MEMORANDUM TO: Mar rie Nordlinger November 29, 1994
Off of the General Counsel

FROM: John Austin, Chief
Low-Level Waste and Decommissioning
Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

SUBJECT: OECD/NEA QUESTIONNAIRE ON RADIOACTIVE WASTE LEGISLATION AND POLICIES

This is in response to the letter dated November 3, 1994, from Patrick Reyners of the OECD Nuclear Energy Agency requesting information on the management of radioactive waste in the United States. The attached document entitled "Radioactive Waste Management in the United States," dated January 1994 addresses all of the questions in the questionnaire supplied with Mr. Reyner's request and provides additional information staff believes may be useful to the NEA Group of Governmental Experts. The document was prepared for the Radioactive Waste Management Committee of the OECD Nuclear Energy Agency and is revised and updated periodically with input from the NRC Waste Management staff.

With respect to the second part of question 7, please note that the Department of Energy (DOE), under the Energy Policy Act of 1992 (EnPA), is responsible for providing active institutional control in the form of post-closure oversight of Yucca Mountain. The details of this oversight, as currently envisioned by DOE, are best provided by DOE. However, the question of the expected duration and effectiveness of this oversight is currently before the National Academy of Sciences, also pursuant to the EnPA. The Academy's recommendations on this subject and others are scheduled for publication in a report in early 1995.

In addition, it should be noted that the waste volumes summarized in the report are current for 1992. DOE subsequently updated these volumes in the 1994 revision to the DOE report entitled "Integrated Data Base for 1993: U.S. Spent Fuel and Radioactive Waste Inventories, Projections and Characteristics (DOE/RW-0006, Rev 9, March 1994)." You may want to direct Mr. Reyner to DOE for this, and subsequent, updates on the volumes and characteristics of U.S. radioactive waste.

If you have any questions concerning the report, please contact Nick Orlando at the number listed.

Attachment: As stated
CONTACT: Dominick Orlando, NMSS
415-6749

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WM-11 PDR

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RADIOACTIVE WASTE MANAGEMENT IN THE UNITED STATES

January 1994

Prepared for
Radioactive Waste Management Committee
of the
OECD Nuclear Energy Agency

T:\KGS\USRWMGMT.392

Attachment

PREFACE

This overview provides a brief description of the civilian radioactive waste management system in the United States. It describes of the policies, strategies, and requirements to ensure safe and environmentally acceptable disposal of nuclear waste.

Every effort has been made to present up-to-date information; however, the reader is advised to seek current information as the programs evolve.

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OVERVIEW OF RADIOACTIVE WASTE MANAGEMENT IN THE UNITED STATES

GENERAL STRATEGY

The policies, strategies and programs for managing civilian and Department of Energy (DOE) radioactive high, low, intermediate, and transuranic (TRU) wastes in the United States are described in this overview. Included is a description of the management of civilian wastes resulting from the production of electricity by nuclear power plants (commercial wastes) and non-reactor, non-fuel cycle wastes (i.e., academic, medical, industrial). Management of radioactive wastes from DOE activities, which include defense activities, is also discussed. Discussion of wastes from uranium mining, milling, conversion and enrichment, and fuel fabrication is not included.

NATIONAL POLICY

The primary objective of radioactive waste management in the United States is to protect: 1) the health and safety of the public and workers, and 2) the quality of the environment. Management of radioactive wastes is considered the responsibility of the present generation and should not be left for future generations.

The U.S. Congress, recognizing that a national problem exists due to the accumulation of commercial spent fuel and high-level wastes (HLW) and that an environmentally acceptable method of permanent disposal is needed, enacted the Nuclear Waste Policy Act of 1982 (NWPA) and in 1987 amended the Act through the Nuclear Waste Policy Amendments Act (NWPAA). The two Acts provide the current bases for the safe, timely, and effective storage, transport, and disposal of spent nuclear fuel (SNF) and HLW.

In October 1992 Section 801 of the Energy Policy Act (EnPA) passed by Congress required the Environmental Protection Agency (EPA) to develop new standards for protection of the public from releases of radioactive materials at the proposed Yucca Mountain repository for SNF and HLW. Also, the Nuclear Regulatory Commission (NRC) was directed to amend its technical requirements and criteria to be consistent with new EPA standards. The EPA criteria are to be based on findings and recommendations by the National Academy of Sciences (NAS). A NAS panel has been holding meetings during 1993 and is expected to make recommendations in 1994.

For HLW at the West Valley (New York) facility, the West Valley Demonstration Project Act of 1980 sets the general policy on activities to be conducted. The Act charged the Federal Government with demonstrating HLW solidification, decontamination, decommissioning, and transportation activities. This waste was of commercial origin. West Valley was a commercial nuclear fuel reprocessing facility from 1966 to 1972, which was transferred to Federal responsibility in 1980.

The general policy for the disposal of commercial low-level waste (LLW) is provided in the Low-Level Radioactive Waste Policy Act of 1980 (LLWPA) and the 1985 amendment to the Act (hereafter called the LLRWPAA). The LLWPA and the LLRWPAA assigned to the individual States the responsibility for providing disposal capability for all commercial LLW generated within their borders with certain exceptions, Greater-than-Class C LLW. For this category of waste, disposal responsibility was assigned to the Federal Government. The Act

encourages States to form interstate agreements (compacts) in order to share responsibility for disposal of LLW.

For DOE radioactive wastes, the general policy is established in the Atomic Energy Act of 1954, as amended. The DOE is responsible for management of wastes generated by its activities (which include HLW, LLW, and TRU wastes). Through a combination of regulations codified in the Code of Federal Regulations (CFR) and a system of DOE Orders, DOE carries out its responsibilities under the Act. The primary DOE Order that provides for the safe and effective management of DOE-generated radioactive waste is DOE Order 5820.2A, "Radioactive Waste Management."

Additionally, in 1979 Congress authorized under P.L. 96-164, the construction of the Waste Isolation Pilot Plant (WIPP), the nation's first research and development facility to demonstrate the safe geologic disposal of defense transuranic wastes. In 1992, the WIPP Land Withdrawal Act, P.L. 102-579, permanently transferred public lands surrounding WIPP to the DOE and mandated a new regulatory framework for the start and conduct of a Test Phase with transuranic waste and the disposal and decommissioning phases of the WIPP Project. However, a recent DOE decision was reached to conduct enhanced laboratory testing at other sites with simulated and radioactive waste in lieu of waste tests at WIPP.

NATIONAL STRATEGIES

The major policies and strategies included in the aforementioned laws are as follows:

Department of Energy Order 5820.2A, "Radioactive Waste Management"

- Outlines the responsibilities of all Departmental elements concerning the safe and effective management of radioactive waste generated by DOE activities
- Establishes the policies for management of all DOE-generated radioactive wastes
- Provides guidelines for the management of DOE-generated radioactive waste, including principles for management, strategies, and planning documentation required for effective management
- Establishes the minimum technical requirements for management of DOE-generated HLW, TRU waste, LLW, from decontaminating and decommissioning (D&D) of DOE facilities, and uranium mill tailings.

Waste Isolation Pilot Plant Land Withdrawal Act

- Establishes a new regulatory framework in which the EPA must certify WIPP's compliance with the radioactive waste disposal regulations prior to a decision regarding use of WIPP as a disposal site
- Establishes several requirements that must be met by DOE and seven other Federal agencies for the start and conduct of a Test Phase with waste (limited to 0.5% by volume of design capacity), and the disposal and decommissioning phases of WIPP. (DOE has recently decided to conduct enhanced laboratory testing at other sites in lieu of waste tests at WIPP.)
  - Key disposal phase prerequisites require DOE to:
    - Obtain EPA certification of compliance with disposal regulations
    - Notify Congress of compliance with all applicable environmental laws and regulations

- Submit to Congress recommendations for the disposal of all TRU waste under DOE control, including a timetable for disposal of such waste
- Complete a survey identifying all TRU waste types at all sites from which waste is to be shipped to WIPP, provide opportunity for public comment, and provide results to EPA
- Submit to Congress decommissioning and post-decommissioning plans
- Wait 180 days after notifying Congress of compliance with all applicable environmental laws and regulations
- Acquire two existing oil/gas leases, unless EPA determines such acquisition is not required.

West Valley Demonstration Project Act of 1980

- Authorizes DOE to carry out a nuclear waste management project at the West Valley facility in New York
- Provides for a demonstration that liquid waste from reprocessing of spent fuel can be managed safely
- Requires DOE to:
    - Solidify liquid HLW in a form suitable for transport and disposal
    - Develop waste containers suitable for permanent disposal
    - Transport the solidified HLW as soon as feasible to a federal repository for permanent disposal
    - Dispose of LLW and TRU waste produced by the solidification of the HLW
    - Decontaminate and decommission the facilities and equipment used in the solidification and temporary storage of HLW at West Valley in accordance with NRC requirements.

Low-Level Radioactive Waste Policy Act of 1980

- Requires each State, either alone or in cooperation with other States (in arrangements referred to as compacts), to provide for the disposal of commercial LLW generated within its borders
- Allows these compacts, ratified by Congress, to exclude waste generated outside their borders.

Low-Level Radioactive Waste Policy Amendments Act of 1985

- Establishes a schedule that individual State or compact regions must meet in providing the required disposal capability. Critical dates are: (1) each State shall ratify compact legislation or indicate its intent to develop its own LLW site by July 1, 1986; (2) identification of the host State responsible for a siting plan by January 1, 1988; and (3) submission of a license application by January 1, 1992.
- Establishes penalties in the form of surcharges and potential denials of access to existing disposal facilities for those States not meeting the schedule.
- Makes Greater-than-Class C (GTCC) waste disposal a Federal responsibility.

- Requires NRC to develop procedures and criteria to act upon petitions to exempt disposal of specific waste streams from regulation by the NRC.

- Specifies precisely which categories of LLW are a State responsibility and establishes volume ceilings for individual nuclear reactors and for disposal sites.

Nuclear Waste Policy Act of 1987 (as amended)

- Establishes a Federal program and responsibility for a geologic repository for permanent isolation of spent fuel and HLW.

- Provides for the permanent isolation of commercial spent fuel and HLW in a manner that ensures the protection of public health and safety, and the environment.

- Names the Yucca Mountain site in Nevada for detailed site characterization to determine its suitability as the first repository.

- Requires a report on the need for a second repository between 2007 through 2010.

- Provides for NRC licensing of repositories for SNF and HLW.

- Provides for the appointment of a Nuclear Waste Negotiator to seek a volunteer host State, Indian Tribe, or local government for a repository or a Monitored Retrievable Storage (MRS) facility.

- Provides for benefits compensation to the host State, Indian Tribe, or local government in which a repository or MRS facility is located.

- Authorizes DOE to seek, negotiate, and enter into written consultation and cooperation agreements with the State of Nevada.

- Authorizes an MRS facility, but requires a number of conditions be met before construction can start.

- Establishes a system for safe transportation of waste to a repository or to other waste management facilities.

- Assigns responsibility for interim storage to the owner/generators of civilian SNF. Directs the Federal Government to expedite approval of new technologies to expand on-site storage. Provides for limited Federal interim storage capacity.

- Provides the State of Nevada and interested parties full and open evaluation of the civilian radioactive waste management program.

- Provides for costs to be borne by the waste generators through the establishment of the Nuclear Waste Fund.

Energy Policy Act of 1992

- Directs EPA to contract with NAS for a study to provide findings and recommendations on reasonable safety standards for protection of public health and safety

- Directs EPA to develop standards specifically for Yucca Mountain based on and consistent with the findings and recommendations of NAS (within 1 year of the findings of the NAS study)

- Directs NRC to amend its rules as necessary to be consistent with the EPA standards

- Directs DOE to provide post-closure oversight of Yucca Mountain to prevent breaching of the repository or radiation exposures above allowable limits

- Directs DOE to prepare (in consultation with NRC and EPA) a study of current waste management programs and plans to determine the adequacy for any additional wastes that might be generated by new nuclear plants.

WASTE SOURCES AND TYPES

Radioactive wastes are broadly classified as follows:

Spent Nuclear Fuel. Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not separated by reprocessing.

High-Level Waste. 1) The highly radioactive material resulting from the reprocessing of spent fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and 2) Other highly radioactive material that the Nuclear Regulatory Commission, consistent with existing law, determines by rule requires permanent isolation.

Low-Level Waste. All the wastes that are not classified as spent nuclear fuel, HLW, TRU waste, or uranium or thorium mill tailings, as well as those wastes that the NRC, consistent with existing law, has classified as LLW.

In 10 CFR 61.55, NRC has classified LLW into three categories (Class A, Class B, and Class C). These categories are based on the concentration limits of long-lived radionuclides and their shorter-lived precursors, and the concentration of shorter-lived radionuclides for which requirements on institutional controls, waste form, and disposal methods are effected. LLW exceeding the Class C concentration limits is termed "GTCC waste." GTCC LLW is not generally acceptable for near surface disposal.

Transuranic Waste. Waste that is contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and concentrations greater than 100 nanocuries per gram of waste. TRU waste results from activities primarily associated with defense activities and research activities on nuclear fuel.

Mixed Waste. Waste that contains radioactive constituents under the purview of the Atomic Energy Act and also constituents that are hazardous as defined in the RCRA. All DOE HLW is considered mixed waste by DOE unless proven otherwise, and many DOE TRU and LLW waste streams are mixed waste streams because of the radioactivity and other hazardous components in the wastes.

Uranium Mill Tailings. The tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its uranium or thorium content.

WASTE INVENTORY

The current and projected inventories of commercial radioactive waste are shown in Table 1, and those for DOE wastes are shown in Table 2.

TABLE 1. Current and Projected Cumulative Inventories of Commercial Radioactive Wastes[a]
(Units are 10^3 m^3 unless otherwise indicated)

Waste Source and Type	1991	2000	2010	2020	2030
HLW Glass Canister (West Valley)	1.729(c)	0.24		0.24	0.24
LWR Spent Fuel, MT of Heavy Metal					
No New Orders Case	23,681	42,400	61,000	77,200	87,700
Lower Reference Case[b]	23,681	42,300	61,200	81,600	103,200
LLW from Operations	1,423	1,722	2,055	2,321	2,508
LLW from D&D					
Classes ABC LLW	—	0.00	7.83	612.84	1292.85
Greater than Class C	—	0.00	0.00	0.22	0.45

(a) DOE/RW-0006, Rev.8. Integrated Data Base for 1992: Spent Fuel and Radioactive Waste Inventories, Projects, and Characteristics, Tables 0.4 and C.11, Department of Energy, Washington, D.C., 10/92.
(b) Includes all existing reactors (either completed or under construction) plus additional new reactors beyond the year 2005.
(c) Interim storage-West Valley as liquid HLW until vitrification, which is planned for 1998.

TABLE 2. Current and Projected Cumulative Inventories of DOE Radioactive Wastes (in thousands of m3)

Waste Source and Type	1991	2000	2010	2020	2030
HLW in Storage	395	332	332	335	333
HLW Glass	0	1.6	3.3	6.8	13.4
TRU Wastes					
Buried	191	191	191	191	191
Stored	63	84	108	(b)	(b)
LLW	2,816	3,787	4,769	5,469	6,231
Environmental Restoration (ER) Activities					
TRU Waste	NA[b]	570	1100	1700	1700
LLW	NA[b]	920	18,000	29,000	29,000
By-product material	11,390	33,000	36,000	38,000	38,000
Mixed LLW	101.4	NA[b]	NA[b]	NA[b]	NA[b]

(a) DOE/RW-0006, Rev. 8
(b) Information not available.

CONSIDERATIONS IN STRATEGIC PLANNING

The overall management of commercial radioactive waste in the United States includes the following activities:

- Development and implementation of regulations to ensure long-term protection to public health and safety and to ensure compliance with environmental standards
- Establishment of a disposal system(s) for LLW from commercial and institutional sources through the collaboration of States, assistance and regulation by the Federal Government, and funding by industry
- Demonstration and application of decontamination and decommissioning technologies for nuclear power reactors and other nuclear facilities.

The overall DOE radioactive waste management strategic plans include the following activities:

- Bring all DOE waste management facilities into full compliance with applicable laws, regulations, and agreements related to health, safety, and the environment
- Reconfigure the DOE waste management facilities as the DOE production complex is reconfigured in order to achieve waste minimization and pollution prevention goals and to safely and efficiently manage the waste that is produced
- Decontaminate and decommission the old DOE facilities as new facilities of the reconfigured DOE complex become operational
- Safely dispose of all TRU waste needing in geologic disposal, safely dispose of all wastes generated by D&D of old DOE facilities and from cleanups of contaminated sites and facilities, and continue to develop better, safer, faster, cheaper methods of waste treatment to allow for better utilization of available disposal capacity.

DOE is revising specific Orders to reflect recent changes in requirements and organizational responsibilities.

IMPLEMENTING AGENCIES

Through the legislation described above, the storage and disposal of most commercially generated LLW is assigned to the States, and all other wastes, including LLW of noncommercial origin and all GTCC low level waste, are the responsibility of the Federal Government. The Federal Agencies that are assigned radioactive waste management responsibilities include the DOE, which is generally responsible for storing and disposing radioactive waste; the NRC, which is responsible for regulating and licensing certain waste management facilities; and the EPA, which is responsible for setting environmental protection standards.

The DOE has the regulatory authority to implement its own regulations and to issue Orders that implement health, safety, and environmental protection policies regarding the radioactive waste generated at DOE facilities. The DOE is subject to regulatory oversight by the U.S. EPA concerning the hazardous constituents of mixed wastes that are generated at DOE facilities.

Within DOE, the Office of Civilian Radioactive Waste Management (OCRWM) is responsible for implementation of the NWPA and its amendments. DOE's Office of Environmental Restoration and Waste Management is responsible for the development and demonstration of methods for "D&D" of commercial facilities and for the West Valley facility.

The Nuclear Waste Negotiator's Office is assigned the task of seeking a volunteer host site for an MRS facility. DOE disburses grant money to eligible-prospective host communities for the MRS, who are interested in pursuing the siting process.

The NRC is responsible for setting technical standards and criteria, and for implementing overall offsite release standards set by the EPA. This includes requirements for licensing and operating storage and disposal facilities, as well as the certification of transport casks. The NRC and Agreement States (States to which NRC has relinquished certain regulatory responsibilities) also establish requirements and regulate LLW disposal. ~~along with Agreement States.~~

Disposal of defense-generated TRU wastes will be carried out by DOE, with oversight by EPA at WIPP. Disposal of commercially generated "GTCC" wastes, including TRU, is the responsibility of DOE, with licensing oversight by NRC.

The EPA has authority for developing generally applicable standards for the protection of the environment from radiological impacts of radioactive waste disposal.

Both the Department of Transportation (DOT) and the NRC are responsible for regulating transportation of radioactive materials.

OVERALL SCHEDULE: Civilian High-Level Radioactive Waste Management Program

- 1987 - DOE is redirected to perform detailed site characterization only on the Yucca Mountain candidate site, Nevada.
- 1992 - Candidate MRS facility sites identified.
- 1998 - Start waste acceptance at MRS facility.
- 2001 - DOE recommends repository site to the President, if approved, DOE will then submit an application to the NRC for construction of the repository.
- 2004 - Start repository construction (if NRC issues a construction authorization for the repository at the Yucca Mountain site).
- 2010 - Earliest date to start emplacing wastes (if NRC issues a license to receive and possess radioactive waste).

OVERALL SCHEDULE: Civilian Low-Level Radioactive Waste Program

The key milestones for the U.S. Civilian Low-Level Waste Management Program include:

- 1985 - Each State is required to provide for the disposal of commercial LLW generated within its borders.
- 1986 - Each State shall ratify compact legislation or indicate intent to develop its own LLW site
- 1988 - Identification of host States for siting of new disposal facilities.
- 1992 - Submission of license applications for new disposal facilities.
- 1996 - 2010 License new disposal facilities and initiate operations.

TOTAL SYSTEM COSTS AND FUNDING

Spent Fuel and High-Level Wastes

The NWPA prescribes that (1) owners and generators of spent fuel and HLW will pay the full costs of its disposal; and (2) a Nuclear Waste Fund was established to cover the cost of the civilian radioactive waste management program. This fund receives revenue from all those planning on using the repository.

An adjustable fee has been charged for the net electricity generated by commercial nuclear power plants beginning in April 1983, in addition to a one-time fee charged for spent fuel generated prior to April 1983 to be paid into the Nuclear Waste Fund. The ongoing fee for electricity generated is currently set at 1 mill ($0.001) per kilowatt-hour (net). The total costs for disposing of commercial spent fuel and HLW are estimated to be approximately $25.6 billion (in 1988 dollars).

On April 5, 1985, a Presidential decision following a study made pursuant to Section 8 of the NWPA authorized DOE to proceed with plans and arrangements to dispose of DOE HLW in the civilian repository. OCRWM's cost for the disposal of the waste will be paid by the Department's annual appropriations from Congress.

During 1992, efforts to change the basic funding mechanism for OCRWM's HLW Program continued. Currently, a 0.1 mil/KwHr tax on electric power use is generating about $600 million annually, but Congress has allocated $300 million or less to OCRWM, with the remainder offsetting other Federal Government spending. Efforts to establish an "off budget" revolving fund have been aimed at increasing program funding. Discussions relative to a revolving fund with Congress and the Office of Management and Budget (OMB) are continuing.

Low-Level Wastes

The costs for management and disposal of LLW vary due to differences in disposal concepts, management practices, and characteristics of the wastes. Estimates for various assumptions are presented in the storage, transportation, and disposal sections of this report. Each generator of commercial LLW provides the funds for storage from its operating budget.

Disposal site operators levy fees on waste generators upon receipt of the wastes for disposal. Initial cost for developing LLW disposal facilities differ from State to State (or compact region). In the majority of States and compact regions, development costs are paid by waste generators, or through some type of assessment on tax fee imposed by the State or compact region.

INTERNATIONAL COOPERATION

The United States cooperates with foreign nations and international organizations to further the development of technology for the management and disposal of radioactive wastes. Presently DOE has bilateral agreements with the Commission of the European Communities and the following countries: Belgium, Canada, Federal Republic of Germany, France, Japan, Spain, Sweden, Switzerland, and the United Kingdom. DOE and NRC also cooperate with the Nuclear Energy Agency (NEA) of the Organization of Economic Cooperation and Development (OECD), and the International Atomic Energy Agency (IAEA) in projects, workshops, and meetings.

STORAGE SYSTEMS

NATIONAL POLICY

Spent Fuel and High-Level Wastes

As designated in the NWPA, commercial nuclear power plants are responsible for interim storage of spent fuel. Commercial power plants are encouraged to expedite the effective use of existing spent fuel storage facilities and to cooperate with DOE in the development and demonstration of technology to increase at-reactor storage (wet storage and/or dry storage).

The Amendments Act authorized a central MRS facility for storage of commercial spent fuel, subject to specific conditions linking MRS operation to the repository schedule, and established an independent MRS Review Commission to review the need for such a facility. In its report to the Congress of November 1, 1989, the Commission found that "cumulatively the advantages of an MRS would justify the building of an MRS if: (1) there were no linkages between the MRS and the repository; (2) the MRS could be constructed at an early date; and (3) the opening of the repository were delayed considerably beyond its presently scheduled date of operation." In a 1992 letter from the Secretary of Energy to Congress, the use of multiple purpose canisters (MPC) was proposed as a parallel plan to address the concern with identifying a voluntary MRS site and the DOE's commitment to accept SNF in 1998. The letter also called for investigating the use of Federal sites for hosting an MRS.

The Amendments Act prohibits the selection of an MRS site through a DOE-directed survey and evaluation process until a site is recommended by the President for development as a repository. However, the Amendments Act allows siting to proceed via the Nuclear Waste Negotiator, who may negotiate a proposed agreement with a volunteer host that offers a technically qualified site on reasonable terms. If negotiations are successful, the Negotiator will submit the proposed agreement to the Congress, along with an Environmental Assessment, for enactment into law. Under the Amendments Act, financial assistance for assessing the feasibility of siting an MRS facility is available to the potential host.

The NWPA requires that the MRS facility be licensed by the NRC. The DOE can construct and operate an MRS only after obtaining a license from the NRC, including a site on Federal land.

The DOE completed the MRS Conceptual Design report in 1992 that describes the configuration of the MRS facility for interim storage of commercial spent nuclear fuel. The proposed MRS facility will accept spent fuel from the reactors and store it under closely monitored conditions. Several proven concepts for handling and storing spent fuel were investigated by the MRS designers. Several of these facility designs have either been licensed by the NRC or are in the process of being licensed. The choice of concept or combination of concepts will depend on, among other considerations, safety, licensability, cost, and schedule considerations. Some of the storage technologies currently being considered include wet spent fuel pools, multiple element sealed metal canisters in concrete modules, modular vault dry storage, metal dual purpose transport/storage casks, and concrete casks. The stored spent fuel will be retrieved, loaded into large-capacity casks, and shipped to the geologic repository in dedicated trains.

Under the DOE's current plans, the MRS facility will store only commercial spent nuclear fuel. DOE-generated high-level waste will not be stored in the MRS. Spent fuel consolidation and pre-disposal packaging, previously envisioned to be performed at the MRS, would become optional functions that might be added later, if they were determined desirable.

All DOE-generated HLW is in storage at one of three DOE facilities: Hanford, Idaho National Engineering Laboratory, and Savannah River. This HLW is currently stored as a liquid or sludge in underground tanks. Conditioning and solidification (vitrification) will begin when facilities now under construction are completed. The Defense Waste Processing Facility at Savannah River is planned to begin operation with radioactive waste in 1994.

Historically, DOE-generated spent nuclear fuel was stored for a short time and then reprocessed to recover fissile materials. In April 1992, the Secretary of Energy decided to phase-out reprocessing for the purpose of recovery of highly enriched uranium and plutonium. DOE has estimated its spent fuel inventory at about 4,600 tons. Most of this is at three sites (Hanford, Idaho National Engineering Laboratory, Savannah River), but small amounts are at a few other sites.

Commercial Greater-than-Class C Low-Level Wastes

Under the LLRWPA of 1985, the Federal Government (i.e., DOE) is responsible for disposing of GTCC LLW generated by licensees of the NRC. The strategy to fulfill DOE's responsibility under this Act is to provide for disposal of GTCC LLW, recognizing that acceptance and management of this waste before actual availability of disposal capacity are integral to a comprehensive management plan designed to protect public health and safety. The DOE is investigating sites and concepts for Federal interim storage of these wastes. At the present, all commercial GTCC LLW is not being held by generators. A number of commercial generators have been producing GTCC LLW, and through contractual arrangements with the DOE and/or for health and safety reasons, the waste is being stored by DOE.

Low-Level Wastes

Generators of commercial LLW generally store the wastes on-site, for short time periods (e.g., a few weeks to a few months) until enough waste is available for a sufficient shipment to a disposal site; however, the failure to provide LLW disposal capacity is expected to increase storage needs. In addition, because of the rapidly increasing costs of disposal, many commercial LLW generators reduce the volumes of their LLW before shipment, primarily by mechanical compaction and incineration.

Similar to commercial generators, DOE LLW generators store most of their LLW on-site for short periods of time until shipment to a DOE LLW disposal facility. However, some (not all) mixed LLW (i.e., LLW that also contains hazardous components) is being stored until appropriately designed mixed waste disposal facilities are available.

Transuranic Wastes

All TRU wastes and mixed TRU wastes that are generated at DOE facilities are placed temporarily in storage, because no disposal capacity is yet available for this type of waste. TRU wastes have been stored at facilities for many years, so many modes of storage are present in the DOE complex of numerous facilities.

REQUIREMENTS

Spent Fuel and High-Level Wastes

In general, storage of the commercial spent fuel and HLW is the responsibility of the generator until the Federal Government takes title to such wastes, which begins in 1998.

As many utilities begin running out of wet storage facilities, the option of dry on-site storage for older/colder fuel is being utilized. Each utility must submit a license application for these storage facilities to the NRC under 10 CFR Part 72. These at-reactor dry storage facilities have been called: Independent Spent Fuel Storage Installations(ISFSI).

Storage of commercial spent fuel by the Federal Government in an MRS facility is to be regulated by the NRC and licensed under 10 CFR Part 72 (Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste). Various safety features must be incorporated into the design of any storage facility for commercial spent fuel and HLW to protect the environment, the health and safety of the facility workers, and the public. In addition to the standard industrial safety regulations, the facility must operate under the radiation protection standards established by the EPA and NRC. A Safety Analysis Report (SAR) and an Environmental Impact Statement (EIS) must be submitted with the application for an NRC license to construct and operate such a facility. On August 27, 1993, the NRC published a proposed rule change to 10 CFR 72: "Notification of Events at Independent Spent Fuel Storage Installations [ISFSI] and the Monitored Retrievable Storage Installation." The proposed rule will ensure that significant occurrences at ISFSIs and the MRS, such as failure of safety equipment, contamination events, personal injuries, and fires and explosions, are reported quickly to the NRC so that the NRC can protect the health and safety of the public.

Once the NRC license is granted, construction of the MRS facility will begin. From that point forward, throughout the construction, operation, and decommissioning of the MRS, monitoring and oversight by the NRC will continue. All applicable Federal, State, and local environmental, safety, and health laws and regulations will be strictly observed during construction, operation, and decommissioning of the MRS facility.

DOE Order 5820.2A establishes the principles and minimum criteria for safe storage of DOE-generated radioactive wastes. Radiation protection principles and technical criteria that will enable the waste to be safely stored, treated, and finally disposed are carried out by Department elements by following the Order.

Commercial Greater-than-Class C Low-Level Wastes

Regulatory requirements have not been issued by U.S. Government regulatory authorities regarding the duration of storage of these wastes prior to disposal. Storage of commercial wastes at the generator's site is regulated through an NRC license or agreement State license for the facility.

Low-Level Wastes

Storage of LLW at commercial generator sites is regulated by the NRC and/or the Agreement State license for the operating facility. NRC's preference is that LLW be permanently disposed of as soon after it is generated as possible. Commercial waste storage containers used for the transport and disposal of LLW ~~must~~ meet DOT and NRC transportation requirements and must fulfill NRC often waste form criteria.

DESCRIPTION AND EXPERIENCE/STATUS

Spent Fuel and High-Level Wastes

The Nuclear Waste Negotiator had considerable success over the past several years. Twenty applications for Phase 1 grants to learn more about the MRS and other waste management systems were submitted to the Negotiator's office and 12 were awarded. Four applicants have progressed to Phase 2 awards, which can cover identifying potential sites, attending DOE meetings,

receiving benefits, evaluating impact analysis, and developing a proposed agreement with the negotiator on terms and conditions for hosting an MRS.

However, in 1993 the U.S. Congress enacted an amendment to the energy and water appropriations bill that limits the negotiator's disbursement of Phase 2B monies until he believes there is a "reasonable likelihood" that surrounding communities will support an MRS siting. While it is possible that Phase 2B rules and guidelines may be modified and reimplemented to disburse monies appropriately to surrounding communities, the impact seems to have halted the MRS siting process.

On the other hand, considerable progress was made in 1993 for the parallel effort, use of MPCs. The new Secretary of Energy has indicated her support for this project and to date, the MPC Implementation Program has produced a Conceptual Design Phase Report.

While the DOE continues toward accepting commercial spent nuclear fuel in 1998, utilities are independently beginning to utilize dry storage technologies to increase on-site storage capacity. Most commercial spent fuel has been and continues to be stored at reactor in on-site spent fuel pools composed of metal storage racks submerged in water pools. Most nuclear power plant spent fuel pools have installed high density metal storage racks in place of the original racks. The high density metal storage racks incorporate solid neutron absorbers for criticality control to allow for closer spacing of the spent fuel assemblies in the pool and thereby increase the total storage capacity of the pool. Some nuclear power plants have demonstrated limited in-pool (wet) consolidation of the rods from spent fuel assemblies. However, no widespread wet consolidation program is currently practiced in the U.S.

The spent fuel storage option currently being pursued in the U.S. by nuclear power plants that have reached the storage capacity limits of their spent fuel pools, is on-site dry storage. Several dry storage technologies have received approval from the U.S. NRC for use in on-site dry storage, and spent fuel is currently in dry storage at seven nuclear power plants (Virginia Power: Surry; Public Service Co. of Colorado: Fort St. Vrain; CP&L: Robinson and Brunswick plants; Duke Power: Oconee; BG&E: Calvert Cliffs; Northern States Power: Prairie Island; Consumers Power: Palisades). The dry storage technologies that have been approved by the NRC include horizontal concrete module storage of sealed canisters, metal cask storage, and modular vault storage. Some nuclear utilities are utilizing trans-shipment to ship spent fuel from one reactor to another to temporarily alleviate storage problems. However, this practice is not widespread since many utilities do not operate a sufficient number of reactors to make this option feasible.

The horizontal concrete module storage technology is currently in use at two utilities in the U.S. For this technology, the spent fuel assemblies are loaded into a multi-assembly canister inside a shielded transfer cask in the spent fuel pool. The canister is dried, backfilled, and sealed by welding, after which it is moved in the transfer cask to an on-site storage field where the concrete modules are located. The modules are located within the physical security boundary of the nuclear power plant. The sealed canisters are then transferred into the horizontal concrete storage modules by use of a hydraulic ram. After loading with the sealed canister, a metal door is welded in place over the opening to the concrete module. The Carolina Power and Light Company's H.B. Robinson site has loaded eight horizontal concrete modules that hold seven PWR spent fuel assemblies in a sealed canister in each module. The Duke Power Company is using the same horizontal concrete module dry storage technology at their Oconee site and has loaded 20 concrete modules that hold 24 PWR spent fuel assemblies in a sealed canister in each horizontal module. Other utilities are also planning to implement the horizontal concrete module for on-site dry storage. Most notably, the horizontal concrete module technology has also been licensed for use at Baltimore Gas and Electric's Calvert Cliffs site and the loading of 24 modules holding 24 PWR assemblies in each sealed canister began in 1993. A variant of the horizontal concrete

module storage technology is one in which the sealed canisters to be stored within each module are licensed for both storage and transportation. This technology is currently being used by the Sacramento Municipal Utility District (SMUD) for use at their Rancho Seco site.

The concrete cask storage technology was first used in May 1993 at the Consumers Power Company's Palisades site. The concrete cask storage technology uses a sealed canister similar to that used in horizontal concrete module storage to hold spent fuel assemblies. The loading process for the concrete cask storage technology is similar to that described for horizontal module storage, with the exception that the transfer cask is mated to the concrete cask, and the sealed canister is transferred to the concrete cask in a vertical, instead of horizontal, orientation. The loaded and sealed concrete cask is moved to an on-site storage area where it is placed in a vertical orientation on a reinforced concrete pad. Other utilities are also planning to implement the concrete cask storage technology for on-site dry storage.

The metal cask storage technology is currently in use at one utility in the U.S. For this technology, the spent fuel assemblies are loaded directly into the metal storage cask in the spent fuel pool. The metal storage cask is dried, backfilled, and sealed by bolting, after which it is moved to an on-site storage area where it is placed in a vertical orientation on a reinforced concrete pad. The Virginia Power Company has loaded and stored 17 metal storage casks at their Surry site. The metal casks at the Surry site are of three different designs; 15 of the metal storage casks hold 21 PWR assemblies each, 1 of the casks holds 24 PWR assemblies, and another cask holds 28 PWR assemblies. Other utilities are also planning to implement the metal cask technology for on-site dry storage.

The modular vault storage technology is currently in use at one utility in the U.S. This technology is currently being used in U.S. only for the storage of High-Temperature Gas Reactor (HTGR) spent fuel in the form of prismatic graphite blocks. For this technology, the HTGR spent fuel is loaded into sealed canisters that are transferred into a storage tube inside a large vault that is cooled by a natural convection cooling system. Public Service of Colorado has built, licensed, and completed loading of modular vault storage facility for HTGR spent fuel at Ft. St. Vrain site. The modular vault storage technology is adaptable for dry storage use with light water reactor (PWR and BWR) spent fuel.

To assist in the development of dry storage technology at all reactor sites and to help demonstrate recovery capability, the DOE is participating in a joint demonstration project with the Sacramento Municipal Utility District at their Rancho Seco site to demonstrate the construction, testing, and use of a dry cask-to-cask transfer device to facilitate the dry transfer of spent fuel from at transfer cask to metal transportable storage casks outside of the spent fuel pool.

The DOE has also been developing technologies required for the dry consolidation of commercial spent nuclear fuel assemblies. At the repository or the MRS, dry consolidation would be used to reduce the number of repository waste packages (and thus their cost), to reduce the number of shipments from the MRS to the repository, and possibly to limit the radioactivity of the waste packages (combining older spent nuclear fuel with more recently discharged fuel). The development program has progressed to the point where equipment is being manufactured and non-radioactive demonstration of the equipment is planned for 1992. A follow-on demonstration of the equipment with actual spent fuel may occur depending on budget and expected economic benefits of the technology.

The liquid HLW, alkaline sludges, and acid wastes have been safely stored at the West Valley facility in large underground tanks since 1966.

DOE stores its spent fuel in pools for a short time in its reactor pools, followed by lag storage in the pools at the reprocessing plants. DOE-generated HLW is stored in liquid form in large underground storage tanks (up to one million gallons each) located at three DOE facilities; Hanford, Savannah River, and the Idaho National Engineering Lab, and in granular solid form in concrete vaults at Idaho. The HLW at Hanford and Savannah River is stored in the alkaline condition in mild steel tanks; at INEL, it is stored in the acid condition in stainless steel tanks.

Commercial Greater-than-Class C Low-Level Wastes

Commercial GTCC LLW is waste that is generated by NRC-and Agreement State-licensed generators and exceeds Class C limits defined in 10 CFR 61. Data from existing literature, disposal records, and original research were used to estimate the characteristics and project volumes and activities of GTCC LLW.

GTCC LLW is categorized as Nuclear Utility wastes (57%), sealed sources (0.2%), DOE-held GTCC LLW (33%), and all Other Categories (medical, research, etc.) (10%). Most of the estimated GTCC LLW projected to the year 2035 has not been generated. The existing waste, except for DOE-held GTCC LLW, is stored at the generator sites.

Low-Level Wastes

Commercial LLW has been stored and disposed of in a variety of facilities and containers since the mid-1950s. Listed below are descriptions of the typical structures and containers used.

- Large Engineered Structures: These are permanent buildings designed specifically for the extended storage of LLW. They may be reinforced concrete structures of steel frame buildings with metal siding and roofing. Overhead bridge cranes are used for handling of waste packages that require remote handling.

- Shielded Storage Modules or Bunkers: These are concrete structures with removable covers. Waste containers are emplaced or retrieved with an overhead crane.

- Shielded Storage Casks: These are all-weather concrete containers, usually cylindrical, that can be placed outdoors on pads and are designed to hold waste drums.

- Minimum Unshielded Facilities: These are simple fenced-in outdoor pads or storage sheds. These facilities are generally intended as holding areas for waste packages awaiting pick-up for transport to disposal or long-term storage.

Most commercial LLW storage containers are 55-gallon steel drums. Other types of containers include other types of steel containers, plastic drums, resin liners in cylindrical steel containers, and "dumpsters," which are large steel boxes.

DOE LLW is stored in containers and facilities similar to those used for commercial LLW storage. Mixed LLW is also stored at DOE facilities that have appropriate permits or are designed especially for storage of this type of waste.

Transuranic Wastes

DOE TRU waste generators store all of the TRU waste generated from DOE activities, either at the respective waste generating facility or at a designated DOE storage facility within the DOE complex. Among the storage methods that can be found at DOE facilities are: retrievably-buried TRU waste,

below-ground bunkers, concrete caissons, above-grade concrete pads, and inside buildings. As discussed previously, all TRU wastes are in storage awaiting disposal capability for this type of waste. Therefore, storage of TRU wastes will continue in the DOE complex until disposal capability becomes available.

SCHEDULE

Spent Fuel and High-Level Wastes

In his November 1989 "Report to Congress on Reassessment of the Civilian Radioactive Waste Management Program," the Secretary of Energy announced an initiative to establish an MRS facility that will start accepting commercial spent nuclear fuel as early as 1998. Full MRS facility operational capacity is planned to be available in 2000. DOE plans to submit a license application to the NRC in 1995 in support of this schedule. This schedule has been confirmed in the DOE's Draft Mission Plan Amendment document (DOE-RW-0316P) issued in September 1991.

In another letter dated December 17, 1992, the Secretary proposed an alternative parallel plan based on the delay in identifying a volunteer host site for the MRS. This plan utilizes a multiple purpose canister and the use of Federal Government sites. The new Secretary, Hazel O'Leary, supports the Multi-purpose Canister effort and has indicated the Department of Energy's continued "moral obligation" to take title to commercial spent fuel beginning in 1998.

DOE spent fuel and HLW will continue to be stored until a disposal facility is operational. The HLW will continue to be stored as a liquid until the conditioning facilities are operational. The HLW vitrification facility at Savannah River is expected to become operational in 1994 and the facility at Hanford in 2009. The conditioning facility for converting the granular HLW at INEL to a final form for disposal will be operational about 2010. The current schedule calls for the HLW disposal facility to begin operations about the year 2015.

Commercial Greater-than-Class C Low-Level Wastes

The small amounts of commercial Greater-than-Class C LLW have been stored at the generating sites and some have been disposed of as LLW since the start of their generation in the late 1950s. Storage is expected to continue there until a decision on Federal storage and/or disposal is made. Approximately 33% of the estimated volume of GTCC LLW is presently being held at DOE facilities.

Low-Level Wastes

Storage facilities for commercial LLW are usually constructed by the individual waste generators as needs develop.

As in the commercial industry, LLW and mixed LLW storage capacity is constructed at DOE facilities as needs develop.

Transuranic Wastes

TRU wastes generated by DOE facilities will continue to be stored until the TRU waste disposal facility is operational (WIPP). This facility could begin operations as early as 1998.

COSTS

Spent Fuel and High-Level Wastes

DOE's current estimate of life-cycle costs for the MRS facility for storage of commercial spent nuclear fuel, including development and

evaluation, design, construction, operation, and decommissioning costs, is approximately $2.2 billion in 1988 dollars. This cost is for a basic MRS facility design (an MRS facility that receives and stores only spent fuel from reactors as intact bare assemblies before shipment to the repository) with limited waste acceptance starting in 1998 and reaching fully operational capability in 2000.

The MRS facility estimate does not include a cost of approximately $213 million towards benefits payments to potential hosts for the MRS facility from siting through decommissioning. Further, the costs represent estimates based on previous designs for the MRS facility that were larger in scope than the concepts that are being currently studied.

DECOMMISSIONING CONSIDERATIONS

Spent Fuel and High-Level Wastes

The MRS facility for storage of commercial spent nuclear fuel will be decommissioned in accordance with NRC regulations at the end of operations. The site will be restored as nearly as possible to its former condition, consistent with any terms negotiated by the host entity with the Federal Government.

Decommissioning of DOE facilities for storage of DOE spent nuclear fuel and HLW will be carried out to comply with applicable requirements of DOE, other appropriate Federal agencies, and the respective host States, where applicable.

Commercial Greater-than-Class C Low-Level Wastes

Commercial GTCC LLW storage facilities will be decommissioned when the respective operating facility is decommissioned. This will be done under NRC decommissioning criteria for the storage facility. DOE plans to provide general acceptance of GTCC LLW at a DOE facility for dedicated storage in the late 1990s. Permanent disposal of GTCC LLW will be provided as early as possible.

Low-Level Wastes

Decommissioning of commercial or Federal LLW storage facilities will likely occur when the operating facility that generates the LLW is decommissioned. This will also be done under NRC decommissioning criteria for the commercial facilities and under DOE criteria for the DOE facilities.

Transuranic Wastes

Decommissioning of DOE facilities for storage of DOE TRU wastes will be carried out to comply with applicable requirements of DOE, other appropriate Federal agencies, and the respective host States, where applicable.

QUALITY ASSURANCE CONSIDERATIONS

Spent Fuel and High-Level Wastes

The general quality assurance (QA) criteria in the regulations for commercial nuclear power plants and fuel reprocessing plants apply to all commercial spent fuel storage facilities. The QA program takes into account the need for special controls, processes, test equipment, tools, and skills to attain the required quality, and the need for verification of quality by inspection and tests. At DOE, a QA program that meets the requirements of the

NRC (NRC 10 CFR Part 72, Subpart G) has been established for conducting MRS-related activities.

DOE operates all of their storage facilities in compliance with detailed DOE QA requirements, which include national consensus standards. DOE Order 5700.6C describes the QA requirements that all storage facilities comply with during operations.

Commercial Greater-than-Class C Low-Level Wastes

Commercial facilities are regulated by the NRC. The QA program is developed and monitored by the waste generator and NRC.

Low-Level Wastes

QA for commercial LLW storage facilities is regulated by the NRC ~~and/~~or the Agreement State. The QA program is developed and monitored by the waste generator and NRC.

Transuranic Wastes

DOE operates all of their storage facilities in compliance with detailed DOE QA requirements specified in DOE Orders, which include national consensus standards.

TRANSPORTATION SYSTEMS

NATIONAL POLICY

Through the Department of Transportation Act, 1966, the Hazardous Material Transportation Act,1974, and the Hazardous Materials Transportation Uniform Safety Act, 1990, the DOT has the authority over transportation of all hazardous materials. Radioactive material has been designated as hazardous material for transportation under these laws.

Overall regulation of transportation of radioactive materials in the civilian sector is the responsibility of the NRC and the Department of Transportation (DOT). The responsibilities of each agency with regard to the transportation of radioactive material were identified in a 1979 Memorandum of Understanding between the two agencies. Their requirements are consistent with the international transportation standards promulgated by the International Atomic Energy Agency (IAEA) as of 1985. Economic regulation of rail and motor carriers is the responsibility of the Federal Interstate Commerce Commission (ICC). With the reduced Federal regulation of the transportation industry in recent years, the impact of the ICC on carriers has been greatly reduced.

Transportation of most commercially generated radioactive wastes is the responsibility of the waste generator (except as discussed in subsequent subsections) using commercial carriers. Commercial radioactive wastes are transported by truck and conventional rail.

Spent Fuel and High-Level Wastes

Transportation of commercial spent fuel *between* nuclear power plants, or to licensed commercial interim storage facilities, is the responsibility of the owner/licensee of the spent fuel. This transportation is normally carried out under contract with commercial carriers or radioactive waste service vendors. Transportation is by truck or rail, using exclusive-use shipments in Type B transport packagings that meet the design and certification criteria of the NRC. Spent fuel and solidified HLW that is transported by truck must follow preferred highway routes as specified by the DOT, since they contain a Highway Route-Controlled Quantity of radioactive material (i.e., radioactivity quantities that are large enough to require control of the shipment routes according to Federal requirements).

DOE is expected to begin spent fuel acceptance from commercial reactors beginning in 1998. Current plans call for this fuel to be transported to an interim storage facility (MRS). DOE/OCRWM's Office of Storage and Transportation is responsible for developing the spent fuel and HLW transportation system including cask development and systems for spent fuel acceptance. Initial OCRWM cask development efforts are focused on from-Reactor Cask Systems. Additionally, the new Secretary of Energy supports the ongoing, parallel MPC development effort.

Commercial Greater-than-Class C Low-Level Wastes

The transportation of commercial Greater-than-Class C LLW has not occurred to any great extent, except for a few unusual situations. For the few shipments of commercial GTCC wastes that have taken place, some were the responsibility of the waste generator and some were the responsibility of DOE. The transportation of GTCC commercial waste has been the responsibility of the waste generator. Transportation is typically carried out under contract with commercial carriers, or radioactive waste service contractors, in full compliance with NRC and DOT regulations.

GTCC wastes can be transported in Type A or Type B transport packages, depending on the radioactive content and waste form. Waste is transported by truck or rail, using exclusive-use shipments for the vehicles.

The DOE will be responsible for the transportation of GTCC waste from commercial generators, which will be disposed of at a Federal disposal site. These exclusive-use shipments will be transported in Type A or Type B transport packaging by truck or rail.

Low-Level Wastes

Transportation of commercial LLW is the responsibility of the commercial waste generator and the waste hauler. These wastes are usually transported by truck in exclusive-use vehicle shipments under contract with commercial carriers or radioactive wastes service contractors using equipment that meets regulations of NRC and DOT. Transport packages for LLW depend on the content and form of the waste. Some small generators use the services of a "broker" who consolidates waste packages from a number of generators.

Each shipment to a commercial LLW disposal site must be accompanied by a waste manifest that meets the requirements of NRC LLW disposal regulations.

Transuranic Wastes

Transportation of TRU waste is destined for the WIPP from DOE's defense facilities if the WIPP is determined to be a suitable disposal facility. The DOE is responsible for the transportation of TRU waste from DOE generator sites. TRU wastes can be transported via truck or train using equipment that meets regulations of NRC and DOT. The TRUPACT-II, an NRC-certified type B transport package will be used exclusively to transport contact-handled TRU waste to or from WIPP. DOE is currently developing plans for a remote handled TRU waste cask.

REQUIREMENTS

The general requirements of a transportation system are to safely transport the wastes from the source of generation to the disposal facility within the United States. In some cases, such as may occur with commercial spent fuel, an additional transport step to an interim storage facility may be required before shipment to the final disposal facility. The packaging and transportation of radioactive materials is regulated by the DOT (49 CFR Parts 100-199) and NRC under 10 CFR Part 71 and other applicable requirements in Parts 20, 21, 30, 40, 61, 70, and 73.

The EPA sets standards for protecting the public and environment from the potential hazards of radioactive material. The EPA also plays a role in coordinating Federal response to emergencies involving radioactive materials.

Spent Fuel and High-Level Wastes

Spent fuel from commercial nuclear power plants will be transported from reactor sites to either an MRS facility or a geologic repository. Transport distance to the repository will average about 3000 km if the Yucca Mountain site in Nevada becomes the repository for spent fuel and HLW. In some cases, spent fuel may be first transported between the originating nuclear power plant and another power plant or to a commercial storage facility by the waste generator before transport to a Federal storage or disposal facility. Spent fuel shipments from reactors will be by truck or rail/barge. Spent fuel shipments from an MRS facility are planned to be by rail.

The NRC is responsible for regulating the design, fabrication, and maintenance of transportation casks for spent fuel and high-level wastes (DOT retains this responsibility for shipments of all other hazardous materials [49

CFR 173]). The NRC also has the responsibility for regulating the safeguarding of spent fuel and HLW shipments while in transit (10 CFR 73).

DOT regulations apply to shipment preparation (packaging), labeling, and routing of hazardous materials. DOT has the authority to review State, tribal, and local transportation regulations, and resolve conflicts between these and Federal transportation regulations. The OCRWM has the responsibility for the shipment of solidified DOE high-level waste from the generating sites to the repository.

Low-Level Wastes

As of January 1993, LLW is currently being transported from the waste generating sites to one of ~~two~~ three shallow-land burial sites for commercial wastes. LLW may also be transported from the waste generating site to a commercial waste processing facility for volume reduction and/or consolidation prior to being shipped for disposal.

DOE LLW is transported to DOE disposal sites for generators not having their own disposal capability. Transport is in accordance with applicable NRC, DOT, and host State regulations.

Transuranic Wastes

Section 16 of the WIPP Land Withdrawal Act (P.L. 96-164) sets forth a number of requirements related to the transportation of TRU waste to or from WIPP, including accident prevention and emergency preparedness requirements. No TRU waste may be shipped to or from WIPP except in packages whose design has been certified by the NRC and which have been determined by the NRC to satisfy its quality assurance requirements. NRC completed an audit and certified the quality assurance program for the TRUPACT-II containers in 1993. Additionally, prior to shipping TRU waste to or from WIPP, DOE must provide advanced notification to States and Indian Tribes through whose jurisdiction DOE plans to transport TRU waste to or from WIPP.

DESCRIPTION AND EXPERIENCE

Spent Fuel and High-Level Wastes

Around 9,000 spent fuel assemblies were shipped from commercial nuclear power stations to other sites in the United States between 1964 and 1989. These assemblies were shipped in 2,576 separate shipments and represent 1,861 metric tons of uranium (MTU).

Currently, DOE is developing procedures, institutional relationships (between the Federal Government and local government agencies), and transportation equipment for shipping commercial spent fuel and HLW to an MRS facility and to a repository.

Currently, OCRWM is sponsoring the development of two types of SNF shipping casks: legal-weight truck (LWT) cask and a rail/barge cask. The LWT has two versions: one with a deign capacity of four PWR assemblies and one with a design capacity of nine BWR assemblies. The rail/barge cask has a design capacity of 21 PWRs or 52 PWRs. The design of special casks for transporting the reprocessed vitrified HLW to the deep geologic repository is underway. Additionally, the MPC effort is proceeding concurrently with the design of transport-only casks.

Currently, available casks were designed to carry commercial spent fuel that has not been cooled as long as the fuel that will be transported by DOE. DOE is designing SNF casks that will take advantage of this longer cooling and as a result will carry a greater payload per cask. This greater payload will

allow for a substantial reduction in both the risk and cost of the transportation system.

The use of multiple purpose canisters (storage, transportation, and disposal) would greatly alter DOE's cask development program.

Low-Level Wastes

Commercial LLW have been transported to commercial shallow-land disposal facilities since 1962. In calendar year 1991, a total of 38,600 m^3 of LLW was shipped to the three existing commercial LLW shallow-land disposal facilities. The total volume of commercial LLW transported to LLW disposal facilities through 1991 was 1,423,000 m^3.

In calendar year 1991, a total of 53,500 m3 of DOE LLW was transported to DOE shallow-land disposal facilities. The total volume of DOE LLW transported to DOE LLW disposal facilities through 1991 was 2,816,000 m3.

SCHEDULE

Spent Fuel and High-Level Wastes

- 1988 - Contracts awarded for legal-weight truck and rail/barge casks for from-reactor shipments of commercial spent fuel
- 1995 - Certification of legal-weight truck and rail/barge transport casks for from-reactor shipments of commercial spent fuel
- 1996 - Fabrication of prototypes completed
- 1998 - First shipments of commercial spent fuel from reactors to a MRS facility
- 2005 - Certification of rail spent fuel transport casks for commercial spent fuel from the MRS facility
- 2010 - First shipments of commercial spent fuel to geologic repository

Low-Level Wastes

- 1962 - First shipments of low-level wastes started to a commercial waste burial facility

Transuranic Wastes

- The TRUPACT-II was initially used to make intrasite waste shipments in 1992.
- First shipment of TRU waste to WIPP could occur as early as 1998.

COSTS

Spent Fuel and High-Level Wastes

The estimated costs for transporting spent fuel from commercial nuclear power plants, defense HLW from defense sites, and waste from the MRS facility to the repository are listed below. Costs are in millions of 1988 U.S. dollars and are total life-cycle costs for transporting 86,800 MTU equivalent of spent fuel and 8,875 MTU equivalent of DOE HLW.

	Millions ($)
Total development costs for transportation system	900
Total transportation costs for commercial spent fuel	2,450
Total transportation costs for defense HLW	350
Decommissioning costs (decon, costs approx. = salvage value)	0
Total transportation & development costs, spent fuel, and HLW	3,700

Low-Level Wastes

Transportation costs for commercial LLW depend on negotiated contracts with the carriers and are highly variable. In addition, costs are dependent on the part of the country, whether or not shielded casks are needed and numerous other factors. These same factors affect DOE transportation costs.

DECOMMISSIONING CONSIDERATIONS

Decommissioning of transportation equipment is typically carried out by decontamination to allow subsequent unrestricted use of the equipment or materials that comprise the equipment. The decontaminated materials are then salvaged for re-use. Items such as transportation casks may be converted to other uses such as on-site LLW storage containers. Fixed transportation maintenance and operating facilities are typically decommissioned in a similar manner.

QUALITY ASSURANCE CONSIDERATIONS

QA requirements for transportation of commercial wastes are established by the NRC and DOT. QA/QC requirements are applicable to all aspects of the transportation system. Each organization that transports a "Greater-than-Type A quantity" of radioactive wastes is required to have an NRC-approved QA program. The QA programs and activities must be audited periodically, and records must be kept for the duration period of the regulatory requirements. Organizations that transport less than a "Type A quantity" of radioactive waste do not need a regulatory-approved QA program, but must control their activities using a modified program as described in NRC and DOT regulations.

SAFETY CONSIDERATIONS

Regulations for commercial transport are generally consistent with the 1985 revised IAEA Transportation Safety Standards. To obtain certification of transport packages by the regulatory authorities, safety may be demonstrated by approved destructive testing, by approved methods of analysis, or by a combination of testing and analysis. Each transportation packaging design is normally recertified by the regulatory authority every 5 years. Other specific safety requirements are identified below.

Pre-notification of expected arrival time of commercial waste-hauling vehicles at a State border may be required for safety inspections or other purposes if the shipment contains a sufficient amount of radioactivity.

Spent Fuel and High-Level Wastes

Currently, truck shipments require communication with the dispatcher every 2 hours. Rail shipments are followed through the standard train tracking system. Future shipments will have the capability for continual vehicle contact with base stations using satellite communication systems.

Low-Level Wastes

Some truck shipments of commercial LLW contain sufficient concentrations of radioactive materials to require control of the highway routing for safety purposes.

DISPOSAL SYSTEMS

NATIONAL POLICY

Spent Fuel and High-Level Wastes

Under the authority of the NWPA, the DOE has sought to identify a suitable site for geologic disposal of SNF and HLW. In 1987, three sites (including Yucca Mountain in the State of Nevada) were selected from among nine sites under consideration as potentially acceptable and were recommended as suitable for characterization. Shortly thereafter, Congress amended the NWPA and directed the DOE to characterize only the Yucca Mountain candidate site. If this site is found to be suitable, the Secretary of Energy will submit a report to the President recommending Yucca Mountain for development as a repository. This report must be accompanied by a comprehensive statement of the basis for the recommendation and must include an environmental impact statement. If the President approves, the recommendation will go to the Congress.

After Congress receives the recommendation from the President, the State of Nevada may submit a notice of disapproval to the Congress to prevent selection of the site as a repository. Congress must pass a joint resolution of repository-siting approval in order to overturn the State's notice. If no notice is submitted, or if it is overturned, then the site designation will become effective. The State may choose to enter into a benefits agreement with the DOE at any time during site characterization but, in doing so, will forfeit its right to submit the notice of disapproval. Currently, the State of Nevada has declined to enter into any benefits negotiations.

If the Yucca Mountain site designation becomes effective as a repository for SNF and HLW, the DOE must submit a license application to the NRC seeking authorization to construct the repository. If NRC authorization is received, construction may then begin.

The DOE-generated HLW will be disposed of in the same geologic repository as commercial spent fuel and HLW. Also, any DOE spent fuel to be disposed of meeting the waste acceptance criteria of the repository will be disposed with the commercial spent fuel. Other DOE spent fuel that does not meet the waste acceptance criteria will most likely be disposed of in the repository after receiving appropriate treatment.

Low-Level Wastes

The LLRWPAA (1985 Act) requires that each State, either through a compact with one or more other States or individually, provides for safe management and disposal of LLW generated within its borders, according to a defined timetable or incur penalties. Nuclear power plants are required under the Act to meet certain waste volume limits during a 7-year transition period provided for the opening of new disposal sites.

It is the policy of the DOE to manage LLW it generates and to dispose of it at DOE facilities. It is also the policy of DOE to safely manage the mixed LLW (i.e., LLW that also contains hazardous components) it generates. However, mixed waste disposal facilities and capability are not available within the DOE complex to date. Facilities for disposal of DOE mixed LLW are in the planning phases.

Commercial Greater-Than-Class C Low-Level Wastes

Under the Low-Level Radioactive Waste Policy Amendments Act of 1985, DOE is responsible for disposing of GTCC LLW in a facility licensed by NRC. The small amount of these wastes have radioactivity levels that are generally too

high for disposal in near-surface facilities. These wastes, for which DOE is responsible for ultimate disposal, must be disposed of in a deep geologic repository, or other NRC-licensed facility. The site and concept for disposal of these wastes is being studied.

Transuranic Wastes

The WIPP mission is to demonstrate the safe disposal of defense-related transuranic radioactive waste. WIPP is unique in that its mission is to address the resolution of waste management issues at other DOE sites that store TRU waste. The WIPP has yet to receive any TRU waste. The designation of WIPP as a permanent disposal facility is dependent upon demonstrated compliance with long-term disposal regulations and EPA certification of such compliance.

In October 1993, DOE announced a revised test strategy that focuses activities on development of the DOE application for certification of compliance with disposal regulations. The new strategy includes enhanced laboratory testing of both real and simulated waste in lieu of waste tests, previously planned for WIPP. Implementation of the new test strategy should allow for an earlier and more cost effective disposal decision and, if determined suitable, permanent disposal of TRU waste. In order to accomplish this, DOE will accelerate its activities associated with demonstrating compliance with applicable regulations. The first step is to prepare a draft regulatory compliance application package that will be submitted to EPA, the State of New Mexico, and others for review in early 1995. It is DOE's intent to seek comments on the draft compliance application package from the NEA/OECD to facilitate the subsequent preparation of a final compliance application.

The decision to operate the site as a permanent disposal facility or to abandon the project will be based on a thorough evaluation of the repository and system performance, informed public participation, and institutional and regulatory acceptance. If compliance can be demonstrated, the WIPP will be used for disposal of the TRU waste currently stored at various DOE sites throughout the nation.

REQUIREMENTS

The EPA sets the general standards for the protection of the environment, which includes regulations for disposal of radioactive and other hazardous materials. The NRC is responsible for specific regulations relating to radiation protection and radioactive materials. The NRC radiation protection regulations, which have been amended to be consistent with those of the International Commission on Radiation Protection, are given in 10 CFR Part 20, "Standards for Protection Against Radiation." These regulations establish the general requirements for radiation protection, including general amounts and concentrations of radionuclides that may be released to the environment or disposed of in the ground.

Spent Fuel and High-Level Wastes

The EPA issued environmental standards (40 CFR Part 191) for the management and disposal of spent nuclear fuel, HLW, and TRU wastes in 1985. The regulation was challenged in court and, as a result, the rule was remanded in 1987. Subpart A, which establishes radiation dose standards for repository operations, was reinstated that same year. As directed in the EnPA of 1992, EPA has contracted with the NAS to provide recommendations by the end of 1994 on part of the regulation that establishes the standards to be met following repository closure. The EPA then has until December 31, 1995 to promulgate new standards.

The NRC regulations (10 CFR Part 60) provide the specific requirements that must be addressed in a license application for a repository for commercial spent fuel and HLW. In addition to implementing the standards set by the EPA, the regulations require the demonstration of a "multiple barrier" system that provides: 1) a minimum period of 300 to 1,000 years of containment within the waste packages; 2) a maximum fractional release rate of one part in 100,000 per year following the containment period; and 3) a minimum pre-waste-emplacement groundwater travel time from the underground facility to the accessible environment of 1,000 years. Also, as directed in the EnPA of 1992, the NRC has 1 year after the EPA promulgation to modify 10 CFR Part 60 to be consistent with the EPA standards.

A recently proposed amendment to 10 CFR Part 60 clarifies the requirements for the investigation and evaluation of potentially adverse conditions (PACs) and their relationship to post-closure performance objectives. Currently, DOE must show that a PAC has been "adequately investigated" and "adequately evaluated." The proposed rule clarifies the language by requiring DOE show that the presence of a PAC does not compromise the ability of the repository to meet the performance objectives related to isolation of the waste. The proposed rule also clarifies that the effect of a particular condition is not to be studied in isolation, but in the context of other characteristics of the site and design.

DOE siting guidelines (10 CFR Part 960) identify the factors to be considered in evaluating sites on the basis of the regulatory preclosure and postclosure requirements. It establishes the technical and environmental requirements that a candidate site must meet and specifies the site evaluation process to be followed by the DOE.

Because DOE-generated HLW and SNF will be disposed in the same repository as commercial waste streams of this type, the DOE will be following the same requirements as the commercial sector for the disposal of its comparable wastes.

Low-Level Wastes

The regulations governing the disposal of commercial LLW are found in NRC's regulation 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste." Specific technical requirements are given for near-surface (up to approximately 30 meters deep) disposal. NRC amended 10 CFR Part 61 (1993) to clarify that its regulations apply to above ground facilities. The amendment does not provide design guidance for above ground LLW disposal. NRC will develop above ground design criteria on a case by case basis. All facilities, above ground and below ground, will have to meet performance objectives in Subpart C of 10 CFR Part 61.

Title 10 CFR Part 61 establishes, among other things, (1) performance objectives for disposal facilities during operations and after closure (including inadvertent intrusion), (2) requirements for institutional controls after closure, (3) technical requirements for near-surface disposal sites and facilities, and (4) definitions of the upper radionuclide limits for the three classes of LLW. Class A wastes are of low concentrations or decay to low concentrations within 100 years. Thus, no special waste form stability requirements are necessary. Instead, a ~~100-year~~ institutional control period of not to exceed 100 years required for safe disposal. Classes B&C wastes remain sufficiently hazardous beyond 100 years so that institutional controls cannot be relied on to ensure safety. Special emphasis is placed on structural stability of the waste form or disposal units to ensure safe disposal. Class C wastes also require use of an engineered barrier to preclude inadvertent intrusion of individuals into the buried waste.

DOE Order 5820.2A provides the criteria that govern the disposal of DOE LLW at DOE disposal facilities. The Order contains many of the same basic principles in health and environmental protection as the NRC regulations that

apply to commercial LLW disposal. Disposal of DOE mixed wastes will comply with the DOE Order and also with appropriate EPA or State requirements for the disposal of hazardous waste.

EPA is in the process of developing environmental protection standards for LLW.

Commercial Greater-Than-Class C Low-Level Wastes

GTCC LLW may need to be disposed of in a deep geologic repository or other specially authorized facility that is licensed by NRC. The site and concept for disposal of these wastes is being studied. GTCC wastes are generally not acceptable for disposal in commercial disposal facilities. In the past, however, specific exemptions, issued by the site regulating authority, have authorized the disposal of some of this material in commercial LLW burial grounds.

Transuranic Wastes

Public Law 102-579, the Waste Isolation Pilot Plant (WIPP) Land Withdrawal Act, was enacted on October 30, 1992. This Act permanently transferred the WIPP site and surrounding public lands for sole use by the Department of Energy, established a new regulatory framework involving oversight by seven Federal agencies, establishes oversight roles and responsibilities for WIPP oversight groups, and places numerous requirements for start and conduct of Test, Disposal, and Decommissioning Phases.

The DOE must demonstrate WIPP's compliance with long-term disposal regulations for transuranic waste and hazardous waste as well as other agreements and DOE orders including:

- Environmental Protection Agency certification of compliance with long-term disposal regulations (Title 40, Code of Federal Regulations, Part 191); the most recent amendment to this rule became effective Dec 20, 1993
- Provisions of the Resource Conservation and Recovery Act regarding land disposal of mixed waste under a No Migration Determination administered by the Environmental Protection Agency (Title 40, Code of Federal Regulations, Part 268)
- Resource Conservation and Recovery Act regulations administered by the State of New Mexico (Title 40, Code of Federal Regulations, Part 264)
- Provisions of stipulated agreements with the State of New Mexico
- DOE orders protecting the environment, and public and worker safety and health.

In order to begin the Disposal Phase, the following key prerequisites must be met:

- EPA must certify, by rulemaking, that DOE will comply with the disposal regulations
- DOE must notify Congress of compliance with all applicable environmental laws and regulations
- DOE must submit to Congress recommendations for the disposal of all TRU waste under DOE control, including a timetable for disposal of such waste

- DOE must complete a survey identifying all TRU waste types at all sites from which wastes are to be shipped to WIPP, with notice and opportunity for public comment, and provide these results to EPA

- DOE must submit to Congress decommissioning and post-decommissioning plans

- DOE must wait 180 days after notifying Congress that DOE is incompliance with all applicable environmental laws/regulations to allow a Congressional review prior to start of disposal operations.

The Waste Isolation Pilot Plant must demonstrate compliance with long-term disposal regulations for transuranic waste and hazardous waste as well as other agreements and DOE Orders including:

- Environmental Protection Agency certification of (40 CFR 191) compliance with long-term disposal regulations. (The most recent amendments to this rule will become effective in early 1994.)

- Provisions of the Resource Conservation and Recovery Act regarding land disposal of mixed waste under a No Migration Determination administered by the Environmental Protection Agency (40 CFR 268).

- Resource Conservation and Recovery Act regulations administered by the State of New Mexico.

- DOE Orders protecting the environment, and public and worker safety and health.

SITE SELECTION/CHARACTERIZATION

Spent Fuel and High-Level Wastes

The NWPA, as amended, requires that DOE characterize Yucca Mountain, Nevada, to determine its suitability as a repository. The DOE prepared a Site Characterization Plan (SCP) for Yucca Mountain as required by the NWPA as amended and released a consultation draft of the SCP in January 1988 for comment by the NRC and the State of Nevada. After revision, the final SCP was issued in December 1988 to the NRC, the State of Nevada, local governments, and the general public for comment. Significant changes made in the SCP as a result of these comments are reported in the semiannual progress reports.

The SCP is a comprehensive document that describes and presents the rationale for more than 100 technical studies comprising approximately 300 activities. More detailed descriptions are provided in separate study plans. The studies outlined in the SCP involve surface-based testing and underground testing in the exploratory studies facility (ESF), laboratory studies, and computer modeling. Results from the studies will be used to conduct quantitative evaluations and performance assessments to evaluate site suitability and satisfy licensing requirements, as well as to refine the repository and waste package designs.

Underground tests will be performed in the ESF that will be constructed to provide access to the potential host rock for characterization of surrounding rock units. The ESF will be a U-shaped facility with a north entrance ramp, a main cross tunnel, and a south exit ramp. Site preparation for the ESF began November 25, 1992 and the starter tunnel excavation began in April 1993. Excavation will be by tunnel boring machine (TBM). The TBM will be delivered to the site in spring 1994 and excavation is expected in August 1994.

DOE began limited surface-based site characterization studies at Yucca Mountain in July 1991. The final permit (water) from the State of Nevada for

site characterization work was received in March 1992. Since that time, DOE has begun a full scale, surface-based site characterization with various drilling, trenching, mapping, and sampling activities. Dry drilling of UZ-16 (523 meters) was completed during fiscal year 1993, and a second large diameter dry-drilled hole was begun. Shallow neutron drill holes continue to aid the understanding of the unsaturated zone hydrology at Yucca Mountain. Trenching across suspected fault-zones will aid in the understanding of the age and degree of fault movements.

Low-Level Wastes

Selection of a commercial LLW disposal site is the responsibility of States and compact regions. Selection of a site is done through a screening process that requires characterization of available land and comparison of the potential sites with the NRC criteria in 10 CFR 61. There are 10 compacts (states that have grouped together to site on LLW repository) and 6 states that have opted to go it alone. Texas, Vermont, and Maine recently formed a new compact. Currently, three sites are either in the characterization or licensing phase in California (Soutwestern Compact), North Carolina (Southeastern Compact), and Texas (Compact with Vermont and Maine). California's Ward Valley site completed the characterization and licensing phase in 1993 and is awaiting Federal to State land transfer.

Careful site selection and characterization is performed by the DOE for disposal facilities for DOE LLW and mixed LLW. These sites are purposely selected from candidate sites on DOE facility land, because it is the policy of the DOE to dispose of its own LLW streams.

Transuranic Wastes

The WIPP site was chosen through a selection process that started in the 1950s, when the National Academy of Sciences conducted a nationwide search for geological formations stable enough to contain wastes for thousands of years without releasing them into the environment and in 1955 recommended bedded salt as a promising storage medium for radioactive wastes. In 1962 the U.S. Geological Survey reported that the Permian Basin was one of the most likely locations for such a repository. The portion of the Permian Basin in New Mexico, near Carlsbad, was selected as the location best meeting both site selection guidelines from this report and experiments conducted by Oak Ridge National Laboratory.

Furthermore, the remote location of WIPP makes it an excellent choice for a nuclear waste repository. Salt beds in the vicinity are accessible without disturbing established communities or residences, and the area is removed from any potentially disruptive geological features.

The performance objective for WIPP is to adequately and permanently isolate transuranic waste from the accessible environment. When the evaluation of the Test Program data is completed, the WIPP's ability to comply with all applicable environmental regulations can be evaluated. The decision will then be made regarding WIPP's suitability as a repository.

UNDERGROUND TESTING

Spent Fuel and High-Level Wastes

The Yucca Mountain site was recognized in the late 1970s as a possible site for an underground repository. As a result, the Nevada Nuclear Waste Storage Investigations program was initiated in 1977. Underground testing was performed in both tuff and granite. Experiments were conducted to obtain data on radionuclide migration and rock mechanics in tuff. In the early 1980s, 11 canisters of spent fuel were placed in a granite test facility 1,400 feet below the surface within the Climax granite stock (the test program called

"Spent Fuel Test - Climax") to evaluate granite as a medium for deep geologic disposal and as a general demonstration of geologic disposal of spent fuel and HLW. In 1980 through 1988, G-tunnel (on the Nevada Test Site) was the site of active underground testing and equipment prototyping. A key part of this work was the set of accelerated heater experiments, which were the first such tests done in an unsaturated tuff environment (UCRL-ID-106159).

During detailed site characterization at the Yucca Mountain site, an ESF will be constructed for in-situ testing. The major test categories are Hydrologic, Mechanical Properties, Geologic, Geochemical, and Thermal Response (Waste package Environment). The 42 test activities identified by the YMP Site Characterization Plan within these categories will be deployed both during facility construction and after construction is completed. Test results will provide information to increase confidence in the understanding of coupled processes (thermal-hydrologic-mechanical-chemical) and establish the parameter basis for the licensing process. Prior to the underground heater test, DOE will be conducting a prototype heater test in surface rock at Fran Ridge, located approximately ? Km east of Yucca Mountain.

Low-Level Wastes

Extensive R&D has been done to develop an understanding of the characteristics of existing disposal sites for commercial LLW and of potential improvements at these sites. Each State that hosts a LLW disposal site is responsible for developing its own plans for site characterization and to carry out site characterization activities in preparing an application for the selected site.

Transuranic Wastes

The WIPP facility is being utilized to collect data on repository performance for use in preparation of performance assessments to demonstrate compliance with long-term disposal regulations. WIPP will continue these ongoing non-radioactive experiments such as: seal design and implementation activities, rock mechanics, transport studies, and hydrology experiments.

DISPOSAL CONCEPTS - DISPOSAL FACILITY DESCRIPTION

Spent Fuel and High-Level Wastes

The Yucca Mountain candidate site is located in southern Nevada, approximately 100 miles northwest of Las Vegas. The region is arid with sparse vegetation and few people. If the site is suitable, the repository will be constructed in densely welded ash-flow tuff about 1,000 feet below the ground surface. Because the water table is very deep at the candidate site, it will be possible to construct the repository in the unsaturated zone, approximately 600 to 1,300 feet above the water table.

The repository for spent fuel and HLW will resemble a mine with both surface and underground facilities. Based on current design concepts, the surface facilities will receive, handle, and package the wastes and transfer the wastes down to the underground disposal galleries. The surface facilities would be connected to the underground area of the repository through two ramps and one possible shaft. The wastes would be transferred down the ramp and along horizontal passageways (drifts) to waste-emplacement panels consisting of a number of disposal rooms. In the reference conceptual design, vertical holes would be bored into the floor of these rooms and the waste containers would be inserted into them. Other methods, such as horizontal in-borehole emplacement and in-drift emplacement, are possible alternative approaches that are still being considered. Underground development and waste emplacement will proceed simultaneously with sufficient separation between the development and emplacement operations to ensure that construction workers are isolated from the waste-handling activities.

Low-Level Wastes

A total of seven shallow-land disposal facilities for commercial LLW wastes have been sited, developed, and operated; of these, five are no longer operational. Near-surface disposal in excavated trenches is presently in general use at the past and currently-operating sites for commercial Class A LLW. Classes B and C LLW are disposed of in similar but separate trenches. Class C LLW are disposed of with a minimum of 5-meter cover or with an engineered cover (e.g., concrete barrier) to provide additional intruder protection.

Several alternative disposal concepts are currently being considered by the States and compacts for new commercial disposal facilities using engineering methods such as below-ground vaults and earth-mounded concrete bunkers. It is expected that future disposal facilities will likely incorporate engineered barriers to a greater extent than do currently operating facilities.

The DOE has six facilities for the disposal of its LLW. The facilities are located at Savannah River, Oak Ridge, the Nevada Test Site, the Los Alamos National Laboratory, the Idaho National Engineering Laboratory, and Hanford. There are several disposal designs used at these facilities for the disposal of LLW that include: shallow land burial trenches, below ground vaults, tumuli, above-ground vaults, and deep shaft disposal. DOE is currently developing plans for mixed LLW treatment in response to Federal Facilities Compliance Act of 1992. This will impact the types and locations of DOE mixed LLW disposal.

Commercial Greater-Than-Class C Low-Level Wastes

The disposal concept and the site for disposal of GTCC LLW have not been determined. However, regulations require that disposal be in a deep geologic formation or other suitable special type of facility.

Transuranic Wastes

The WIPP deep geologic facility for disposal of DOE-generated TRU wastes is designed and constructed very similarly to the proposed design of the HLW repository. WIPP is located 26 miles east of Carlsbad, New Mexico. The site covers 10,240 acres of Federal land with a 4-square-mile area. WIPP has both above-ground and below-ground facilities. The underground facilities are constructed in a 2,000-foot thick salt formation 2,150 feet below the surface. Access to the underground facility is via four shafts. There are currently over 10 linear miles of tunnels constructed. A separate area of the facility has been used to conduct the tests and experiments to demonstrate the technology, while most of the disposal area remains undisturbed awaiting TRU wastes for disposal.

DISPOSAL CONCEPTS - WASTE RECEIPT AND HANDLING

Spent Fuel and High-Level Wastes

In the reference conceptual design, commercial spent fuel and HLW will be received at the surface facilities interim storage racks in a hot cell. Subsequently the spent fuel and HLW will be encapsulated in disposal containers and transferred underground to be emplaced in disposal rooms. The repository design will provide the capability for retrieval at any time for up to 50 years after the start of waste package emplacement. If MPCs, suitable for disposal, are chosen for the Civilian Radioactive Waste Program as a whole, then the functions for this type of above-ground facility will be modified.

Low-Level Wastes

For current disposal of commercial LLW, the waste packages are usually unloaded from the transport vehicle onto an on-site trailer or platform by fork lift and crane. Temporary shielding may be used to handle wastes with high radiation levels. Waste packages with high radiation levels are usually placed near the bottom and center of the trench to allow the shielding from surrounding packages. Partially-filled trenches are typically backfilled periodically to minimize exposure of the waste packages to the elements and possible exposures to disposal facility personnel.

Transuranic Wastes

General transuranic waste handling operations at WIPP will be conducted as outlined below:

- Waste shipments are received at WIPP by either truck or rail transport system
- External inspection of shipping containers is performed and containers are moved to the Waste Handling Building
- Shipping containers are opened and their contents off-loaded and inspected to verify compliance with documentation
- Waste is inventoried and verified and data are recorded;
- Waste is prepared for emplacement underground and lowered to the underground facility area
- Waste containers are removed, positioned on the underground transport system, and transported to the final storage area and the location is documented.

DISPOSAL CONCEPTS - WASTE PACKAGE

Spent Fuel and High-Level Wastes

If a repository is developed at the Yucca Mountain candidate site, the principal engineered barrier, which includes the waste package, will be designed to meet various functional and regulatory requirements. For the postclosure period, these requirements include providing substantially complete containment for the waste for at least 300 to 1,000 years and thereafter controlling the rate of release from the engineered-barrier system to a small fraction of the inventory present at 1,000 years after the closure of the repository.

The current advanced conceptual design for both commercial spent fuel and HLW glass will utilize a multi-barrier design approach. Several materials are being considered including corrosion resistant and corrosion allowance types. The list includes: low carbon/iron-based alloys, Cast iron/mild steel, iron-silicon base alloy, Ti12, Hastelloy C4, Inconnel 825, and Cu-alloy (Cupronickel 70-30). The use of MPCs would alter current conceptual designs. Several proposed options for waste packages that are being evaluated provide substantially complete containment of radionuclides for a very long time period (perhaps thousands of years).

The HLW form is monolithic borosilicate glass cast into a stainless steel canister 3.00 meters tall and 0.60 meters outside diameter, with 1-centimeter thick walls. The bottom is dished, the top is flared to accept a cap, and the seams are welded. The filling nozzle is sealed with a plug by pressure and electrical resistance welding. Nominally, each canister will be at least 80% full and contain about 2 metric tons of borosilicate glass having about 100,000 curies of activity (mostly strontium-90 and cesium-137).

Low-Level Wastes

Commercial LLW packages disposed of in near-surface disposal facilities cannot be made of cardboard or fiberboard (NRC 10 CFR 61.56). The most common LLW package is the 55-gallon steel drum (208-liters, with wall thickness ca. 0.12 cm) that is painted, galvanized, or plastic-coated. Recently, 55-gallon drums comprised about 75% of all the LLW packages, but accounted for less than 20% of the waste volumes that are disposed. Other sizes of steel drums are also used, ranging from 5 gallons to 80 gallons. In addition, cylindrical containers made of plastic, fiberglass-plastic, and reinforced concrete are used, particularly for Classes B and C wastes ranging in size from 30 gallons to about 500 gallons.

DOE packages its LLW in many of the same containers that are used by the commercial disposal facilities. Steel drums with capacities of 55 and 30 gallons are common containers used for disposal of LLW, and a rectangular metal box of approximate dimensions of 4 feet x 4 feet x 7 feet is also used quite regularly for disposal of DOE LLW. Mixed LLW will likely be packaged in similar containers for disposal when capability for its disposal becomes available.

Transuranic Wastes

DOE has packaged its TRU wastes in many of the standard containers known throughout the radioactive waste industry. TRU wastes are most commonly contained in 55-gallon drums and standard metallic waste boxes with approximate dimensions of 4 feet x 4 feet x 7 feet. Other containers are used for odd shaped wastes or for wastes with extremely high surface radiation levels. Current plans call for contact-handled TRU wastes to be disposed without any special container or overpack.

DISPOSAL CONCEPTS - BUFFER AND BACKFILL

Spent Fuel and High-Level Wastes

Under the reference design concept, no buffer material will be used around the waste packages (with either spent fuel or HLW) at the Yucca Mountain site because the waste package is designed to be surrounded by an air gap. Alternatives to this reference design concept are being evaluated. If drift emplacement is selected, the drifts may be backfilled prior to permanent closure. The permanent closure of the repository would require the sealing of all shafts, ramps, boreholes, and other underground openings to reduce, to the extent practicable, the potential for creating preferential pathways for groundwater or radionuclide migration.

Low-Level Wastes

No buffer materials are used around packages for commercial LLW in the ~~two~~ three currently operating commercial LLW disposal facilities. Backfill is typically the soil material that was excavated to make the disposal trenches. NRC is currently evaluating the use of backfill as a capillary barrier to minimize water infiltration. In some cases for Class C wastes, cement backfill is used around the waste package to enhance intruder protection. For DOE LLW, buffer materials are also typically not used.

DISPOSAL CONCEPTS - TEMPERATURE AND PRESSURE

Spent Fuel and High-Level Wastes

DOE is currently examining the effects of thermal loading on the waste package and repository environment, both near- and far-field. The engineered-barrier system is being designed to meet the performance objectives of the NRC's regulations. The appropriate thermal loading will be determined by the

DOE considering licensing and safety implications, restrictions on operations, rock stability, transport of radionuclides, and long-term corrosion effects of water on the waste packages. Thermal tests are planned for the ESF (drift scale), surface based (large block test), and the laboratory (small block tests) to investigate model concepts of the thermal, hydrological, mechanical, and geochemical processes. For the far-field (i.e., regional-scale), the temperature increases will be tentatively limited to temperatures of about 5°C in the aquifer and 0.5°C in the earth surface. Further evaluation is underway to determine if these tentative limits are appropriate.

Low-Level Wastes

LLW commercial disposal facilities have no temperature requirements. Class A LLW have no specific structural requirements except they must withstand the forces of normal operations. Commercial Classes B and C LLW are required to maintain gross physical properties and identity for 300 years, and are required to maintain structural integrity under expected disposal conditions such as weight of overburden. High-integrity containers (HICs) for Classes B and C LLW must meet the waste form stability requirements.

DISPOSAL CONCEPTS - DECOMMISSIONING

Spent Fuel and High-Level Wastes

After the repository has been filled and the caretaker and performance-confirmation program has been completed (about 25 years), the DOE plans to submit to the NRC an application for a license amendment to close the repository. After NRC approval, the DOE will seal the repository and decommission the surface facilities. Repository shafts will be sealed; surface facilities will be decontaminated and dismantled; the mined rock that is not used in backfilling will be stabilized or moved off the site; the surface area will be returned to its original natural condition to the extent feasible; and permanent markers will be erected.

Low-Level Wastes

The operator or holder of the license for a commercial LLW disposal facility must D&D surface facilities to the extent defined in the site closure plan provided in the original license application. The disposal facility operator must show by measurements and modeling that the closed facility will meet regulatory requirements without active controls. Permanent markers must show locations of all burial trenches. A passive site surveillance system must be installed that requires minimum maintenance. The disposal facility is turned over to the State or Federal landowner for custodial care for a minimum 100-year institutional-control period.

DOE imposes similar requirements on the commercial sector as defined in DOE Order 5820.2A.

Transuranic Wastes

During the decommissioning phase the repository will be prepared for permanent closure. All remaining underground openings will be backfilled with crushed salt; seals will be installed in selected drifts; and shafts and boreholes will be sealed. The surface facilities will be decontaminated and decommissioned, and the surface area will be returned to its original natural condition.

DISPOSAL CONCEPTS - POSTCLOSURE

Spent Fuel and High-Level Wastes

The regulation 10 CFR 60 requires that a description of the program for monitoring of the repository during the postclosure period be included in the license amendment for permanent closure. However, the performance confirmation of the repository will be carried out during the potential retrieval period (through the period of caretaking and performance confirmation, about 25 years after emplacement has stopped). Because this performance confirmation program is expected to provide final assessment of repository performance, additional monitoring subsequent to postclosure is not expected to be necessary.

Low-Level Wastes

For commercial LLW disposal facilities, postclosure activities by the State custodian for the duration of institutional control will involve periodic visits, inspections, maintenance (if any), and environmental monitoring of the performance of the site. The period of institutional control will be determined by the NRC or the agreement State, but may not be relied upon for more than 100 years in evaluating the license application.

The principles and requirements in the DOE Order 5820.2A are relative to post-closure of DOE LLW disposal facilities and are similar to the requirements that apply to the commercial disposal facilities. For the DOE facilities, the Federal Government will continue to be the custodian in charge of care of the closed facilities.

Transuranic Wastes

The postclosure period for WIPP will employ both active and passive institutional controls to prevent human intrusion into the repository. Initially, for approximately 100 years, active measures such as access control shall be implemented. Beyond the initial period permanent markers will be placed to deter human intrusion.

SCHEDULE

Spent Fuel and High-Level Wastes

- 1988 - Site Characterization Plan was issued for the Yucca Mountain site for evaluation as a repository
- 1991 - Start comprehensive surface-based testing at Yucca Mountain
- 1992 - Start site preparation for the ESF
- 1993 - Start portal construction of the ESF
- 1993 - Start ramp/drift construction of the ESF with the TBM
- 1996 - Begin in-situ testing in the ESF
- 2001 - If site is suitable, submit license application to NRC
- 2004 - Receive construction authorization from NRC for repository and start construction
- 2010 - Start operations at repository.

For specific dates, see the previous "Overall Schedule" subsection in the "Overview" section.

Low-Level Wastes

~~Two~~ Three sites are currently operating for disposal of commercial LLW (Richland, Washington; ~~and~~ Barnwell, South Carolina; and Clive, Utah) and the plans for additional sites vary from State to State. The LLRWPAA of 1985 establishes a schedule that each State must meet for commercial LLW or face penalties.

- July 1, 1986 - Each State shall ratify compact legislation or indicate its intent to develop its own LLW site
- January 1, 1988 - Identification of the host State responsible for a siting plan
- January 1, 1992 - Submission of a license application.

Seven DOE disposal sites are currently operating, with no new sites currently planned.

Transuranic Wastes

The key milestones for the Transuranic Waste Management Program at the Waste Isolation Pilot Plant include:

- 1975 - Site Selected for WIPP Carlsbad, New Mexico
- 1979 - Congress authorizes construction of WIPP (Public Law 96-164)
- 1980 - Final Environmental Impact Statement issued
- 1983 - Initial site characterization and design completed; facility construction started
- 1990 - Supplemental Environmental Impact Statement Issued
- 1991 - Construction complete and operational readiness (for waste tests) declared (operation prevented due to litigation)
- 1992 - Congress enacts the WIPP Land Withdrawal Act (Public Law 102-579)
- 1993 - DOE announces revised test program (simulated and transuranic waste tests in laboratories instead of WIPP)
- 1995 - Draft regulatory compliance certification package submitted to EPA, State of New Mexico, and others (as proposed including the NEA/OECD) for review
- 1996 - Final regulatory compliance package submitted to EPA and State of New Mexico
- 1997 - DOE receives certification of compliance with Disposal Standards and a No Migration Determination for disposal from EPA, and a Resource Conservation and Recovery Act Part B permit from the State of New Mexico
- 1997 - DOE completes all remaining legislative requirements to begin disposal operations
- 1997 - The Secretary of Energy makes a decision whether to operate WIPP as disposal facility and notifies Congress
- 1998 - DOE begin disposal operations.

COSTS

Spent Fuel and High-Level Wastes

The following are the estimated total life-cycle costs to site, develop, construct, operate, and decommission the repository based on the schedule presented in the previous section. The costs are for a single repository system based on the no-new-orders and end-of-reactor-life spent-fuel projection and intact disposal.

Estimated Repository Costs
(in Millions of 1988 Dollars)

Development & Evaluation	6,700
Engineering & Construction	1,200
Operation	7,100
Decommissioning	500
TOTAL	15,500

Low-Level Wastes

Costs for commercial LLW disposal vary due to differences in disposal facility concepts, capacities, management practices, State fees and surcharges, number and size of waste packages, and the characteristics of the radioactive wastes received. Forecast costs for existing and planned disposal facilities are typically in the range of $150 to $500 per cubic ft.

The following cost estimates were made (which includes pre-operating, operating, closure, and post-operating costs) for each general type of commercial LLW disposal facility in a study comparing alternative disposal systems for 8,800,000 square feet of commercial LLW over a 30-year period.

Estimated Commercial LLW Disposal Facility Costs
(in millions of 1986 Dollars)

Near-Surface Burial	406
Intermediate-Depth Disposal	421
Below-Ground Vault	617
Above-Ground Vault	790
Modular Concrete Canisters	630
Earth-Mounded Concrete Bunker	893

Transuranic Wastes

The following are the estimated WIPP total life-cycle costs by category in year-of-expenditure dollars. These include costs for facility construction, plant operations, a test program, regulatory compliance, impact assistance to the State of New Mexico, decontamination and decommissioning, and waste transportation.

WIPP Life-Cycle Cost by Category
(Year-of-Expenditure $ in millions)

Capital Construction	434
Plant Operations	3,818
Test Program	1,158
Institutional & Regulatory Compliance	895
Impact Assistance	826
Decommissioning & Decontamination	973
Transportation	312
Total Estimated Life-Cycle Costs	8,416

RADIATION PROTECTION

During the operational period, releases of radioactive materials to the general environment from a repository for commercial LLW disposal facilities must not result in an annual dose to any member of the public in excess of 25 mrems to the whole body, 75 mrems to the thyroid, and 25 mrems to any other critical organ. Occupational doses at repositories are limited to values indicated in NRC regulations 10 CFR 20, revised in 1991. Occupational doses are limited to a total effective dose equivalent of 5 rem/yr (0.05 Sv). However, the principle of ALARA (As Low as Reasonably Achievable) must also be applied, and occupational doses significantly below this value are anticipated.

The allowable releases from a DOE LLW disposal facility, specified in DOE Order 5820.2A, are similar to the criteria that are applicable to commercial facilities. However, the performance objectives that are in the Order for DOE LLW disposal facilities utilize a newer dose assessment methodology than the NRC requirements for commercial LLW disposal facilities, so there are slight differences. The Order allows an annual dose to any member of the public to be 25 mrem/yr effective dose equivalent (EDE), and also specifies a maximum dose to the inadvertent intruder of 100 mrem/yr EDE, or 500 mrem from an acute exposure.

QUALITY ASSURANCE CONSIDERATIONS

Spent Fuel and High-Level Wastes

The NRC's regulation 10 CFR 60 mandates that the general QA criteria in NRC's regulation 10 CFR 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Facilities," as applicable shall be applied to disposal of commercial spent fuel and HLW. An extensive program has been developed by DOE to ensure quality in the total commercial system for managing SNF and HLW.

A major goal in the commercial waste management activities is to sustain a high level of quality, both technically and administratively, in all activities. This concept is referred to as "Managing for Quality," and QA is an important aspect of this broad concept. QA includes elements of management planning and control, verification, and overview. QA elements are systematically and selectively applied in a formal and auditable QA program that is designed to: (1) validate the program compliance with regulatory and other programmatic requirements and standards; and (2) validate that the program has demonstrated the technical appropriateness, adequacy, and completeness.

Low-Level Wastes

A ~~stringent~~ QA plan, approved by the regulatory agencies, must be in effect for all commercial disposal facility siting, verification, evaluation, design and construction, operations, and decommissioning.

DOE operates all of their disposal facilities in strict compliance with detailed QA requirements specified in DOE Order 5700.6C. DOE Order 5820.2A references DOE Order 5700 as the applicable QA requirements.

Transuranic Wastes

All WIPP personnel have the responsibility for and are committed to achieving and improving quality. Senior management has established and cultivated practices that effectively integrate quality assurance requirements into daily work activities. They provide individuals with the proper resources necessary to achieve WIPP Project technical and quality objectives.

Line organizations are responsible for achieving quality. Each individual is required to meet the established WIPP quality assurance program requirements while recommending improvements in associated processes. A formal internal/external assessment process is used to evaluate overall performance.

According to DOE Order 5820.2A, "consistent with DOE 5700.6B, TRU waste operations shall be conducted in accordance with applicable requirements of ASME NQA-1 standards and other appropriate national consensus standards." The WIPP is now committed to DOE Order 5700.6B. EPA is currently in the process of establishing quality assurance requirements that will be used in the certification process for WIPP.

SAFETY CONSIDERATIONS

Spent Fuel and High-Level Wastes

Analytical techniques developed for and successfully used in the radiological assessment and licensing of other nuclear facilities are being used for estimating public and occupational radiation doses from waste disposal facilities. For long-term safety, performance assessment includes estimation of the potential release of radionuclides to ensure that release levels and resulting environmental impacts are below the NRC criteria and EPA standards. All commercial spent fuel and HLW storage, transportation, and disposal facilities and activities are monitored by the NRC.

Commercial Greater-than-Class C Low-Level Wastes

Stringent industrial and radiological safety requirements are dictated by the Federal, DOE, or State agencies responsible for regulating the various aspects of commercial GTCC wastes.

Low-Level Wastes

All commercial LLW disposal activities are monitored by regulatory personnel from the NRC or the Agreement State, and by other regulatory and enforcement organizations to ensure that facility activities conform to applicable industrial (OSHA) and radiological safety regulations (10 CFR Part 20).

DOE LLW disposal activities are monitored by DOE in accordance with the environmental monitoring requirements of DOE Order 5820.2A.

Transuranic Wastes

DOE complies with numerous Orders and regulations to protect workers, the public, and the environment. A Final Safety Analysis Report is in place and updated periodically to cover operations at the WIPP site. Safety is the highest priority among DOE site operations

In addition, the WIPP Land Withdrawal Act provides a regulatory framework and the statutory process for demonstrating compliance with long-term disposal regulations as well as other safety considerations. Some of the key provisions include:

- Certification by EPA that DOE has complied with all terms and conditions specified in the long term disposal standards and issuance of a No Migration Determination under the Resource Conservation and Recovery Act regulations
- Issuance of a permit for disposal operations by the State of New Mexico
- Certification by the Nuclear Regulatory Commission of transportation packages and quality assurance programs

- Certification by the Occupational Safety and Health Administration (OSHA) that DOE transportation accident prevention and emergency response training comply with OSHA regulations

- Review and concurrence by the Mine Safety and Health Administration on DOE's Plan for Underground Stability.

REFERENCES

1. 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," amended through January 1991.

2. 10 CFR Part 72, "Independent Spent Fuel Storage Facility Licenses," amended through January 1991.

3. 10 CFR 50 Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Facilities," July 1985.

4. 10 CFR Part 20, "Standards for Protection Against Radiation," amended in May, 1991.

5. 10 CFR Part 71, "Packaging and Transportation of Radioactive Material," amended through January 1991.

6. 10 CFR Part 72, "Licensing Requirements for Independent Storage of Spent Fuel and High Level Radioactive Waste," 1991.

7. 40 CFR Part 191, "Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," August 1985.

8. 10 CFR Part 60, "Disposal of High-Level Wastes in Geologic Repositories," amended through January 1991.

9. 10 CFR Part 960, "Nuclear Waste Policy Act General Guidelines for the Recommendations of Sites for the Nuclear Waste Repositories," December 1984.

10. Prototype Engineered Barrier System Field test (PEBSFT) Final Report (A.L. Ramirez Ed.)1991.*