

Appendix C

Program Drivers: Materials Destined for Geologic Disposal

Spent nuclear fuel generated by commercial nuclear reactors constitutes by far the largest stock of nuclear materials destined for geologic disposal. But a repository is also essential to the disposition of an array of other nuclear materials that are managed by the Department of Energy. This appendix summarizes current planning assumptions about how the disposal capacity of the repository would be allocated among all waste forms. It also consolidates some historical, technical, and policy information about these DOE-managed nuclear materials, and reports current and projected inventories of those materials and of commercial spent nuclear fuel.

Allocation of Repository Capacity: Current Planning Assumptions

Projected inventories and the statutory limit on the quantity of waste emplaced

The Nuclear Waste Policy Act of 1982 places a statutory limit of 70,000 metric tons heavy metal (MTHM) on the quantity of waste that can be emplaced in the first repository until a second repository is in operation. The 1987 Amendments Act requires the Secretary to report to the President and to Congress on or after January 1, 2007, but not later than January 1, 2010, on the need for a second repository. OCRWM's current projections of waste inventories extend through the year 2035, a date beyond both the expiration of all commercial reactor operating licenses in effect when the projections were made (licenses for two plants at one site have since been extended) and the last year for which DOE's Office of Environmental Management believes it can reliably project its operations for planning purposes. The total inventory of commercial spent nuclear fuel and DOE-managed nuclear materials requiring geologic disposal, projected through 2035, exceeds 70,000 MTHM.

Based on a Presidential decision to use disposal capacity at repositories developed pursuant to the Act for disposal of high-level radioactive waste resulting from atomic energy defense activities, OCRWM planning basis allocates 7,000 MTHM of the 70,000 MTHM statutory limit to DOE-managed nuclear materials. Of that 7,000 MTHM, DOE has specified that two-thirds would be high-level radioactive waste and one-third would be DOE and naval spent nuclear fuel.

For planning purposes, we analyze a range of design and operational capacities. The lower bound of the proposed repository capacity for spent fuel is consistent with the 70,000-MTHM statutory limit. The upper bound is based on projections of the total quantity of spent nuclear fuel and high-level radioactive waste requiring disposal. Analyses of the upper bound enable us to evaluate the actual physical capability of a potential repository at the Yucca Mountain site to safely isolate these wastes. The analyses of lower and upper bounds support site characterization, design work, a site recommendation, the environmental impact statement, preparation of a license application, and definition of repository operations.

Description of Materials Destined for Geologic Disposal

This section provides background information on projected quantities of material destined for geologic disposal. The projections are subject to change as decisions on materials disposition are made and carried out.

Consistent with information presented in the draft environmental impact statement (EIS) for the proposed repository at Yucca Mountain, this section divides the materials destined for geologic disposal into three groups: (1) commercial spent nuclear fuel, (2) DOE-managed spent nuclear fuel, and (3) DOE-managed high-level radioactive waste.

The table and figure at the end of this appendix provide an overview of the quantities of nuclear materials destined for geologic disposal and indicate the sources of data for information presented throughout this appendix.

Commercial spent nuclear fuel

Background

Commercial spent nuclear fuel is fuel that has been withdrawn from a nuclear reactor following irradiation. The fuels discussed in this section are those discharged from commercial reactors. Nuclear power reactors store spent nuclear fuel in spent fuel pools under NRC licenses; they can use a combination of storage options: (1) in-pool storage and (2) above-grade dry storage in an independent spent fuel storage installation.

The final form of commercial spent nuclear fuel to be disposed of in the proposed repository would be reactor fuel assemblies as they are discharged from reactors. The repository would receive spent fuel assemblies or spent nuclear fuel packaged in canisters. In the *DOE Record of Decision for the Surplus Plutonium Disposition Final Environmental Impact Statement*, issued in January 2000, DOE decided that up to 33 metric tons of the up to 50 metric tons of surplus plutonium would be converted to a mixed oxide fuel that would subsequently be burned in commercial reactors and disposed of in the repository as spent nuclear fuel.

Current and projected inventories

By December 1999, spent nuclear fuel containing approximately 40,000 MTHM was stored at 72 commercial power reactor sites and one independent storage site, as indicated in the figure below. Those sites are located in 33 States. Of the 118 reactors at these 72 sites, 14 are no longer in operation. Ten operating sites have added on-site above-grade dry storage to supplement their in-pool storage capacity; others are approaching full pool capacity and will require additional storage.

Based on current projections, by 2035, when the last of the existing 118 commercial power reactors will have completed its initial 40-year license period, spent nuclear fuel containing a total of about 85,000 MTHM will have been generated. This inventory includes spent nuclear fuel resulting from burning approximately 33 MTHM of surplus weapons-usable plutonium in the form of mixed-oxide fuel in commercial nuclear reactors. The resulting spent nuclear fuel would be stored at the reactor sites until it was transported to the repository for disposal.

DOE-managed spent nuclear fuel

Background

DOE stores most of its spent nuclear fuel at three locations: (1) the Hanford Site in Washington State, (2) the Idaho National Engineering and Environmental Laboratory, and (3) the Savannah River Site in South Carolina. A relatively small amount is stored at the Fort St. Vrain dry storage facility in Colorado. Small quantities remain at

other locations. The inventory of spent nuclear fuel created by the U.S. Navy from propulsion of its submarines and surface vessels is included in the DOE spent nuclear fuel inventory.

Over the past 40 years, DOE and its predecessor organizations have generated more than 200 varieties of spent nuclear fuel from weapons production, nuclear propulsion, and various research endeavors. Because there are so many varieties of DOE spent nuclear fuel and to facilitate total system performance assessments, fuel was grouped into 16 categories. To define the categories, regulatory requirements were used to identify the parameters that would affect the performance of DOE spent nuclear fuel in a repository and that would support analyses needed for a license application. A list of these 16 categories is included in Appendix A of the draft EIS for the proposed geologic repository at Yucca Mountain.

Current and projected inventories

Through the year 2035, the total inventory of DOE spent nuclear fuel is projected to be approximately 2,500 MTHM. The following paragraphs provide an overview of the materials and their respective quantities that constitute the total inventory.

- **Hanford Site.** Most of the DOE inventory of spent nuclear fuel, 2,100 MTHM, is now at the Hanford Site in Washington State, where spent nuclear fuel was generated in the N-Reactor for use in the weapons program. The Department plans to continue with plans to move this fuel, which is metallic-based, from wet storage to dry storage at the Hanford site.
- **Idaho National Engineering and Environmental Laboratory (INEEL).** The DOE spent nuclear fuel stored at this site originated in activities to promote the peaceful uses of atomic energy, beginning with the passage of the Atomic Energy Act of 1954. (The naval spent nuclear fuel stored at this site is discussed below.) The approximately 240 MTHM inventory, projected to remain essentially unchanged through 2035, includes spent nuclear fuel from demonstration reactors, from research and development activities, and from activities to demonstrate storage technologies and characterization for disposal. The research reactor fuel stored at this site is not aluminum-based; it will include 1.0 MTHM of foreign research reactor spent nuclear fuel. Debris from the Three Mile Island reactor is also stored at this site. Under a consent agreement between DOE, the Navy, and the State of Idaho, DOE shall remove spent nuclear fuel stored in that State by January 1, 2035.
- **Savannah River Site.** Spent nuclear fuel from production reactors has been stored at this South Carolina site, and some of it has been converted to high-level radioactive waste for disposal. The 44 MTHM of spent nuclear fuel in storage includes remaining unprocessed production reactor fuel and some domestic research reactor fuel. This inventory is projected to remain unchanged through the year 2035. The Department has also designated this site for storage of aluminum-clad spent nuclear fuel from domestic and foreign research reactors. The uranium in foreign reactor fuel was originally exported by the U.S. Government under the Atoms for Peace Program. In keeping with nuclear nonproliferation policies, foreign research reactor fuel is being returned to this country and placed under DOE management. Up to 16 MTHM is projected to be returned, of which approximately 15 MTHM will be stored at the Savannah River Site.
- **Naval spent nuclear fuel.** The Department of the Navy fabricates its own nuclear fuel for its nuclear-powered vessels using highly enriched uranium. For many years, naval spent nuclear fuel was shipped to the Idaho Chemical Processing Plant, where DOE reprocessed it to recover the uranium. Following DOE's termination of reprocessing activities in 1992, an agreement was reached in October 1995 between the Federal Government and the State of Idaho to allow the temporary storage of naval spent nuclear fuel

at INEEL. Under the consent agreement, naval spent nuclear fuel will be among the early shipments to a repository. In 1996, the Navy decided that it would store its spent nuclear fuel in dual-purpose canisters in Idaho prior to shipping it to a geologic repository for disposal. The current inventory consists of approximately 14 MTHM and is projected to total approximately 65 MTHM by 2035.

The total projected inventory of DOE spent nuclear fuel includes approximately 15 MTHM stored at other sites, including some commercially irradiated spent nuclear fuel now managed by DOE. In addition to the quantities of DOE-managed spent nuclear fuel discussed above, 60 metric tons of sodium-bonded spent nuclear fuel, most of it stored at INEEL and Argonne National Laboratory-West, are being evaluated to determine whether it requires treatment to make it suitable for disposal. The Department is preparing an environmental impact statement for proposed disposition of this spent nuclear fuel, as required by the National Environmental Policy Act. If the fuel is treated, it could be disposed of as high-level radioactive waste.

High-level radioactive waste

Background

High-level radioactive waste inventories have resulted from prior reprocessing spent nuclear fuel to recover plutonium and uranium. DOE originally intended to reprocess most of its spent nuclear fuel, and reprocessing began at a number of Federal sites as early as the 1940s. In 1985, when President Reagan decided that high-level radioactive waste resulting from atomic energy defense activities could be disposed of in the civilian repository, DOE and naval spent nuclear fuel were still being reprocessed, and reprocessing continued until 1992, when the Administration discontinued the practice.

In the *DOE Record of Decision for the Surplus Plutonium Disposition Final Environmental Impact Statement*, issued in January 2000, DOE decided that up to approximately 17 metric tons of the up to 50 metric tons of surplus plutonium would be immobilized in a ceramic form to be disposed of in canisters of vitrified high-level waste.

Current and projected inventories

Wastes from reprocessing are stored as aqueous solutions, sludges, and calcines at DOE's INEEL, Hanford, and Savannah River sites. If the decision is made to send these wastes to the repository, the Department will solidify them as borosilicate glass in canisters prior to transport. The canisters will be safely stored near the vitrification site until they are transported to the repository for disposal. At the Savannah River site, the production of borosilicate glass canisters has already begun. A total of approximately 22,000 canisters of high-level radioactive waste are projected to be produced at DOE sites through 2035. In addition, the West Valley Demonstration Project in New York State, a facility now managed by DOE, is vitrifying high-level radioactive waste that resulted from commercial reprocessing of spent nuclear fuel. Approximately 300 canisters of vitrified waste will be produced at West Valley.

Other nuclear materials no longer essential to national security needs

Through the work of its Nuclear Materials Stewardship Initiative, the Department is examining whether certain nuclear materials no longer essential to national security needs should be maintained as a national resource or disposed of, possibly in the geologic repository that OCRWM would develop.

These materials include curium and americium, now in solutions, metals and oxides of neptunium-237 at the

Savannah River Site, and uranium-233-rich materials at Oak Ridge and INEEL. If the Department determines that disposal in the repository is warranted, total system performance assessment analyses would evaluate the impacts on repository system performance of disposing of these materials in the repository.

Summary of Quantities of Materials Intended for Geologic Disposal

The table below is based on references that support both the Yucca Mountain repository viability assessment and the recently released DEIS for the proposed repository at Yucca Mountain. They identify quantities of materials requiring geologic disposal that are projected through 2035 and quantities allocated to the first repository for planning purposes. The map in the Introduction to this report indicates the location of these materials.

In the table below, quantities of spent nuclear fuel are expressed in MTHM. But other measures are also important for expressing quantities of spent nuclear fuel and high-level radioactive waste. The table expresses quantities of high-level radioactive waste in terms of canisters of vitrified high-level radioactive waste, and it identifies the number of waste packages that would be required for spent nuclear fuel and high-level radioactive waste.

In addition, the table reflects the Department's current plans to dispose of 50 metric tons of surplus weapons-usable plutonium by both immobilizing it in ceramic, to be disposed of in containers of vitrified high-level radioactive waste, and irradiating it in mixed oxide fuel that would become part of the commercial spent nuclear fuel inventory. Accordingly, the table identifies the number of canisters containing immobilized plutonium and high-level radioactive waste, and it counts the spent mixed oxide fuel as part of the inventory of commercial spent nuclear fuel.

Overview of Nuclear Materials Inventory ¹						
Waste Type	TOTAL Quantities Projected Through 2035			Planning Allocation for Repository under the 70,000 MTHM Statutory Limit		
	MTHM	Canisters	Disposal Containers Required	MTHM ²	Canisters	Disposal Containers Required
Commercial Spent Nuclear Fuel ⁴	85,000	N/A	10,000	63,000	N/A	7,600
DOE Spent Nuclear Fuel	2,500	4,000 ³	300 for Naval SNF 2,400 for HLW only	2,333	3,800 ³	290 for Naval SNF 910 for HLW only
High-Level Radioactive Waste	12,000 ³	22,000	1,300 in Co-disposal	4,667	8,300	1,300 in Co-disposal
<p>Sources of data for this table: Basis for the VA and TSLCC Cost Estimate Operational Waste Stream, June 1998, CRWMS M&O: A80-01717-1710-0002, Rev. 00 Drawn from references to Appendix A of the Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada</p> <p>Notes: ¹ All values, unless otherwise noted, are based on the best available data and are rounded to 2 significant figures. ² Calculated allocations based on the statutory limit. ³ Calculated using DOE-accepted method for determining MTHM equivalence. ⁴ Figures for commercial SNF assume no new reactor construction and no license extensions or renewals.</p>						

Materials intended for geologic disposal

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