date: February 1993)
NUREG-1535 *Ingestion of Phosphorus-32 at Massachusetts Institute of Technology, Cambridge, Massachusetts, Identified on August 19, 1995* (Publication Date: December 1995)
Links to Additional Information on Response to Incidents
State Emergency Management Agencies: http://www.nrc.gov/what-we-do/emerg-preparedness/federal-state-local/agency-sites.html
Federal Emergency Management Agency (FEMA): http://www.fema.gov/
Department of Energy (DOE): http://energy.gov/engine/content.do?BT_CODE=NS_SS5
U.S. Environmental Protection Agency (EPA): http://www.epa.gov/
Department of Agriculture (USDA): http://www.usda.gov/
Department of Health and Human Services (HHS): http://www.hhs.gov/
Department of State (DOS): http://www.state.gov/
Federal Bureau of Investigation (FBI): http://www.fbi.gov/
Department of Homeland Security: http://www.dhs.gov/dhspublic/

[102]For more information on NRC Incident Investigation Program, see NRC Management Directive 8.3, NRC Incident Investigation Program accessible at: http://www.nrc.gov/what-we-do/emerg-preparedness/faq/ml031250592.pdf
[103]There are equivalent requirements for the relevant Agreement States.

Annex F-6. Emergency Preparedness and Planning at Diverse Waste Management and Disposal Facilities

Geological Repository for Spent Fuel and HLW

NRC requires DOE develop and be prepared to implement a plan to cope with radiological accidents occurring at the geologic repository operations area, at any time before permanent closure and decontamination or decontamination and dismantlement of surface facilities (10 CFR 63.161). The emergency plan must be based on the criteria of 10 CFR 72.32(b). These criteria require an Emergency Plan including:

- Facility description,
- Types of accidents,
- Classification of accidents,
- Detection of accidents,
- Mitigation of consequences,
- Assessment of releases,
- Responsibilities,
- Notification and coordination,
- Information to be communicated,
- Training,
- Safe condition,
- Exercises,
- Hazardous chemicals,
- Comments on Plan,
- Off-site assistance, and
- Arrangements made for providing information to the public.

LLW Facilities

An applicant must provide a description of the radiation safety program for control and monitoring of radioactive effluents as part of the radiation safety program required for a specific license to dispose of LLW. The objective is to ensure compliance with performance requirements in the regulation (10 CFR 61.41), occupational radiation exposure to comply with 10 CFR Part 20 and control contamination of personnel, vehicles, equipment, buildings, and the disposal site. Both routine operations and accidents are addressed. The program description includes procedures, instrumentation, facilities, and equipment. The regulations specific to emergency planning are in 10 CFR 61.12(k) and §61.13.

The applicant for a near surface disposal site for low-level radioactive waste (LLW) must propose an emergency response plan. NRC or Agreement States will review this plan to determine whether the licensee would be able to respond to all credible radiological accidents and emergencies consistent with the proposed method of operations. The criteria to assess such a demonstration are in NUREG-1200 *Standard Review Plan for the Review of a license application for a LLW Disposal Facility*. These criteria include:

- Compliance with 44 CFR Part 350, *Review and Approval of State and Local Radiological Emergency Plans and Preparedness*;
- Establishing plans to respond to all credible radiological accidents and emergencies consistent with the proposed method of operations; and

- Demonstrating the maximum off-site releases for the most credible accident consistent with the projected source term will yield an off-site dose equivalent of less than 0.1 mSv (0.01 rem) to the whole body and 0.5 mSv (0.05 rem) to the lungs.

The applicant must develop emergency procedures, including interaction with local and State authorities, as well as notification of affected populations where the maximum potential off-site releases yield greater dose equivalents. Such procedures must be developed with knowledge, participation and cooperation of these authorities and affected populations.

The applicant presents this analysis in the safety analysis report provided with the license application; the Standard Format and Content of a license application for a Low-Level Radioactive Waste Disposal Facility (NUREG-1199, Rev. 2) and the Environmental Standard Review Plan for the review of a license application for a Low-Level Radioactive Waste Disposal Facility (NUREG-1300) provide guidance for prospective applicants. The accident scenarios addressed include:

- Waste spillage
- Fire and/or chemical reactions
- Transportation accidents
- Nuclear criticality, and
- On-site effects of off-site accidents.

Uranium Recovery Waste Management Facilities

Accidental releases and emergency preparedness are addressed as part of the operational phase of uranium recovery. The perpetual disposal design is required to be robust and not need active maintenance to assure isolation and stability from 200 to 1000 years. Operational considerations for emergency planning during the operational phase are addressed in 10 CFR 40.31(j)(3). The list of items to address is provided in Section F.11.1.1.

Credible incidents at a uranium milling facility and at a uranium mine would result in minor exposures as mentioned in Section F11.1.1. The analysis documented in NUREG-1140 estimates a 1-mSv (0.1-rem) effective dose equivalent under the most adverse weather conditions for a fire at a uranium mill. Fires and uranium mill tailings releases (dam failures, pipeline ruptures, etc…) from the late 1950s through the early 1980s are documented in NUREG-1140.

Decommissioning

NRC does not identify a critical radiological accident for 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 decommissioning or license termination plan (DP or LTP). NRC reviews the plan as part of its review and approval of the DP or LTP.

NRC initiated an effort in the early 1990s, to revise the regulatory requirements for decommissioning nuclear power plants. NRC published NUREG-1738 *Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants* with the focus on accidents and off-site exposure. This report concluded the only postulated scenario at a decommissioning plant resulting in a significant off-site radiological release is a beyond-design-basis event commonly referred to as a zirconium fire. An event sequence resulting in a zirconium fire begins with a substantial loss of water from the spent fuel pool (SFP), uncovering the spent fuel.[104]

NRC concluded in NUREG-1738 the risk from an SFP zirconium fire at decommissioning plants is very low, and well below NRC safety goals for operating reactors. The study found the event sequences most important to the zirconium fire risk at decommissioning plants are large (catastrophic) earthquakes and dropped spent fuel casks. The likelihood of a large off-site radiological release impacting public health and safety from a decommissioning plant is considerably lower than the likelihood of such a release from an operating reactor when including initiating events with normal and abnormal operations, design basis accidents, and beyond design basis accidents.

NUREG-1738 also presented thermal-hydraulic analyses of the stored spent fuel when SFP cooling is lost or the spent fuel is uncovered. NRC found a generic decay heat level (and, therefore, decay time) beyond which a zirconium fire is physically impossible cannot be defined. This is because the geometry of the spent fuel assemblies, the associated air cooling flow paths, and the resultant heat transfer rates are not predictable following a major dynamic event (such as a very severe earthquake), which could rupture and rapidly drain the SFP. The study concluded the possibility of a zirconium fire cannot be dismissed even many years after final reactor shutdown. NRC notes, however, the sequences in which a zirconium fire comes about are very low likelihood sequences. The sufficiency of previous exemptions ruling out a zirconium fire based on air cooling calculations assuming normal SFP assembly configurations and geometries has been reconsidered.

The risk from a zirconium fire was examined in NUREG-1738 for a "generic" decommissioning plant. The study quantified the initiating event frequencies (i.e., events that can lead to uncovering spent fuel). The initiating event frequencies were determined to be very low and dominated by the frequency of severe earthquakes. The frequency of such events leading to a zirconium fire is less than $3x10^{-6}$ per year at most decommissioning plant sites. These conclusions apply to decommissioning facilities having certain design, operational, and administrative characteristics assumed in the risk study. Such characteristics are identified in NUREG-1738 as industry decommissioning commitments and staff decommissioning assumptions (SDAs). Zirconium fire probabilities may be higher for facilities not satisfying these staff assumptions or industry commitments, and may be lower for facilities having different seismic characteristics. The likelihood of a zirconium fire at a facility not implementing all the industry decommissioning commitments and SDAs cannot be determined from NUREG-1738. A plant-specific assessment would be required to determine the likelihood of a zirconium fire at such a facility. The NUREG-1738 study also included zirconium fire consequence assessments. The results demonstrated as long as the fuel uncovery frequency is less than 10^{-5} per year, the zirconium fire risk is low and within the Commission's Quantitative Health Objectives. The study also developed an approach similar to Regulatory Guide 1.174, *An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis*, to assist decommissioning plant regulatory decision making.

Plant-specific evaluations were performed by estimating the frequency of a significant loss of coolant or a sustained loss of cooling. These estimated frequencies were compared with the criteria of NUREG-1738. NRC concluded no new or revised requirements were warranted. The issue was closed in December 2001.

[104]SECY-01-0100 Policy Issues Related To Safeguards, Insurance, And Emergency Preparedness Regulations At Decommissioning Nuclear Power Plants Storing Fuel In Spent Fuel Pools. Available at URL - http://www.nrc.gov/reading-rm/doc-collections/commission/secys/2001/secy2001-0100/2001-0100scy.html#_1_4_

The regulations governing the development and implementation of EALs for nuclear power licensees are in 10 CFR Part 50. However, NRC Regulatory Issue Summary 2003-18, Supplement 1, Use of Nuclear Energy Institute 99-10, *Methodology for Development of Emergency Action Levels*, was issued to all holders of operating licenses for nuclear power reactors and licensees that have permanently ceased operations and have certified fuel has been permanently removed from the reactor vessel. Specific guidance is provided that licensees can justify such changes, in some cases not needing prior NRC approval.

Role of Inspection and Emergency Preparedness for Decommissioning

NRC is developing a Master Inspection Plan using, in part, existing procedures. Existing Inspection Manual Chapters, Inspection Procedures and Temporary Instructions are now applicable and recommended for use in inspection of sites undergoing decommissioning. IP 88045 can be used for emergency preparedness inspection at facilities undergoing decommissioning. The objectives of this procedure are to ensure:

- The licensee's emergency preparedness program is maintained in a state of operational readiness.
- The licensee has developed procedures to implement its emergency preparedness program.
- Appropriate training is provided to plant personnel to implement the emergency procedures.
- The licensee's emergency preparedness program is coordinated with off-site support agencies.
- The licensee conducts drills and/or exercises to test the facility emergency plan.
- The emergency equipment and facilities in the emergency preparedness program are operable and properly maintained.

Additional implementation guidance is further detailed in the IP.[105]

[105] This document can be downloaded from URL - http://www.nrc.gov/reading-rm/doc-collections/insp-manual/inspection-procedure/ip88050.pdf

Annex F-7. Criticality Control Standards & Guides for DOE Facilities	
ANSI/ANS-8.1	*Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*
ANSI/ANS-8.3, (ANSI N-16.2)	*Criticality Accident Alarm System*
ANSI/ANS-8.5, (ANSI N-16.4)	*Use of Borosilicate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Material*
ANSI/ANS-8.6	*Safety in Conducting Subcritical Neutron-Multiplication Measurements In Situ*
ANSI/ANS-8.7	*Guide for Nuclear Criticality Safety in the Storage of Fissile Materials*
ANSI/ANS-8.9	*Nuclear Criticality Safety Criteria for Steel-Pipe Intersections Containing Aqueous Solutions of Fissile Materials*
ANSI/ANS-8.10	*Criteria for Nuclear Criticality Safety controls in Operations With Shielding and Confinement*
ANSI/ANS-8.12	*Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors*
ANSI/ANS-8.15	*Nuclear Criticality Control of Special Actinide Elements*
ANSI/ANS-8.17	*Criticality Safety Criteria for the Handling, Storage and Transportation of LWR Fuel Outside Reactors*
ANSI/ANS-8.19	*Administrative Practices for Nuclear Criticality Safety*
ANSI/ANS-8.20	*Nuclear Criticality Safety Training*
ANSI/ANS-8.21	*Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors*
ANSI/ANS-8.22	*Nuclear Criticality Safety Based on Limiting and Controlling Moderators*
ANSI/ANS-8.23	*Nuclear Criticality Accident Emergency Planning and Response*
ANSI/ANS-13.3	*Dosimetry for Criticality Accidents*
NRC Regulatory Guide 3.71	*Nuclear Criticality Safety Standards for Fuels and Material Facilities*
DOE Guidance 421.1-1	*Criticality Safety Good Practices Guide for DOE Nonreactor Nuclear Facilities*

Annex F-8. U.S. EPA Public Outreach on the Waste Isolation Pilot Plant (WIPP)[106]

Development of Public Information Documents

EPA's first outreach document, *EPA's WIPP Implementation Strategy*, explained in detail the Agency's plan for carrying out its WIPP role and responsibilities. Another publication, *EPA and the WIPP* described EPA's regulatory oversight role and responsibilities. *EPA's Communications Plan for the WIPP* set forth the Agency's commitment to conducting business in an open and public manner, outlined its public outreach program, including the needs assessment findings and recommendations, and provided a listing of public information documents and resources as well as opportunities for public involvement throughout the rulemaking process. Because the Agency wanted to keep as many New Mexicans as possible informed about and involved in EPA's WIPP-related activities, the Agency also made some of its documents and materials available in both English and Spanish.

Partnership with the National Safety Council

In 1996 EPA entered into a cooperative agreement with the National Safety Council's (NSC) Environmental Health Center to perform activities to improve public awareness of the health risks associated with the WIPP and increase the understanding of the various Federal and state agencies with WIPP-related regulatory responsibilities. NSC, a nonprofit, non-governmental public service organization with state- and community-based chapters and offices throughout the U.S., is a recognized source of worker, public safety, and environmental health information.

In September 1996, the NSC, in conjunction with the University of New Mexico's Institute for Public Policy, conducted three focus groups in New Mexico and a series of statewide public interviews. The purpose of these interviews was to determine the public's knowledge of the WIPP and the oversight and regulatory process surrounding it. In response to the questions New Mexicans posed during the focus groups and interviews, the NSC developed public information materials to address their concerns. These materials ranged from fact sheets and a booklet on frequently asked questions about the WIPP, to poster displays on EPA's public participation opportunities and on EPA's WIPP certification decision. NSC also published *A Reporter's Guide to the WIPP*-- a guide for the media on WIPP issues that includes a listing of contacts and resources.

Development of Public Information Resources

In response to the public's request to keep them informed and involved in EPA's WIPP activities, EPA established these resources:

WIPP Information Line — A toll-free telephone line, 1-800-331-WIPP, with a recorded message (in English or Spanish) provides updates on EPA's WIPP activities.

WIPP Stakeholder Mailing List — The stakeholder list includes members of the general public, interest groups, the media, tribes, environmental groups, private industry, and members of Congress, as well as staff from Federal, state and local government agencies interested in receiving information concerning EPA's WIPP activities.

[106] Excerpts from, *Reaching out to Multiple Stakeholders, EPA's Public Outreach and Communications Program for the Waste Isolation Pilot Plant,*, by Rafaela Ferguson and Cheryl Malina, U.S. Environmental Protection Agency.

WIPP Home Page — EPA provides on-line information about WIPP program activities including announcements, updates on public outreach activities, and publications such as EPA's WIPP-related standards and rulemakings. The address is http://www.epa.gov/radiation/wipp.

WIPP Dockets — Documents supporting EPA's WIPP rulemaking decisions, such as reports, meeting notes, and correspondence, are available for public inspection at libraries in Albuquerque, Santa Fe, and Carlsbad, New Mexico, and Washington, DC.

Consultation with Experts and the Public — EPA consulted frequently with experts and the public on the many issues involving its oversight of the WIPP.

NACEPT WIPP Review Committee — In 1992, EPA established an advisory committee of independent technical experts under the National Advisory Council for Environmental Policy and Technology (NACEPT) to provide advice and counsel on technical and policy issues associated with the Agency's WIPP activities. These meetings were open to the public and provided opportunities to comment on the issues addressed by the advisory committee.

Technical Exchange Meetings and Workshops — EPA has held many technical exchange meetings with DOE since 1992 on DOE's program for demonstrating WIPP's compliance with EPA's radioactive waste disposal standards. The public was invited to attend these meetings and summary reports were filed in the WIPP dockets. EPA also invited national and international experts and representatives from other Federal agencies and from New Mexico, including citizen groups, to participate in a three-day Technical Workshop on WIPP Compliance Criteria issues. The Workshop included time for audience comments and questions.

Public Hearings — Public hearings with significant advance notice are official parts of EPA WIPP rulemakings. They offer the public a forum where individuals can personally testify and present their opinions to the Agency. Some 815 people testified at EPA's WIPP hearings and EPA reviewed and addressed more than 1,450 oral and written public comments in developing its WIPP rulemaking decisions.

Stakeholder Meetings — EPA held frequent, informal meetings with interested stakeholders to keep then informed and to receive their feedback on WIPP oversight issues.

Meeting Information and Notices — Information about public meetings, hearings, and requests for written comments were published in the *Federal Register*, announced on the WIPP Information Line, and advertised in local and major newspapers in New Mexico in both English and Spanish.

Media Relations — EPA issues press advisories and conducted audio teleconferences with the media to announce key EPA decisions about WIPP. The NSC *A Reporter's Guide to the WIPP*. This guide was well received by the news media.

Congressional Relations — EPA conducts briefings before members of Congress to keep them informed of EPA's WIPP activities and publishes an annual Report to Congress on the Agency's WIPP activities and resources.

Conferences and Meetings — EPA participates in international, national, state, and industry-sponsored conferences on radioactive waste management issues and in quarterly meetings of the National Academy of Sciences' WIPP Panel.

Annex F-9. Additional Information on DOE Safety Requirements

The Joint Convention references the need for commissioning programs to demonstrate that a facility, as constructed, is consistent with design and safety requirements. This is required for DOE facilities under DOE Order 425.1B, *Startup and Restart of Nuclear Facilities*. All DOE spent fuel management and radioactive waste management facilities fall under this startup order. The Order requires a readiness review and assessment process, in all cases, demonstrating it is safe to start (or restart) the facility. The facility must be started (or restarted) only after documented independent reviews of readiness have been conducted and the approvals specified in this Order have been received. Readiness reviews provide an independent confirmation of readiness to start or restart operations and are not line management tools. Operational readiness reviews evaluate minimum core principles:

- Line management is responsible for the protection of employees, the public, and the environment;
- Clear and unambiguous lines of authority and responsibility for ensuring safety and health and protection of the environment are established and maintained at all organizational levels;
- Personnel possess the experience, knowledge, skills, and abilities necessary to perform their responsibilities;
- Resources are effectively allocated for environment, safety and health, programmatic, and operational considerations - protecting employees, the public, and the environment is a priority whenever activities are planned and performed;
- Associated hazards are evaluated and an agreed-upon set of standards and requirements is established Before work is performed, if properly implemented, provide adequate assurance employees, the public, and the environment are protected from harm;
- Administrative and engineering controls to prevent and mitigate hazards are tailored to the work being performed and associated hazards - emphasis should be on designing the work and/or controls to reduce or eliminate the hazards and to prevent accidents and unplanned releases and exposures; and
- The conditions and requirements for start and conduct of operations are established and agreed-upon by DOE and the contractor performing the work.

DOE has an extensive set of regulations and orders covering nuclear safety, conduct-of-operations, maintenance, and other functions such as monitoring, inspection, and testing to ensure safe operation of its nuclear facilities. DOE has a system to provide strict discipline for operations and maintenance programs. It is built on 10 CFR Part 830 and DOE Order 420.1A, *Facility Safety*, which covers nuclear safety design, criticality safety, fire protection, natural phenomena hazards mitigation, and a system engineer program. The following discussion focuses on activities demonstrating how the DOE facilities meet the terms of the Joint Convention.

Additional guidance on the implementation of 10 CFR Part 830 is found in DOE G 421.1-1, *Criticality Safety Good Practices Guide for DOE Nonreactor Nuclear Facilities*, DOE G 421.1-2, *Implementation Guide For Use in Developing Documented Safety Analyses To Meet Subpart B Of 10 CFR 830*, and DOE G 423.1-1, *Implementation Guide For Use In Developing Technical Safety Requirements*.

DOE Order 430.1A, *Life Cycle Asset Management*, requires DOE, in partnership with its contractors, plan, acquire, operate, maintain, and dispose of physical assets as valuable national resources. The management of physical assets, including spent fuel management facilities, from acquisition through operations and disposition, is integrated in a process linking life cycle phases. This Order also prescribes requirements for preparing decommissioning plans and documents for turnover of facilities at the end of their planned mission, consistent with the Joint Convention.

Another DOE Order impacting safe operations at nuclear facilities, DOE Order 433.1, *Maintenance Management Program for DOE Nuclear Facilities*, defines the program for managing of cost-effective maintenance of DOE nuclear facilities. Guidance for compliance with this Order is contained in DOE Guide 433.1-1, *Nuclear Facility Maintenance Management Program Guide for use with DOE Order 433.1*, which references Federal regulations, DOE directives, and industry best practices using a graded approach to clarify requirements and guidance for maintaining DOE-owned Government property.

A nuclear facility maintenance management program must contain a DOE-approved Maintenance Implementation Plan (MIP) in addition to the general maintenance program requirements of DOE Order 433.1. The nuclear facility maintenance management program must establish metrics to measure program performance and identify voluntary consensus standards incorporated into the program. Stewardship of physical assets is accomplished in a safe and cost-effective manner to meet the DOE mission, and to ensure protection of workers, the public, and the environment. Stewardship involves industry standards, a graded approach, and performance objectives. Operation and maintenance of physical assets must ensure:

- Identification, inventory, and periodic assessment of the condition of physical assets in the maintenance program;
- Establishment of requirements, budgets, and a work management system to maintain physical assets in a condition suitable for their intended use;
- Preventive, predictive, and corrective maintenance to ensure physical asset availability for planned use and/or proper disposition;
- A configuration management process to ensure the integrity of physical assets and system;
- Efficient and effective management and use of energy and utilities;
- A method for the prioritization of infrastructure requirements;
- Management of backlogs associated with maintenance, repair, and capital improvements
- A method to ensure, prior to the completion of mission, actions are implemented to place the facility, systems and materials in stable and known conditions, and to ensure hazards are identified and known, pending transfer or disposition.

As documented in the MIP, DOE mandates implementation of systems engineering to provide engineering and technical support at DOE nuclear facilities and ensure continued operational readiness of safety systems in *Facility Safety*, Order 420.1A. Qualified Cognizant System Engineers (CSE) are designated for each such system. The nuclear facility maintenance management program must be integrated with 10 CFR Part 830 and the overall Integrated Safety Management System (ISMS) established by DOE Policy 450.4, *Safety Management System Policy*, and other safety and quality assurance program regulations. The MIP is reviewed every two years and changes must be formally approved. The MIP addresses the following elements using a graded approach:

- Structures, systems, and components (SSCs) included in the program.
- Periodic inspections of SSCs and equipment, determining whether degradation or technical obsolescence threatens performance and/or safety.

- Management systems to control maintenance activities for the defined SSCs (these include work control, post-maintenance testing, material procurement and handling, and control and calibration of test equipment).
- Assignment of roles and responsibilities and maintenance-related training and qualification requirements.
- Interfaces between the maintenance organization and other organizations (e.g., operations, engineering, quality, training, industrial health).
- A configuration management process to ensure the integrity of the identified SSCs.
- A prioritization process to emphasize safety requirements, maintenance backlog, system availability, and requirements for those infrastructure elements identified as part of the nuclear facility safety basis.
- A process for feedback and improvement to provide information regarding operations, maintenance, and assessment;
- An accurate maintenance history compiling retrievable maintenance, resource, and cost data and a capability to enter required-maintenance costs, actual maintenance costs, and availability data and failure rates for mission-critical and safety SSCs into the DOE Facility Information Management System (per DOE Order 430.1A, described previously, and DOE Guide 433.1-1, *Nuclear Facility Maintenance Management Program Guide* for use with DOE Order 433.1); and
- A systems engineer program to manage vital safety systems consistent with DOE Order 420.1A and designates a "system engineer" with (a) the detailed knowledge of the system safety design basis and operating limits from the safety analysis and (b) the lead responsibility for the configuration management of design.

Large, complex, or very important systems may require assignment of one or more technical staff level personnel as Cognizant Systems Engineers (CSE) consistent with a graded approach to systems engineering. Small, simple, less important systems may only require assignment of technician level personnel. A program is developed within the context of the site and ISMS, including flow down of implementing procedures on the site and facility level and must provide for the CSE authorities, responsibilities, and accountability. A graded approach is used in applying the Program to specific systems. The system engineer program integrates the elements of identification of systems within its scope, configuration management, and CSE support for operations and maintenance. Configuration management is used to develop and maintain consistency among system requirements and performance criteria, system documentation, and physical configuration. Configuration management integrates the elements of system requirements and performance criteria, system assessments, change control/work control, and documentation control. DOE- STD-1073-93, *Guide for Operational Configuration Management Program,* dated November 1993, provides guidance for configuration management. DOE-STD- 3024-98, *Content of System Design Descriptions*, dated October 1998, provides guidance on identification and consolidation of key design documents. This activity directly supports facility safety basis development and documentation required by 10 CFR 830. System assessments include periodic review of system operability, reliability, and material condition during facility inspections required by DOE Order 433.1, *Maintenance Management Program for DOE Nuclear Facilities*. These periodic reviews assess the system's ability to perform its design and safety functions. Cognizant system engineers also periodically compare the system physical configuration to the system documentation. System and component performance is monitored and compared to established performance criteria. Work on systems, including maintenance and repair, is controlled under a formal change control and work control process to ensure changes are not inadvertently introduced and required system performance is not compromised. Systems are tested after modification to ensure continued capability to fulfill system requirements.

The CSE also provides technical assistance in support of line management responsibility to ensure continued operational readiness of the system. This requirement, applied to DOE nuclear facilities, meets the provisions of the Joint Convention. The CSE ensures configuration of assigned system(s) is being effectively managed. The CSE remains apprised of operational status and ongoing modification activities and assists operations personnel to review key system parameters and evaluates system performance. The CSE takes actions to correct problems, remains cognizant of system-specific maintenance/ operations history and industry operating experience, identifies trends from operations, provides assistance in determining operability or correcting out-of-specification conditions or evaluating questionable data, provides or supports analysis to determine operability when the system is suspected of inoperability or degradation. The CSE also reviews and concurs with design changes, and provides input to development of special operating/test procedures. The qualification requirements for the CSE position are strictly defined in DOE Order 5480.20A, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*.

The Joint Convention addresses reporting of incidents significant to safety. DOE Order 232.1A, *Occurrence Reporting and Processing of Operations Information*, prescribes reporting requirements for keeping government officials fully informed on a timely basis of these and a variety of other defined events. This information is analyzed for generic implications and for opportunities to improve operations. An electronic information system for reporting operations information related to DOE-owned and -leased facilities and processing information to identify the root causes of Unusual, Off-Normal, and Emergency Occurrences and provide corrective action has been established. The system is known as “ORPS,” Occurrence Reporting and Processing System. ORPS provides information to DOE for:

- Timely identification, categorization, notification, and reporting to DOE management of reportable occurrences at DOE-owned and -leased facilities;
- Review of reportable occurrences to assess the significance, root causes, generic implications, and the need for corrective actions;
- Timely evaluation and implementation of appropriate corrective actions; and
- Dissemination of occurrence reports to DOE operations and facilities to prevent similar occurrences and facilitate analyses.

A manual accompanies the Order providing specific information on occurrence reporting. The ORPS information system ensures data collection and analysis programs are in effect and working.

Reporting of emergencies is also governed by DOE Order 151.1A, *Comprehensive Emergency Management System*. This Order requires events be properly categorized and emergency notifications made. The DOE Headquarters Emergency Operations Center serves as the point of contact to receive of all emergency notifications and reports. It also coordinates, and disseminates emergency information to DOE organizations, the White House Situation Room, and other Federal agencies.

DOE emergency planning is required under NRC regulations in 10 CFR Part 63, Subpart I. DOE is specifically required to develop and be prepared to implement a plan to cope with radiological accidents occurring at the GROA, at any time before permanent closure and decommissioning of the surface facilities. This plan must comply with NRC’s Regulation 10 CFR 72.32(b) on the storage of spent fuel.

DOE Order 231.1, *Environment, Safety, and Health Reporting*, ensures collection and reporting of information on environment, safety and health required by law or regulation, or essential for evaluating DOE operations and identifying opportunities for improvement needed for planning purposes be collected.

Annex H-1 Locations and Status of Contaminated Formerly Licensed Sites

	Name	Location	Date of Lic. Term.	Status
1	U.S. Army Chemical Corp.	Fort McClellan, AL	1965	In process of decommissioning
2	Reynolds Metals	Bauxite, AR	1957	Transferred to Arkansas and successfully remediated
3	Aerojet General Co.	San Ramon, CA	1970	Transferred to California
4	Isotope Specialties	Burbank, CA	1959	Transferred to California
5	Isotope Specialties	Burbank, CA	1959	Transferred to California
6	Verdi Mill	Mojave, CA	1958	Transferred to California
7	United Nuclear	New Haven, CT	1974	In process of decommissioning
8	U.S. Naval Research Lab.	Washington, DC	1987	Closed via letter from Navy
9	Norton	Worcester, MA	1968	Closed - successfully remediated
10	AAR Manufacturing, Inc.	Livonia, MI	1970	In process of decommissioning
11	American Metal Products	Ann Arbor, MI	1964	Closed - successfully remediated
12	Frome Investment Co.	Detroit, MI	1970	Closed - successfully remediated
13	General Electric	Warren, MI	1970	Closed - successfully remediated
14	Tenneco Chemicals	Fords, NJ	1973	Closed - successfully remediated
15	Navy	St. Albans, NY	1973	Closed - new license issued to Veterans Affairs
16	Cleveland Pneumatic Tool Co.	Cleveland, OH	1972	Closed - successfully remediated
17	Clevite	Cleveland, OH	1962	Closed -successfully remediated
18	Horizons, Inc.	Cleveland, OH	1959	Transferred to Ohio
19	National Carbon Co. (Union Carbide)	Fostoria, OH	1964	Closed - successfully remediated
20	Standard Oil Co. (BP America)	Cleveland, OH	1973	Closed - successfully remediated
21	Thompson Products	Cleveland, OH	1963	Closed - successfully remediated
22	Union Carbide	Parma, OH	1972	Closed - successfully remediated
23	Kaiser Aluminum	Tulsa, OK	1971	In process of decommissioning
24	Atlantic Metals	Philadelphia, PA	1971	Closed - successfully remediated
25	Department of the Army	Frankford Arsenal, Philadelphia, PA	1981	In process of decommissioning

Annex H-1 Locations and Status of Contaminated Formerly Licensed Sites				
	Name	**Location**	**Date of Lic. Term.**	**Status**
26	International Chemical and Nuclear	West Mifflin, PA	1969	Closed - successfully remediated
27	Nuclear Laundry Rental Services	Jeanette, PA	1973	Closed - successfully remediated
28	Superior Steel	Pittsburgh, PA	1958	In process of decommissioning
29	Westinghouse Electric	Blairsville, PA	1961	In process of decommissioning
30	Union Carbide	Lawrenceburg, TN	1974	In process of decommissioning
31	American Smelting & Refining	Houston, TX	1971	Transferred to Texas
32	Dow Chemical	Freeport, TX	1964	Transferred to Texas
33	LTV Corporation	Dallas, TX	1964	Transferred to Texas
34	Marquardt Corp.	Ogden, UT	1971	Transferred to Utah
35	Marquardt Corp.	Hill AFB, UT	1972	Transferred to U.S. Air Force
36	Atlantic Research Corp.	Alexandria, VA	1979	Closed - review of records indicates the facility was decommissioned in 1995
37	Fostoria Glass	Moundsville, WV	1969	Closed - dose assessment indicated facility below 0.25 mSv/yr (25 mrem/yr)
38	Homer Laughlin	Newell, WV	1972	Under NRC review
39	International Mining Co.	Greenville, WY	1961	Under NRC review

Status of decommissioning sites still under NRC's jurisdiction can be found at:
http://www.nrc.gov/info-finder/decommissioning/complex/

Annex I-1. Provisions of Title 10, CFR Part 110: *Specific to Exports and Imports of Radioactive Waste*

Definitions of Radioactive Waste and Incidental Radioactive Material

Radioactive waste *means any waste that contains or is contaminated with source, byproduct, or special nuclear material, including any such waste that contains or is contaminated with "hazardous waste" as defined in section 1004(5) of the Solid Waste Disposal Act, 42 U.S.C. 6903(5), but such term does not include radioactive material that is:*

(1) Contained in a sealed source, or device containing a sealed source, that is being returned to any manufacturer qualified to receive and possess the sealed source or the device containing a sealed source;

(2) A contaminant on service equipment (including service tools) used in nuclear facilities, if the service equipment is being shipped for use in another nuclear facility and not for waste management purposes or disposal; or

(3) Generated or used in a United States Government waste research and development testing program under international arrangements.

Incidental Radioactive Material *means any radioactive material not otherwise subject to specific licensing under this part that is contained in or a contaminant of any non-radioactive material that:*

(1) For purposes unrelated to the regulations in this part, is exported or imported for recycling or resource recovery of the non-radioactive component; and

(2) Will not be processed for separation of the radioactive component before the recycling or resource recovery occurs or as part of the resource recovery process.

The term does not include material that contains or is contaminated with "hazardous waste" as defined in section 1004(5) of the Solid Waste Disposal Act, 42 U.S.C. 6903(5).

General Export License Provisions Modified In 10 CFR Part 110

§110.21 (d) – The general licenses in paragraphs (a), (b), and (c) of this section do not authorize the export of special nuclear material in ***radioactive waste****.*

§110.21 (e) – Persons using the general licenses in paragraphs (a), (b), and (c) of this section as authority to export special nuclear material as ***incidental radioactive material*** *shall file a completed NRC Form 7 before the export takes place if the total weight of the shipment exceeds 100 kilograms.*

§110.22 (f) – Paragraphs (a), (b), (c), and (d) of this section do not authorize the export under general license of source material in ***radioactive waste****.*

§110.22 (g) – Persons using the general licenses in paragraphs (a), (b), (c) and (d) of this section as authority to export source material as ***incidental radioactive material*** *shall file a completed NRC Form 7 before the export takes place if the total weight of the shipment exceeds 100 kilograms.*

*§110.23 (a) (1) – This section does not authorize the export of byproduct material to any embargoed country listed in § 110.28, or byproduct material in **radioactive waste**, or tritium for recovery or recycle purposes.*

*§110.23 (c) – Persons using the general licenses in paragraphs (a) of this section as authority to export byproduct material as **incidental radioactive material** shall file a completed NRC Form 7 before the export takes place if the total weight of the shipment exceeds 100 kilograms.*

Additional Criteria for Reviewing Applications for Export/Import of Radioactive Waste

Additional criteria for reviewing applications for export/import of radioactive waste are found in the Statement of Considerations in the June 1995 *Federal Register* Notice of Part 110 amendments establishing requirements for imports/exports of radioactive waste:

- NRC will consult with EPA regarding Part 110 license applications relating to movements [exports/imports] of [radioactive] mixed waste.
- NRC will publish a [public] notice in the *Federal Register* of receipt of an application for import or export of radioactive waste. NRC will exchange information with interested [state LLW] compacts. NRC will take other reasonable steps to inform states and compacts of pending requests.
- NRC recognizes the authority of LLW compacts to decide whether or not to accept an import of LLW for disposal in the compact region. NRC will consult with interested states and LLW compacts prior to issuing an import license for LLW. NRC will not grant an import license for waste intended for disposal unless it is clear that the waste will be accepted by a disposal facility, host state and compact, where applicable. This will be part of the determination regarding the appropriateness of the facility that has agreed to accept the waste for management or disposal.

Specific Licensing Provisions for Export and Import of Radioactive Waste

110.32 Information required in an application for a specific license/NRC Form 7.

(a) Name and address of applicant.

(b) Name and address of supplier of equipment or material.

(c) Country of origin of equipment or material, if known.

(d) Names and addresses of all intermediate and ultimate consignees, other than intermediate consignees performing shipping services only.

(e) Dates of proposed first and last shipments.

(f) Description of the equipment or material including, as appropriate, the following:

(1) Maximum quantity of material in grams or kilograms (curies for byproduct material) and its chemical and physical form.

(2) For enriched uranium, the maximum weight percentage of enrichment and maximum weight of contained U-235.

(3) For nuclear equipment, total dollar value.

(4) For nuclear reactors, the name of the facility and its design power level.

(5) For proposed exports or imports of radioactive waste, and for proposed exports of incidental radioactive material -- the volume, classification (as defined in §61.55 of this chapter), physical and chemical characteristics, route of transit of shipment, and ultimate disposition (including forms of management) of the waste.

(6) For proposed imports of radioactive waste -- the industrial or other process responsible for generation of the waste, and the status of the arrangements for disposition, e.g., any agreement by a LLW compact or state to accept the material for management purposes or disposal.

(7) Description of end use by all consignees in sufficient detail to permit accurate evaluation of the justification for the proposed export or import, including the need for shipment by the dates specified.

110.42 Export Licensing Criteria.

(d) The review of license applications for the export of radioactive waste requiring a specific license under this part is governed by the following criteria:

(1) The proposed export is not inimical to the common defense and security.

(2) The receiving country, after being advised of the information required by §110.32(f)(5), finds that it has the administrative and technical capacity and regulatory structure to manage and dispose of the waste and consents to the receipt of the radioactive waste. In the case of radioactive waste containing a nuclear material to which paragraph (a) or (b) of this section is applicable, the criteria in this paragraph (d) shall be in addition to the criteria provided in paragraph (a) or (b) of this section.

110.43 Import Licensing Criteria.

The review of license applications for imports requiring a specific license under this part is governed by the following criteria:

(a) The proposed import is not inimical to the common defense and security.

(b) The proposed import does not constitute an unreasonable risk to the public health and safety.

(c) Any applicable requirements of Subpart A of 10 CFR Part 51 are satisfied.

(d) With respect to the import of radioactive waste, an appropriate facility has agreed to accept the waste for management or disposal.

110.45 Issuance or Denial of Licenses.

(a) NRC will issue an export license if it has been notified by the State Department that it is the judgment of the Executive Branch that the proposed export will not be inimical to the common defense and security; and:

(1) Finds, based upon a reasonable judgment of the assurances provided and other information available to the Federal government, that the applicable criteria in §110.42, or their equivalent, are met. (If an Executive Order provides an exemption pursuant to section 126a of the Atomic Energy Act, proposed exports to EURATOM countries are not required to meet the criteria in §110.42(a) (4) and (5)); or

(2) Finds that there are no material changed circumstances associated with an export license application (except for byproduct material applications) from those existing at the time of issuance of a prior license to export to the same country, if the prior license was issued under the provisions of paragraph (a)(1) of this section.

(b) NRC will issue an import license if it finds that:

(1) The proposed import will not be inimical to the common defense and security;

(2) The proposed import will not constitute an unreasonable risk to the public health and safety;

(3) The requirements of subpart A of 10 CFR Part 51 of this chapter (to the extent applicable to the proposed import) have been satisfied; and

(4) With respect to a proposed import of radioactive waste, an appropriate facility has agreed to accept the waste for management or disposal.

(c) If, after receiving the Executive Branch judgment that the issuance of a proposed export license will not be inimical to the common defense and security, NRC does not issue the proposed license on a timely basis because it is unable to make the statutory determinations required under the Atomic Energy Act, NRC will publicly issue a decision to that effect and will submit the license application to the President. NRC's decision will include an explanation of the basis for the decision and any dissenting or separate views. The provisions in this paragraph do not apply to NRC decisions regarding license applications for the export of byproduct material or radioactive waste requiring a specific license.

(d) NRC will deny: (1) Any export license application for which the Executive Branch judgment does not recommend approval; (2) any byproduct material export license application for which NRC is unable to make the finding in paragraph (a)(1) of this section; or (3) any import license application for which NRC is unable to make the finding in paragraph (b) of this section. The applicant will be notified in writing of the reason for denial.

Annex I-2. How NRC's Regulatory Requirements for Imports and Exports of Radioactive Waste Conform to the Relevant Provisions of the Joint Convention

The following is an overview of how NRC's regulations conform to the guidelines established by the Joint Convention's Article 27 provisions on transboundary movement involving radioactive waste and disused sealed sources:

1.(i) A State of origin shall take the appropriate steps to ensure that transboundary movement is authorized and takes place only with the prior notification and consent of the State of destination.

NRC 10 CFR Part 110 regulations require prospective U.S. exporters of any material designated as radioactive waste to submit a formal application to and obtain a specific license from NRC. NRC performs an initial review of all applications to determine that required information is provided and, if so, forwards the application to the U.S. Department of State, which coordinates the review by interested U.S. Government agencies. The U.S. Department of State takes the lead for notifying and obtaining consent from the nation of destination.

(ii) Transboundary movement through States of transit shall be subject to those international obligations, which are relevant to the particular modes of transport utilized.

NRC regulations assign responsibility for ensuring that nuclear materials are transported in accordance with established international requirements for packaging and mode of transport to U.S. licensees. U.S. licensees are subject to enforcement and penalties if they do not comply with these requirements. In addition for all proposed export and import cases, NRC relies on the U.S. Department of State to consult with foreign governments of transit countries as that agency deems appropriate, to obtain any necessary approvals to satisfy obligations undertaken pursuant to this principle of the Joint Convention.

(iii) A State of destination shall consent to a transboundary movement only if it has the administrative and technical capacity, as well as the regulatory structure, needed to manage the spent fuel or radioactive waste in a manner consistent with this Convention.

The U.S. Department of State contacts a prospective nation of destination regarding a proposed export of radioactive waste from the U.S. and seeks that nation's government's consent to accept the proposed import of U.S. material under the terms and conditions of a bilateral Agreement between the U.S. and that nation. (Note that the term "nation" is used here instead of "state" to avoid confusion with the "states" that make up the U.S.) Based on the assurances provided by the nation of destination including acknowledgement and consent that the designated consignee is authorized to receive the radioactive waste, the U.S. accepts such statement as a confirmation that the nation of destination believes it has the administrative and technical capacity and regulatory structure to manage and dispose of the waste.

(iv) A State of origin shall authorize a transboundary movement only if it can satisfy itself in accordance with the consent of the State of destination that the requirements of paragraph iii [above] are met prior to transboundary movement.

NRC regulations do not require performance of independent and specific assessments and findings and an opportunity for adjudication regarding the adequacy of the receiving nation's administrative and technical capacity and regulatory structure for managing and disposing of a proposed export of radioactive waste. The Joint Convention does not specify how the nation of origin should satisfy itself the nation of destination meets the requirements and does not require the performance of an independent assessment. NRC concluded in 1980 that it was not necessary to consider extraterritorial impacts of any nuclear material or equipment exports because the regulation of economic and industrial activities taking place within a nation's territorial boundaries is a function of the territorial sovereignty. Nevertheless, NRC does not contemplate any circumstances for which it would issue a license authorizing the export radioactive waste to a country without a regulated waste disposal program. By obtaining the views of the U.S. Government before approving an application for export of radioactive waste and based on NRC interactions with regulatory authorities from various countries for example in the context of bilateral agreements on public health and safety issues, NRC is confident that appropriate actions can be taken.

(v) A State of origin shall take the appropriate steps to permit re-entry into its territory, if a transboundary movement is not or cannot be completed in conformity with the relevant principles, unless an alternative safe arrangement can be made.

NRC requires its licensees to agree to accept returns of materials they have exported, if they do not meet international standards or the terms of the export license. In practice and depending on the circumstances, when issuing a license authorizing the import of radioactive wastes, NRC may also require the concurrent issuance of a corresponding export license to provide for return of non-conforming radioactive wastes or materials that are not to be disposed of within the U.S. Such licenses involved consultation with relevant foreign government authorities to allow for such exchanges, should they be necessary.

2. A Contracting Party shall not license the shipment of its spent fuel or radioactive waste to a destination south of latitude 60 degrees south for storage or disposal.

Although this principle has not been formally adopted in NRC regulations, NRC does not expect to deviate from this policy and will consider adding it to 10 CFR Part 110 regulations at a future date.

3. Nothing in this Convention prejudices or affects:

(i) the exercise, by ships and aircraft of all States, of maritime, river and air navigation rights and freedoms, as provided for in international law;

Although this principle has not been formally adopted in NRC regulations, NRC does not expect to deviate from this policy and will consider adding it to 10 CFR Part 110 regulations at a future date.

(ii) rights of a Contracting Party to which radioactive waste is exported for processing to return, or provide for the return of, the radioactive waste and other products after treatment to the nation of origin;

As a matter of practice, NRC provides for the return of radioactive waste exported or imported for processing.

(iii) the right of a Contracting Party to export its spent fuel for reprocessing;

Under the terms and conditions of U.S. bilateral cooperation agreements and the assurances provided by recipient countries for exports from the U.S., such export is subject to U.S. prior consent for any proposed retransfer to a third party, whether for reprocessing or any other use. Requests for U.S. approvals of such retransfers must be filed with DOE /National Nuclear

Security Administration, which coordinates U.S. interagency review to determine whether U.S. legal and regulatory criteria would be met. Some U.S. agreements contain programmatic approvals for envisioned retransfers including for reprocessing of spent fuel derived from U.S.-origin materials.

(iv) rights of a Contracting Party to which spent fuel is exported for reprocessing to return, or provide for the return of, radioactive waste and other products resulting from reprocessing operations to the State of origin.

This would also be considered a retransfer subject to U.S. prior consent, which would be reviewed and accommodated if the transaction meets U.S. criteria for such a retransfer. The U.S. has been consulted and has not objected to the return of radioactive waste and other products resulting from reprocessing operations to the nation of origin, i.e., where the U.S.-origin (or obligated) material was used to produce the spent fuel.

Annex I-3. Radioactive Waste Import/Export License Applications Received and Issued by NRC 1995 to 2004

Applicant/ Licensee	Commodity	Country	End Use	Received By NRC	Final NRC Action	Current Status	License Expiration
Licenses for Radioactive Waste Import into U.S.							
NEN Life Science Products	Class A radwaste, containing Ni-63	Mexico	Treatment & disposal	10/18/95	10/03/96 RWA[107]	Complete	N/A
Siemens Power Corp	Class A radwaste, containing LEU	Germany	Incinerate and re-export for uranium recovery	04/10/96	07/03/96 Issued	Amended	12/31/06
Framatome ANP	Class A radwaste, containing LEU	Germany	Amend to change licensee name to Framatome ANP	10/12/00	02/01/01 Issued	Active	12/31/06
ALARON Corp	Class A radwaste, contaminated metal	Taiwan	Decontaminate, recycle, dispose of contaminants	04/25/97	01/26/98 Withdrawn	Complete	N/A
Diversified Scientific Services	Class A mixed radwaste	Canada	Thermal destruction	08/20/97	04/24/98 Issued	Amended	04/30/01
Diversified Scientific Services	Class A mixed radwaste	Canada	Amend to 1) update domestic license info; & 2) ext exp date to 4/30/02	06/22/00	08/28/00 Issued	Amended	04/30/02
Diversified Scientific Services	Class A mixed radwaste	Canada	Amend to ext exp date to 12/31/04	04/22/02	05/21/01 Issued	Hold[108]	12/31/04
Diversified Scientific Services	Class A mixed radwaste	Canada	Amend to ext exp date to 12/31/06	12/28/04		Pending	
Chem-Nuclear Systems	Class A radwaste, contaminated metal	Taiwan	Decontaminate, recycle, dispose of contaminants	10/20/97	03/18/99 Withdrawn	Complete	N/A
Allied Technology Group	Class A radwaste, contaminated metal	Taiwan	Decontaminate, recycle, dispose of contaminants	12/09/97	09/08/98 Issued	Expired	12/31/00
GTS Duratek	Class A radwaste, contaminated metal	Taiwan	Decontaminate, recycle, dispose of contaminants	04/21/98	10/12/01 RWA*	Complete	N/A
Starmet CMI	Class A radwaste, containing DU	UK	Processing to recover DU for use in shielding material	09/01/99	08/25/00 Issued Suspended	Complete	08/31/04

[107] Returned without action

[108] An amendment request must be received at least 30 days or more prior to the expiration date for a license to remain active while the request is being processed. If received with less than 30 days, the license authorization is on hold until the amendment is issued.

Annex I-3. Radioactive Waste Import/Export License Applications Received and Issued by NRC 1995 to 2004

Applicant/ Licensee	Commodity	Country	End Use	Received By NRC	Final NRC Action	Current Status	License Expiration
Starmet CMI	Class A radwaste, containing DU	UK	Amend to 1) incr qty; & 2) add foreign supplier	10/04/00	Suspended	Complete	N/A
Framatome ANP	Class A radwaste, containing LEU	Germany	Incinerate, recover U; dispose of residue	09/29/99	10/16/03 Issued	Active	12/31/10
Philotechnics	Class A radwaste, containing DU	UK	Recycle &/or disposal of aircraft counterweights	07/07/00	11/08/00 Issued	Hold**	06/30/03
Philotechnics	Class A radwaste, containing DU	UK	Amend to 1) incr qty; 2) ext exp date; 3) add U.S. recipient; & 4) update licensee info	06/24/03		Pending	
Allied Technology Group	Class A radwaste, contaminated scrap metal	Taiwan	Decontaminate, recycle, dispose of contaminants	12/28/00	Suspended	Complete	N/A
Diversified Scientific Services	Class A mixed radwaste	Canada	Thermal destruction	01/22/02	03/22/01 Issued	Amended	03/31/04
Diversified Scientific Services	Class A mixed radwaste	Canada	Amend to 1) ext exp date to 3/31/06; & 2) incr qty	03/25/04	12/10/04 Issued	Active	03/31/06
RACE	Class A radwaste	Various	Processing to reduce volume	07/16/03	08/06/03 RWA*	Complete	N/A
Sud-Chemie	Class A mixed radwaste	South Korea	Return waste for disposal	11/12/03	08/10/04 RWA*	Complete	N/A
Diversified Scientific Services	Class A mixed radwaste	Mexico	Thermal destruction	04/21/04		Pending	
Licenses for Radioactive Waste Export from the U.S.							
Master Intl	Class A radwaste	Russia	Disposal	09/27/95	09/30/96 RWA*	Complete	N/A
Diversified Scientific Services	Class A radwaste	Canada	Return waste from processing to Ontario Hydro Technologies	07/25/97	04/24/98 Issued	Amended	04/30/03
Diversified Scientific Services	Class A radwaste	Canada	Amend to change name of ultimate consignee to Ontario Power Generation	06/22/00	08/28/00 Issued	Amended	04/30/03
Diversified Scientific Services	Class A radwaste	Canada	Amend to 1) incr qty; & 2) ext exp date to 12/31/05	04/04/03	08/21/03 Issued	Active	12/31/05
Westinghouse	Class A radwaste, LEU contaminated metal	Canada	Resource recovery	09/08/99	01/19/00 Issued	Amended	12/31/05
Westinghouse	Class A radwaste, LEU contaminated	Canada	Amend to 1) incr quantity & types of metals; & 2) extend	01/11/01	07/19/01 Issued	Amended	12/31/10

Annex I-3. Radioactive Waste Import/Export License Applications Received and Issued by NRC 1995 to 2004

Applicant/ Licensee	Commodity	Country	End Use	Received By NRC	Final NRC Action	Current Status	License Expiration
	metal		exp date to 12/31/10				
Westinghouse	Class A radwaste, LEU contaminated metal	Canada	Amend to add new contaminated metals	08/11/03	03/24/04 Issued	Active	12/31/10
Bayou Steel Corp	Class A mixed radwaste	Canada	Disposal	01/24/00	12/27/01 RWA*	Complete	N/A
Framatome ANP	Class A radwaste, LEU contaminated combustibles	Germany	Return waste from processing to Germany	02/09/01	10/17/03 Issued	Expired	12/31/04
Framatome ANP	Class A radwaste, ash & LEU contaminated non-combustibles	Germany	Return waste from processing to Germany	02/09/01	10/16/03 Issued	Expired	12/31/04
Framatome ANP	Class A radwaste, LEU contaminated metal	Canada	Decontaminate, recycle & dispose of contaminants	07/26/01	12/28/01 Issued	Amended	12/31/06
Framatome ANP	Class A radwaste, LEU contaminated metal	Canada	Amend to 1) add supplier; & 2) add contam stainless steel	05/01/03	07/21/03 Issued	Active	12/31/06
Diversified Scientific Services	Class A mixed radwaste	Canada	Return waste from processing	01/22/02	03/26/02 Issued	Active**	03/31/05
Diversified Scientific Services	Class A mixed radwaste	Canada	Return waste from processing	01/22/02		Pending	

* Returned without action

** An amendment request must be received at least 30 days or more prior to the expiration date for a license to remain active while the request is being processed. If received with less than 30 days, the license authorization is on hold until the amendment is issued.

Annex J-1. Additional NRC Regulations Applicable to Sealed Sources and Devices	
Some specific-licensed products are required, by regulation, to meet certain specific requirements in addition to the general registration criteria provided in 10 CFR 32.210. The following Parts of 10 CFR contain regulations applicable to sealed source and devices:	
10 CFR Part 2	*Rules of Practice for Domestic Licensing Proceedings and Issuance of Orders*
10 CFR Part 19	*Notices, Instructions and Reports to Workers: Inspection and Investigation*
10 CFR Part 21	*Reporting of Defects and Noncompliance*
10 CFR Part 31	*General Domestic Licenses for Byproduct Material*
10 CFR Part 32	*Specific Domestic Licenses to Manufacture or Transfer Certain Items Containing Byproduct Material*
10 CFR Part 34	*Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations*
10 CFR Part 35	*Medical Use of Byproduct Material*
10 CFR Part 36	*Licenses and Radiation Safety Requirements for Irradiators*
10 CFR Part 39	*Licenses and Radiation Safety Requirements for Well Logging*
10 CFR Part 71	*Packaging and Transportation of Radioactive Material*

LIST OF ACRONYMS

Acronym	Name
AEC	Atomic Energy Commission
ACNW	Advisory Committee on Nuclear Waste
AEA	1954 Atomic Energy Act
ALARA	As Low as Reasonably Achievable
ANSI	American National Standards Institute
ANS-8	American Nuclear Society Standards Subcommittee 8
ASLB	Atomic Safety Licensing Board
CCA	Compliance Certification Application
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CNS	Convention on Nuclear Safety
COE	U.S. Army, Corps of Engineers
CSE	Cognizant Systems Engineers
D&D	Decontamination & Decommissioning
DHS	Department of Homeland Security
DNFSB	U.S. Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DOE-EH	DOE Office of Environment, Safety and Health
DOE-OA	DOE Office of Security and Safety Performance Assurance
DOL	U.S. Department of Labor
DOT	U.S. Department of Transportation
DP	Decommissioning Plan
EIS	Environmental Impact Statement
EnPA	Energy Policy Act of 1992
ERAMS	Environmental Radiation Ambient Monitoring System
ERDA	Energy Research and Development Administration
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FTE	Full Time Equivalent
FUSRAP	Formerly Utilized Sites Remedial Action Program
GTCC	Greater Than Class C Low-Level Waste
GROA	Geologic Repository Operations Area
HEU	Highly-Enriched Uranium
HEW	Department of Health, Education and Welfare
LEU	Low-Enriched Uranium
HLW	High-Level Waste
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiation Protection
IMPEP	Integrated Materials Performance Evaluation Program
INES	International Nuclear Event Scale
INL	Idaho National Laboratory

Acronym	Name
ISFSI	Independent Spent Fuel Storage Installation
ISL	In-Situ Leach
ISMS	Integrated Safety Management System
LANL	Los Alamos National Laboratory
LAW	Low-Activity Waste
LILW	Low and Intermediate Level Waste
LILW-LL	Low and Intermediate Level Waste – Long Lived
LILW-SL	Low and Intermediate Level Waste – Short Lived
LLW	Low-Level Waste
LLRWPA	Low-Level Radioactive Waste Policy Act of 1980
LSN	Licensing Support Network
LLRWPAA	Low-Level Radioactive Waste Policy Amendments Act of 1985
LTP	License Termination Plan
LTR	License Termination Rule
LTSP	Long-Term Surveillance Plan
MED	Manhattan Engineering District
MIP	Maintenance Implementation Plan
MLLW	Mixed Low-Level Waste
MOX	Mixed Oxide
MPRSA	Marine Protection, Research, and Sanctuaries Act of 1972
MRB	Management Review Board
MRS	Monitored Retrievable Storage
MT	Metric Tons
MTHM	Metric Tons Heavy Metal
NAS	National Academy of Sciences
NCRP	National Council on Radiation Protection And Measurements
NDAA	National Defense Authorization Act
NEA	Nuclear Energy Agency (Organisation for Economic Co-operation and Development)
NEPA	National Environmental Policy Act
NESHAPs	Emission Standards under the Clean Air Act for Hazardous Air Pollutants
NMED	State of New Mexico Environmental Department
NNSA	National Nuclear Security Administration
NORM	Naturally Occurring Radioactive Materials
NOV	Notice of Violation
NRC	U.S. Nuclear Regulatory Commission
NSC	National Safety Council
NTS	Noncompliance Tracking System
NUREG	NRC Regulatory Guide
NWF	Nuclear Waste Fund
NWPA	Nuclear Waste Policy Act
NWPAA	Nuclear Waste Policy Amendments Act of 1987
NWTRB	U.S. Nuclear Waste Technical Review Board

Acronym	Name
ORNL	Oak Ridge National Laboratory
PAAA	1988 Price-Anderson Amendments Act
PFS	Private Fuel Storage, LLC
QA	Quality Assurance
RBOF	Receiving Basin for Off-Site Fuels
RCRA	Resource Conservation and Recovery Act of 1976
RMEI	Reasonably Maximally Exposed Individual
S/CI	Suspect/Counterfeit Items
SDAs	Staff Decommissioning Assumptions
SDMP	Site Decommissioning Management Plan
SDP	Significance Determination Process
SF	Spent Fuel
SFP	Spent Fuel Pool
SSAB	Site-Specific Advisory Boards
SSC	Systems, Structures, and Components
SQA	Software quality assurance
TEDEs	Total Effective Dose Equivalents
TENORM	Technologically Enhanced NORM
TMI-2	Three-Mile Island Unit-2
TRU Waste	Transuranic Waste
TSPA	Total System Performance Assessment
U.S.	United States of America
USPS	U.S. Postal Service
UMTRCA	Uranium Mill Tailings Radiation Control Act
VPP	Voluntary Protection Program
WIPP	Waste Isolation Pilot Plant
WIPP LWA	Waste Isolation Pilot Plant Land Withdrawal Act Of 1992
WP	Waste Package

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, Table E-2, Annex E-1, Annex F-7, Annex F-2, and Annex J-1) for brevity. Internet web sites are also provided in Table A-2. The following additional resources were used:

International Atomic Energy Agency, *Classification of Radioactive Waste; A Safety Guide,* Safety Series No. 111-G-1.1., IAEA 1994.

International Atomic Energy Agency, *Establishing a National System for Radioactive Waste Management*, Safety Series No 111-S-1.1, Vienna Austria, 1995.

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*, Vienna, Austria, December 13, 2002.

International Atomic Energy Agency, *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, INFCIRC/516, December 24, 1997.

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U.S. Nuclear Regulatory Commission, *Radioactive Waste: Production, Storage, Disposal*, (NUREG/BR-0216).

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U.S. Department of Energy, Energy Information Administration Form RW-859 Spent Fuel Data (1998),

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U.S. Department of Energy, Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, DOE/EIS-0250, Washington DC, February 2002.

U.S. Department of Energy National Spent Fuel Database (Version 4.2.0, March 2002).

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U.S. Environmental Protection Agency, *Data from Studies of Previous Radioactive Waste Disposal in Massachusetts Bay*, Office of Radiation Programs, Washington, DC, 1984 (web site).