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Civilian Nuclear Waste Disposal

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SUMMARY

Management of civilian radioactive waste has posed difficult issues for Congress since the beginning of the nuclear power industry in the 1950s. Federal policy is based on the premise that nuclear waste can be disposed of safely, but new storage and disposal facilities have frequently been challenged on safety, health, and environmental grounds. Although civilian radioactive waste encompasses a wide range of materials, most of the current debate focuses on highly radioactive spent fuel from nuclear power plants.

The Nuclear Waste Policy Act of 1982 (NWPA) calls for disposal of spent nuclear fuel in a deep geologic repository unlikely to be disturbed for thousands of years. NWPA established an office in the Department of Energy (DOE) to develop such a repository and required the program's civilian costs to be covered by a fee on nuclear-generated electricity, paid into the Nuclear Waste Fund. Amendments to NWPA in 1987 restricted DOE's repository site studies to Yucca Mountain in Nevada. DOE is studying numerous scientific issues at Yucca Mountain in preparing a license application to the Nuclear Regulatory Commission (NRC) for the planned repository. Questions about the site include the likelihood of earthquakes, volcanoes, water infiltration, and human intrusion.

NWPA's goal for loading waste into the repository was 1998, but DOE now does not expect to open the facility until after 2012. President Bush recommended the site to Congress February 15, 2002, and Nevada Governor Guinn exercised his right to "veto" the site April 8, 2002. A resolution to allow Yucca Mountain licensing to proceed despite the state veto was signed by the President July 23, 2002 (P.L. 107-200).

Upon releasing the civilian nuclear waste program's FY2006 budget request on February 7, 2005, DOE officials announced that the opening of the Yucca Mountain repository would be delayed at least two years from the previous goal of 2010. The waste program's funding request of $651.4 million was about 14% above the FY2005 level. The conference agreement provides $500 million for nuclear waste disposal, with $50 million set aside for DOE to develop a spent nuclear fuel recycling plan.

DOE announced on October 25, 2005, that it would require most spent fuel to be sealed in standardized canisters before shipment to Yucca Mountain, a change that would largely eliminate the handling of individual fuel assemblies at the site. DOE subsequently informed NRC that making those changes in the repository's operational plans would further delay submission of the Yucca Mountain license application.

Delays in the Yucca Mountain project could be exacerbated by a July 2004 federal circuit court decision that the Environmental Protection Agency's (EPA's) 10,000-year regulatory compliance period for the repository was too short.

Low-level waste disposal sites are a state responsibility under the Low-Level Radioactive Waste Policy Act of 1980. Pursuant to that act, 10 regional compacts for disposal of low-level waste have been approved by Congress. Three commercial low-level waste sites are currently operating, in the states of South Carolina, Utah, and Washington. The Washington facility is accepting waste just from within the Northwest and Rocky Mountain regional compacts, and the Utah site accepts only the least-concentrated waste class.

MOST RECENT DEVELOPMENTS

The FY2006 Energy and Water Development Appropriations bill, signed by the President on November 19, reduces funding for the Department of Energy (DOE) civilian nuclear waste program to $500 million — 14% below the previous year — and sets aside $50 million of that amount for the development of a spent nuclear fuel recycling plan (H.R. 2419, H.Rept. 109-275). In cutting the budget for the waste program and laying the groundwork for its potential redirection, conferees on the bill cited delays in DOE's license application to the Nuclear Regulatory Commission (NRC) for a planned national nuclear waste repository at Yucca Mountain, Nevada.

DOE announced on October 25, 2005, that it would require most spent fuel to be sealed in standardized canisters before shipment to Yucca Mountain, a change that would largely eliminate the handling of individual fuel assemblies at the site. DOE subsequently informed NRC that making those changes to the repository's operational plans would further delay submission of the Yucca Mountain license application. DOE officials had indicated that the opening of the repository would be delayed at least two years — to 2012 — when the program's FY2006 budget request of $651.4 million was released in February 2005.

The Environmental Protection Agency (EPA) on August 9 proposed new regulations for the Yucca Mountain repository that would allow higher radiation exposure after 10,000 years than during the first 10,000 years of repository operation. The previous EPA regulations were overturned July 9, 2004, by the U.S. Court of Appeals for the District of Columbia Circuit, which ruled that the regulations' 10,000-year compliance period was too short. The state of Nevada has strongly objected to the EPA-proposed rule.

NRC on September 9 authorized the issuance of a license for a private interim waste storage facility in Utah being developed by a nuclear utility consortium called Private Fuel Storage (PFS). However, PFS still needs approval from the Bureau of Land Management to widen a highway or build a railroad to the site. The above-ground PFS facility is intended to store up to 4,000 casks of spent nuclear fuel awaiting eventual disposal at Yucca Mountain.

BACKGROUND AND ANALYSIS

Introduction

Nuclear waste has sometimes been called the Achilles' heel of the nuclear power industry; much of the controversy over nuclear power centers on the lack of a disposal system for the highly radioactive spent fuel that must be regularly removed from operating reactors.

Under the Nuclear Waste Policy Act of 1982 (NWPA) and 1987 amendments, the Department of Energy (DOE) is focusing on Yucca Mountain, Nevada, to house a deep underground repository for spent nuclear fuel and other highly radioactive waste. The state of Nevada has strongly opposed DOE's efforts on the grounds that the site is unsafe, pointing

to potential volcanic activity, earthquakes, water infiltration, underground flooding, nuclear chain reactions, and fossil fuel and mineral deposits that might encourage future human intrusion.

Despite those concerns, DOE contends that the evidence so far indicates that Yucca Mountain is likely to prove suitable and that licensing of the site by the Nuclear Regulatory Commission (NRC) should proceed. A Draft Environmental Impact Statement (EIS) completed by DOE in July 1999 and finalized in February 2002 recommended that the project proceed as planned. However, DOE now does not expect the planned Yucca Mountain repository to open until 2012 at the earliest, more than 14 years later than the 1998 goal specified by NWPA.

The safety of geologic disposal of high-level waste (HLW), as planned in the United States, depends largely on the characteristics of the rock formations from which a repository would be excavated. Because many geologic formations are believed to have remained undisturbed for millions of years, it appeared technically feasible to isolate radioactive materials from the environment until they decayed to safe levels. "There is strong worldwide consensus that the best, safest long-term option for dealing with HLW is geologic isolation," according to the National Research Council.[1]

But, as the Yucca Mountain controversy indicates, scientific confidence about the concept of deep geologic disposal has turned out to be difficult to apply to specific sites. Every high-level waste site that has been proposed by DOE and its predecessor agencies has faced allegations or discovery of unacceptable flaws, such as water intrusion or earthquake vulnerability, that could release radioactivity into the environment. Much of the problem results from the inherent uncertainty involved in predicting waste site performance for the 10,000 years or longer that nuclear waste is to be isolated. Opponents of geologic disposal have urged greater emphasis on new or alternative technologies that might allow entirely different approaches to high-level radioactive waste management.

Other Programs. Other types of civilian radioactive waste have also generated public controversy, particularly low-level radioactive waste, which is produced by nuclear power plants, medical institutions, industrial operations, and research activities. Civilian low-level waste currently is disposed of in large trenches at sites in South Carolina and Washington state; however, the Washington facility does not accept waste from outside its region. The lowest-concentration class of low-level radioactive waste is also accepted by a Utah commercial disposal facility, which is no longer seeking approval to receive all major classes of low-level waste. Threats by states to close their disposal facilities led to congressional authorization of regional compacts for low-level waste disposal in 1985, although no new sites have been opened by any of the 10 approved disposal compacts. Pursuant to a 2003 Texas statute, an application to build a disposal facility for commercial and federal low-level waste in Andrews County, Texas, was filed August 2, 2004, by Waste Control Specialists LLC.

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[1] National Research Council, Board on Radioactive Waste Management, *Rethinking High-Level Radioactive Waste Disposal: A Position Statement of the Board on Radioactive Waste Management* (1990), p. 2.

Nuclear Utility Lawsuits

Nuclear utilities, which pay for most of the high-level waste disposal program through a fee on nuclear power, have sued DOE for failing to begin the removal of spent nuclear fuel from storage at commercial reactors by January 31, 1998, the deadline established by the Nuclear Waste Policy Act.

In response to a utility lawsuit, the U.S. Court of Appeals for the District of Columbia Circuit ruled November 14, 1997, that DOE would be liable for unspecified damages to nuclear utilities if it missed the 1998 deadline. DOE was ordered to work out a remedy with the utilities under the procedures of the standard disposal contract signed by all nuclear utilities pursuant to NWPA.

In the first set of rulings on breach-of-contract suits filed by several utilities, the U.S. Court of Federal Claims decreed on October 29, 1998, that DOE must pay fuel storage costs for three closed commercial reactors. Those costs are to be determined by future trials; the three utilities are claiming damages of $2.4 billion. Damage claims were denied to Northern States Power by another Court of Federal Claims judge on April 6, 1999, but that ruling was reversed by the U.S. Court of Appeals for the Federal Circuit on August 31, 2000.

The Appeals court decision cleared the way for nuclear power companies to proceed with lawsuits in the Court of Federal Claims against DOE. Industry officials contend that total damages for missing the 1998 disposal deadline could eventually reach tens of billions of dollars, assuming that no disposal ever takes place. Claims from more than 20 nuclear utilities are pending.[2] The Court of Claims on May 21, 2004, denied a claim of $100 million in damages from Indiana Michigan Power Company, ruling that the company had not demonstrated any costs resulting from DOE's breach of contract.[3]

DOE has been negotiating with various reactor owners since 1999 on the missed nuclear waste deadline and reached its first settlement agreement with a nuclear utility, PECO Energy Co. (now part of Exelon), on July 19, 2000. The agreement allowed PECO to keep up to $80 million in nuclear waste fee revenues during the subsequent 10 years. However, other utilities sued DOE to block the settlement, contending that nuclear waste fees may be used only for the DOE waste program and not as compensation for missing the disposal deadline. The U.S. Court of Appeals for the 11th Circuit agreed, ruling September 24, 2002, that any compensation would have to come from general revenues or other sources than the waste fund.

Exelon announced a settlement with the Department of Justice August 10, 2004, in which compensation for the company's nuclear waste storage costs would be paid from the federal Judgment Fund. Exelon, which operates 17 reactors, calculates that it would be reimbursed $300 million if DOE began taking waste by the previous goal of 2010, and up to $600 million if the schedule slipped to 2015.

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[2] "More Utility Damage Claims Expected," *NuclearFuel*, January 20, 2003, p. 8.

[3] Elaine Hiruo, "Indiana Michigan Mulls Appeal in Spent Fuel Default Case," *Nucleonics Week*, June 3, 2004, p. 5.

Although some of the program's delays have been blamed on poor management, DOE contends that tight funding has been a major barrier. DOE cannot spend the nuclear industry's mandatory waste fees without congressional appropriations, and only about half the total fees collected have been appropriated to the program so far. However, some surplus in the fund may be necessary to pay future nuclear waste disposal costs after today's nuclear plants have ceased operation. The nuclear industry and others have long urged changes in the waste program's funding mechanism but have consistently been stymied by budget scoring and policy issues.

Nuclear Spent Fuel Legislation

President Bush recommended the Yucca Mountain site to Congress on February 15, 2002, and Nevada Governor Guinn submitted a notice of disapproval, or "state veto," April 8, 2002, as allowed by NWPA. The state veto would have blocked further repository development at Yucca Mountain if a resolution approving the site had not been passed by Congress and signed into law within 90 days of continuous session.

Senator Bingaman introduced the approval resolution in the Senate April 9, 2002 (S.J.Res. 34), and Representative Barton introduced it in the House April 11, 2002 (H.J.Res. 87). The Subcommittee on Energy and Air Quality of the House Committee on Energy and Commerce approved H.J.Res. 87 on April 23 by a 24-2 vote, and the full Committee approved the measure two days later, 41-6 (H.Rept. 107-425). The resolution was passed by the House May 8, 2002, by a vote of 306-117. The Senate Committee on Energy and Natural Resources approved S.J.Res. 34 by a 13-10 vote June 5, 2002 (S.Rept. 107-159). Following a 60-39 vote to consider S.J.Res. 34, the Senate passed H.J.Res. 87 by voice vote July 9, 2002. President Bush signed the resolution July 23, 2002 (P.L. 107-200).

Characteristics of Nuclear Waste

Radioactive waste is a term that encompasses a broad range of material with widely varying characteristics. Some has relatively slight radioactivity and is safe to handle, while other types are intensely hot in both temperature and radioactivity. Some decays to safe levels of radioactivity in a matter of days or weeks, while other types will remain dangerous for thousands of years. Major types of radioactive waste are generally defined by DOE and the Nuclear Regulatory Commission (NRC) as follows:

Spent nuclear fuel. Fuel rods that have been permanently withdrawn from a nuclear reactor because they can no longer efficiently sustain a nuclear chain reaction (although they contain uranium and plutonium that could be extracted through reprocessing to make new fuel). By far the most radioactive type of civilian nuclear waste, spent fuel contains extremely hot but relatively short-lived fission products (fragments of the nuclei of uranium and other fissile elements) as well as long-lived radionuclides such as plutonium, which remains dangerously radioactive for tens of thousands of years or more.

High-level waste. Highly radioactive residue created by spent fuel reprocessing (almost entirely for defense purposes in the United States). High-level waste contains most of the

radioactive fission products of spent fuel, but most of the uranium and plutonium usually has been removed for re-use. Enough long-lived radioactive elements remain, however, to require isolation for 10,000 years or more.

Transuranic (TRU) waste. Relatively low-activity waste that contains more than a certain level of long-lived elements heavier than uranium (primarily plutonium). Shielding may be required for handling of some types of TRU waste. In the United States, transuranic waste is generated almost entirely by nuclear weapons production processes. Because of the plutonium, long-term isolation is required.

Low-level waste. Radioactive waste not classified as spent fuel, high-level waste, TRU waste, or byproduct material such as uranium mill tailings (below). Four classes of low-level waste have been established by NRC, ranging from least radioactive and shortest-lived to the longest-lived and most radioactive. Although some types of low-level waste can be more radioactive than some types of high-level waste, in general low-level waste contains relatively low amounts of radioactivity that decays relatively quickly. Low-level waste disposal facilities cannot accept material that exceeds NRC concentration limits.

Uranium mill tailings. Sand-like residues remaining from the processing of uranium ore. Such tailings have very low radioactivity but extremely large volumes that can pose a hazard, particularly from radon emissions or groundwater contamination.

Mixed waste. High-level, low-level or TRU waste that contains hazardous non-radioactive waste. Such waste poses serious institutional problems, because the radioactive portion is regulated by DOE or NRC under the Atomic Energy Act, while the Environmental Protection Agency (EPA) regulates the non-radioactive elements under the Resource Conservation and Recovery Act (RCRA).

Spent Nuclear Fuel

When spent nuclear fuel is removed from a reactor, usually after several years of power production, it is thermally hot and highly radioactive. The spent fuel is in the form of fuel assemblies, which consist of arrays of metal-clad fuel rods 12-15 feet long.

A fresh fuel rod, which emits relatively little radioactivity, contains uranium that has been enriched in the isotope U-235 (usually 3-5%). But after nuclear fission has taken place in the reactor, many of the uranium nuclei in the fuel rods have been split into a variety of highly radioactive fission products; others have absorbed neutrons to become radioactive plutonium, some of which has also split into fission products. Radioactive gases are also contained in the spent fuel rods. Newly withdrawn spent fuel assemblies are stored in deep pools of water adjacent to the reactors to keep them from overheating and to protect workers from radiation.

Spent fuel discharged from U.S. commercial nuclear reactors is currently stored at 72 power plant sites around the nation, plus two small central storage facilities. At the end of 2002 (the most recent DOE survey), commercial spent fuel totaled 46,927 metric tons. A typical large commercial nuclear reactor discharges an average of 20-30 metric tons of spent fuel per year — an average of about 2,150 metric tons annually for the entire U.S. nuclear power industry. As a result, the total amount of commercial spent fuel is expected to exceed

53,000 metric tons by the end of 2005 and 62,000 metric tons by 2010, when the Yucca Mountain repository had been planned to open. Including 7,000 metric tons of DOE spent fuel and high-level waste that is also planned for disposal at Yucca Mountain, the total amount would nearly reach NWPA's 70,000-metric-ton limit by 2010. (For details on current spent fuel storage, see CRS Report RS22001, *Spent Nuclear Fuel Storage Locations and Inventory*, by Anthony Andrews.)

As long as nuclear power continues to be generated, the amounts stored at plant sites will continue to grow until an interim storage facility or a permanent repository can be opened — or until alternative treatment and disposal technology is developed. DOE estimates that the amount of commercial spent fuel and other highly radioactive waste may grow to 105,000 metric tons by 2035.[4]

New storage capacity at operating nuclear plant sites or other locations will be required if DOE is unable to begin accepting waste into its disposal system for another five years or longer. Most utilities are expected to construct new dry storage capacity for their older fuel. On-site dry storage facilities currently in operation or planned typically consist of metal casks or concrete modules. NRC has determined that spent fuel could be stored safely at reactor sites for up to 100 years.[5]

The terrorist attacks of September 11, 2001, heightened concerns about the vulnerability of stored spent fuel. Concerns have been raised that an aircraft crash into a reactor's pool area could drain the pool and cause the spent fuel inside to overheat. A report released by NRC January 17, 2001, found that overheating could cause the zirconium alloy cladding of spent fuel to catch fire and release hazardous amounts of radioactivity, although it characterized the probability of such a fire as low.

In a report released April 6, 2005, the National Academy of Sciences (NAS) found that "successful terrorist attacks on spent fuel pools, though difficult, are possible." To reduce the likelihood of spent fuel cladding fires, the NAS study recommended that hotter and cooler spent fuel assemblies be interspersed throughout spent fuel pools, that spray systems be installed above the pools, and that more fuel be transferred from pools to dry cask storage.[6] NRC has agreed to consider some of the recommendations, although it contends that current security measures would prevent successful attacks. The nuclear industry contends that the several hours required for uncovered spent fuel to heat up enough to catch fire would allow ample time for alternative measures to cool the fuel. The FY2006 Energy and Water appropriations bills (P.L. 109-103) gives NRC an additional $21 million to implement the NAS recommendations.

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[4] DOE Office of Civilian Radioactive Waste Management, *OCRWM Annual Report to Congress, Fiscal Year 2002*, DOE/RW-0560, October 2003, Appendix C.

[5] Nuclear Regulatory Commission, *Waste Confidence Decision Review*, 55 *Federal Register* 38474, September 18, 1990.

[6] National Academy of Sciences, *Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report*, released April 6, 2005, p. 2.

Commercial Low-Level Waste

Low-level waste disposed of in commercial sites makes up about a third of all accumulated low-level waste in the United States; the remaining two-thirds has been generated by DOE activities and sent to DOE-owned disposal sites. Several million cubic feet of commercial low-level waste is shipped to disposal sites each year, according to NRC. Volumes can vary widely from year to year, based on the status of nuclear decommissioning projects and cleanup activities that can generate especially large quantities.

For more background on radioactive waste characteristics, see CRS Report RL32163, *Radioactive Waste Streams: An Overview of Waste Classification for Disposal*, by Anthony Andrews.

Current Policy and Regulation

Spent fuel and high-level waste are a federal responsibility, while states are authorized to develop disposal facilities for commercial low-level waste. In general, disposal requirements have grown more stringent over the years, in line with overall national environmental policy and heightened concerns about the hazards of radioactivity.

Spent Nuclear Fuel

Current Program. The Nuclear Waste Policy Act of 1982 (NWPA, P.L. 97-425) established a system for selecting a geologic repository for the permanent disposal of up to 70,000 metric tons (77,000 tons) of spent nuclear fuel and high-level waste. DOE's Office of Civilian Radioactive Waste Management (OCRWM) was created to carry out the program. The Nuclear Waste Fund, holding receipts from a fee on commercial nuclear power and federal contributions for emplacement of high-level defense waste, was established to pay for the program. DOE was required to select three candidate sites for the first national high-level waste repository.

After much controversy over DOE's implementation of NWPA, the act was substantially modified by the Nuclear Waste Policy Amendments Act of 1987 (Title IV, Subtitle A of P.L. 100-203, the Omnibus Budget Reconciliation Act of 1987). Under the amendments, the only candidate site DOE may consider for a permanent high-level waste repository is at Yucca Mountain, Nevada. If that site cannot be licensed, DOE must return to Congress for further instructions.

The 1987 amendments also authorized construction of a monitored retrievable storage (MRS) facility to store spent fuel and prepare it for delivery to the repository. But because of fears that the MRS would reduce the need to open the permanent repository and become a de facto repository itself, the law forbids DOE from selecting an MRS site until recommending to the President that a permanent repository be constructed. The repository recommendation occurred in February 2002, but DOE has not announced any plans for an MRS.

Waste Facility Schedules. Upon releasing the civilian nuclear waste program's FY2006 budget request on February 7, 2005, DOE officials announced that the opening of

the planned Yucca Mountain repository would be delayed at least two years from the previous goal of 2010 — and more than 14 years after the statutory deadline of January 1998. The waste program's funding request of $651.4 million was about 14% above the FY2005 level but only about half the amount that last year's budget justification said would have been needed to open the repository by 2010.

DOE announced on October 25, 2005, that it would require most spent fuel to be sealed in standardized canisters before shipment to Yucca Mountain, a change that would largely eliminate the handling of individual fuel assemblies at the site. DOE subsequently informed NRC that the changes would further delay submission of the Yucca Mountain license application: "Until this plan is approved and these changes have been incorporated into the project's baseline design, DOE will be unable to estimate realistically when the license application will be submitted."[7]

The major activity at the Yucca Mountain site so far has been the construction and operation of an "exploratory studies facility" (ESF) with a 25-foot-diameter tunnel boring machine. The ESF consists primarily of a five-mile tunnel with ramps leading to the surface at its north and south ends. The tunnel boring machine began excavating the north ramp in October 1994 and broke through to the surface at the south entrance April 25, 1997. Underground studies are being conducted at several side alcoves that have been excavated off the main tunnel.

DOE completed a "viability assessment" of Yucca Mountain in December 1998, which was followed by a draft environmental impact statement (EIS) for the project in July 1999. DOE issued a preliminary site suitability evaluation August 21, 2001, that found Yucca Mountain could meet EPA and NRC requirements.

Energy Secretary Abraham on February 14, 2002, recommended to the President that the Yucca Mountain project go forward. At the same time, the Secretary submitted the final EIS (see [http://www.ocrwm.doe.gov/documents/feis_a/index.htm]) and other supporting materials (for details, see the Yucca Mountain Project home page at [http://www.ocrwm.doe.gov]). As noted previously, President Bush recommended the Yucca Mountain site to Congress the day after the Secretary's recommendation, and Nevada Governor Guinn subsequently submitted a notice of disapproval, or "state veto," as allowed by NWPA. An approval resolution passed by the House and Senate to overturn the state veto was signed by the President July 23, 2002 (P.L. 107-200).

DOE announced April 8, 2004, that it planned to transport nuclear waste mostly by rail to the planned Yucca Mountain repository. The Record of Decision on the waste transportation mode was published in the *Federal Register* along with the selection of a corridor in Nevada for a 300-mile rail spur to the Yucca Mountain site. DOE estimated that Yucca Mountain would receive 9,000-10,000 rail shipments and 3,000-3,300 truck shipments over a 24-year period after the repository opened. The repository is to be permanently closed in 2116, according to the DOE viability assessment.

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[7] Nuclear Regulatory Commission, *The Department of Energy's Sixth Monthly Status Report Regarding LSN Certification and License Application Submittal*, November 1, 2005.

The quality of scientific work at Yucca Mountain was called into question by DOE's March 16, 2005, disclosure of e-mails from geologists indicating that some quality assurance documentation had been falsified. DOE currently is determining whether the problems affect the completeness and accuracy of information submitted to NRC in support of the planned Yucca Mountain license application. Members of the Nevada congressional delegation and state officials have called for the Yucca Mountain project to be suspended and for an independent commission to review all of DOE's scientific work at Yucca Mountain.[8]

The state of Nevada is also fighting DOE in court. A suit filed in June 2002 charged DOE with violating NWPA by relying too strongly on casks and other engineered barriers to prevent radioactive releases, rather than on Yucca Mountain's natural site characteristics. The most recent, filed January 9, 2003, contended that Congress violated the Constitution in eliminating all candidate waste sites except Yucca Mountain. The U.S. Court of Appeals for the District of Columbia Circuit rejected those challenges July 9, 2004, but it struck down EPA's 10,000-year regulatory compliance period as too short (discussed in more detail below).

Nevada also successfully challenged DOE's June 30, 2004, certification that it had made all licensing background materials available. NRC requires that such material be available on its Web-based Licensing Support Network (LSN) at least six months before a repository application is docketed, so the DOE certification was on the last day that would still have allowed docketing before the end of 2004. An NRC licensing board ruled August 31, 2004, that DOE had not yet placed all relevant information onto the system. DOE informed NRC on November 1, 2005, that the Department "is unable to provide a predicted date for LSN certification at this time."[9]

Delays in the Yucca Mountain project prompted the House Appropriations Committee to include language in its report on the FY2006 Energy and Water appropriations bill directing DOE "to begin the movement of spent fuel to centralized interim storage at one or more DOE sites within fiscal year 2006."[10] The bill as passed by the House (H.R. 2419) would have added $10 million to the Administration's nuclear waste funding request for that purpose. During floor debate, questions arose about potential conflicts between the committee report language and restrictions on DOE interim storage imposed by NWPA and state agreements. The Senate-passed version of the bill did not include comparable report language on spent fuel storage.

The conference agreement on the FY2006 Energy and Water bill (H.Rept. 109-275, P.L. 109-103) provides $500 million for nuclear waste disposal — $150 million from the Nuclear Waste Fund and $350 million from the Defense Nuclear Waste Disposal Account. Of the defense waste funding, $50 million is provided for DOE to develop a spent nuclear fuel recycling plan, in conjunction with a recycling technology development plan required under the Advanced Fuel Cycle Initiative. The detailed program plan is to be submitted by March

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[8] Elaine Hiruo, "DOE Sought Help From Scientist Who Wrote E-mails," *NuclearFuel*, April 11, 2005, p. 1.

[9] Nuclear Regulatory Commission, *The Department of Energy's Sixth Monthly Status Report Regarding LSN Certification and License Application Submittal*, November 1, 2005.

[10] H.Rept. 109-86, May 18, 2005.

31, 2006, and a "site selection competition" for an integrated reprocessing facility is to begin by June 30, 2006. A reprocessing site is to be selected in FY2007 and construction to begin in FY2010. "The site competition should not be limited to DOE sites, but should be open to a wide range of other possible federal and nonfederal sites on a strictly voluntary basis," according to the conference report. Applicants for a reprocessing facility can receive up to $5 million per site, up to a total of $20 million, to prepare detailed proposals.

The DOE Total System Life Cycle Cost Report, issued in May 2001 and updated in September 2003, estimates that the entire program will cost $56 billion (in constant 2000 dollars) through 2119.

Private Interim Storage. In response to delays in the federal nuclear waste program, a utility consortium signed an agreement with a Utah Indian tribe on December 27, 1996, to develop a private spent fuel storage facility on tribal land. The Private Fuel Storage (PFS) consortium submitted a license application to NRC on June 25, 1997, and an NRC licensing board recommended approval on February 24, 2005. On September 9, 2005, NRC denied the State of Utah's final appeals and authorized the NRC staff to issue the license.

Despite the NRC license, the PFS facility still needs approval from the Bureau of Land Management (BLM) to build a rail line or widen a highway through federal land to transport waste to the site. BLM officials said in November 2005 that such approval would not be given until the Department of Defense has studied the impact of any such land-use changes on nearby military facilities, as required by section 2815 of the National Defense Authorization Act for FY2000 (P.L. 106-65). That study has reportedly not begun.[11]

Project officials told NRC in March 1997 that the dry-cask storage facility would be located on 98 acres of the sparsely populated reservation of the Skull Valley Band of Goshute Indians, about 70 miles southwest of Salt Lake City. The initial lease for the site would run for 25 years, with possible renewal for another 25 years. The facility's capacity would be 40,000 metric tons, available to any U.S. nuclear utility in addition to the eight consortium members.

The PFS facility, strongly opposed by the state of Utah, would not require DOE assistance or congressional or state approval. Six of the eight partners in the PFS consortium have told the state of Utah that they would continue to fund the project only through the NRC licensing phase and not move into the construction phase unless progress on Yucca Mountain were to bog down. No contracts to store waste at the PFS site have been announced.

The NRC licensing board had determined on March 10, 2003, that the PFS facility should not be licensed without sufficient evidence that it could withstand a crash from fighter jets based nearby. In February 2005, the three-member panel decided 2-1 that most crashes would not breach the storage casks and that the probability of radioactive releases was therefore low enough to allow the facility to be licensed. The U.S. Circuit Court of Appeals for the 10th Circuit on August 4, 2004, struck down several statutes that Utah had enacted to block the PFS project, but the state is appealing the decision.

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[11] Foy, Paul. "BLM Blocking Skull Valley Nuclear Waste Project." *Associated Press.* November 2, 2005.

Regulatory Requirements. NWPA requires that high-level waste facilities be licensed by the NRC in accordance with general standards issued by EPA. Under the Energy Policy Act of 1992 (P.L. 102-486), EPA was required to write new standards specifically for Yucca Mountain. NWPA also requires the repository to meet general siting guidelines prepared by DOE and approved by NRC. Transportation of waste to storage and disposal sites is regulated by NRC and the Department of Transportation (DOT). Under NWPA, DOE shipments to Yucca Mountain must use NRC-certified casks and comply with NRC requirements for notifying state and local governments. Yucca Mountain shipments must also follow DOT regulations on routing, placarding, and safety.

NRC's licensing requirements for Yucca Mountain, at 10 CFR 63, require compliance with EPA's standards (described below) and establish procedures that DOE must follow in seeking a repository license. For example, DOE must conduct a repository performance confirmation program that would indicate whether natural and man-made systems were functioning as intended and assure that other assumptions about repository conditions were accurate.

The Energy Policy Act of 1992 (P.L. 102-486) made a number of changes in the nuclear waste regulatory system, particularly that EPA must issue new environmental standards specifically for the Yucca Mountain repository site. General EPA repository standards previously issued and subsequently revised no longer apply to Yucca Mountain. DOE and NRC had complained that some of EPA's general standards might be impossible or impractical to meet.

The new standards, which limit the radiation dose that the repository could impose on individual members of the public, were required to be consistent with the findings of a study by the National Academy of Sciences (NAS), which was issued August 1, 1995.[12] The NAS study recommended that the Yucca Mountain environmental standards establish a limit on risk to individuals near the repository, rather than setting specific limits for the releases of radioactive material or on radioactive doses, as under previous EPA standards. The NAS study also examined the potential for human intrusion into the repository and found no scientific basis for predicting human behavior thousands of years into the future.

Pursuant to the Energy Policy Act, EPA published its proposed Yucca Mountain radiation protection standards on August 27, 1999. The proposal would have limited annual radiation doses to 15 millirems for the "reasonably maximally exposed individual," and to 4 millirems from groundwater exposure, for the first 10,000 years of repository operation. EPA calculated that its standard would result in an annual risk of fatal cancer for the maximally exposed individual of seven chances in a million. The nuclear industry criticized the EPA proposal as being unnecessarily stringent, particularly the groundwater standard. On the other hand, environmental groups contended that the 10,000-year standard proposed by EPA was too short, because DOE had projected that radioactive releases from the repository would peak after about 480,000 years.

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[12] National Research Council. *Technical Bases for Yucca Mountain Standards*. National Academy Press. 1995.

EPA issued its final Yucca Mountain standards on June 6, 2001. The final standards included most of the major provisions of the proposed version, including the 15 millirem overall exposure limit and the 4 millirem groundwater limit. The most significant changes in the final rules were to require that compliance be demonstrated about one mile closer to the repository and to double the amount of groundwater that would be analyzed. Despite the Department's opposition to the EPA standards, DOE's site suitability evaluation determined that the Yucca Mountain site would be able to meet them. NRC revised its repository regulations September 7, 2001, to conform to the EPA standards.

In a ruling that could delay the nuclear waste program, a three-judge panel of the U.S. Court of Appeals for the District of Columbia Circuit on July 9, 2004, struck down the 10,000-year regulatory compliance period in the EPA and NRC Yucca Mountain standards. The court ruled that the 10,000-year period was inconsistent with the NAS study on which the Energy Policy Act required the Yucca Mountain regulations to be based. In fact, the court found, the NAS study had specifically rejected a 10,000-year compliance period because of analysis that showed peak radioactive exposures from the repository would take place several hundred thousand years in the future.

In response to the court decision, EPA proposed a new version of the Yucca Mountain standards on August 9, 2005. The proposal would retain the dose limits of the previous standard for the first 10,000 years but allow a higher annual dose of 350 millirems for the period of 10,000 years through 1 million years. The Final Environmental Impact Statement for the Yucca Mountain repository estimates that mean peak doses — occurring after 400,000 years — would be about 150 millirems (Volume 1, Chapter 5). EPA also is proposing to base the new Yucca Mountain standard on the median dose, rather than the mean, potentially making it easier to meet. Nevada state officials called EPA's proposed standard far too lenient and charged that it was "unlawful and arbitrary."[13]

Alternative Technologies. Several alternatives to the geologic disposal of spent fuel have been studied by DOE and its predecessor agencies, as well as technologies that might make waste disposal easier. However, most of these technologies involve large technical obstacles, uncertain costs, and potential public opposition.

Among the primary long-term disposal alternatives to geologic repositories are disposal in deep ocean trenches and transport into space, neither of which is currently being studied by DOE. Other technologies have been studied that, while probably not replacing geologic disposal, might make geologic disposal safer and more predictable. Chief among these is the reprocessing or "recycling" of spent fuel so that plutonium, uranium, and other long-lived radionuclides could be converted to faster-decaying fission products in special nuclear reactors or particle accelerators. The spent fuel recycling provisions in the FY2006 Energy and Water Development Appropriations bill, discussed above, seem to indicate growing congressional interest in this area.

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[13] Office of the Governor, Agency for Nuclear Projects. *Comments by the State of Nevada on EPA's Proposed New Radiation Protection Rule for the Yucca Mountain Nuclear Waste Repository*. November 2005.

Funding. The nuclear waste program's FY2006 funding request of $651.4 million was about 14% above the FY2005 level. The House-passed Energy and Water Development appropriations bill (H.R. 2419, H.Rept. 109-86) added $10 million to the Administration's nuclear waste request for DOE interim spent fuel storage, as discussed above under "Waste Facility Schedules." The Senate version of the bill, passed July 1, 2005, would have provided $577 million, about the same as the FY2005 level (S.Rept. 109-84). The conference agreement provides $500 million for the nuclear waste program, with $50 million set aside for DOE to develop a spent nuclear fuel recycling plan (H.Rept. 109-275, P.L. 109-103).

Funding for the program is provided under two appropriations accounts, as shown in **Table 1**. The Administration requested $300.0 million from the Nuclear Waste Fund, which holds the fees paid by nuclear utilities. An additional $351.5 million was requested under the Defense Nuclear Waste Disposal account, which pays for disposal of high-level waste from the nuclear weapons program in the planned Yucca Mountain repository. The final bill provides $150 million from the Nuclear Waste Fund and $350 million from the Defense Nuclear Waste Disposal Account.

Table 1. DOE Civilian Spent Fuel Management Funding
(in millions of current dollars)

Program	FY2005 Approp.	FY2006 Request	FY2006 House	FY2006 Senate	FY2006 Approp.
Yucca Mountain	413.1	427.3	— *	— *	— *
Transportation	30.7	85.4	—	—	—
Program integration	49.3	57.2	—	—	—
Program direction	79.4	81.5	—	—	—
Spent fuel storage and recycling	—	—	10.0	—	50.0
Total	**572.4**	**651.4**	**661.4**	**577.0**	**500.0**
Source of Funding					
Nuclear Waste Fund appropriations	343.3	300.0	310.0	300.0	150.0
Defense waste appropriations	229.2	351.4	351.4	277.0	350.0

Sources: Appropriations Committee reports, DOE FY2006 Congressional Budget Request.
*Subcategories not specified.

Although nuclear utilities pay fees to the Nuclear Waste Fund to cover the disposal costs of civilian nuclear spent fuel, DOE cannot spend the money in the fund until it is appropriated by Congress. Through the end of FY2004, utility nuclear waste fees and interest totaled $22.509 billion, of which $6.160 billion had been disbursed to the waste disposal program, according to DOE's program summary report (see [http://www.ocrwm.doe.gov/pm/budget/]), leaving a balance of $16.349 billion in the Nuclear Waste Fund. The nuclear waste program's appropriations for FY1983-FY2004 total $8.076 billion, according to DOE, including $2.344 billion for defense waste disposal.

Low-Level Radioactive Waste

Current Policy. Selecting disposal sites for low-level radioactive waste, which generally consists of low concentrations of relatively short-lived radionuclides, is a state responsibility under the 1980 Low-level Radioactive Waste Policy Act and 1985 amendments. Most states have joined congressionally approved interstate compacts to handle low-level waste disposal, while others are developing single-state disposal sites. Under the 1985 amendments, the nation's three (at that time) operating commercial low-level waste disposal facilities could start refusing to accept waste from outside their regional interstate compacts after the end of 1992. One site is currently using that authority and another closed, leaving one open to nationwide disposal of all major types of low-level waste. A third site, in Utah, has since become available nationwide for most Class A low-level waste.

Despite the 1992 deadline, no new disposal sites have been opened. A facility in California's Ward Valley to serve California, Arizona, North Dakota, and South Dakota received a state operating permit in 1993. However, the site is on federal land, which the Department of the Interior would not transfer to the state as had originally been expected.

Legislation providing congressional consent to a compact among Texas, Maine, and Vermont was signed by President Clinton September 20, 1998 (P.L. 105-236). However, on October 22, 1998, a proposed disposal site near Sierra Blanca, Texas, was rejected by the Texas Natural Resource Conservation Commission, and Maine has since withdrawn. Texas Governor Perry signed legislation June 20, 2003, authorizing the Texas Commission on Environment Quality to license adjacent disposal facilities for commercial and federally generated low-level waste. Pursuant to that statute, an application to build a disposal facility for commercial and federal low-level waste in Andrews County, Texas, was filed August 2, 2004, by Waste Control Specialists LLC.

The Midwestern Compact voted June 26, 1997, to halt development of a disposal facility in Ohio. Nebraska regulators rejected a proposed waste site for the Central Compact December 21, 1998, drawing a lawsuit from five utilities in the region. A U.S. district court judge ruled September 30, 2002, that Nebraska had exercised bad faith in disapproving the site and ordered the state to pay $151 million to the compact. A settlement was reached August 9, 2004, in which Nebraska will pay the compact $140.4 million, and the compact will seek access to the planned Texas disposal facility. Most other regional disposal compacts and individual states that have not joined compacts are making little progress toward finding disposal sites, largely because of public opposition and the continued availability of the disposal facilities in South Carolina and, for most Class A waste, Utah.

One disposal facility, at Barnwell, S.C., is currently accepting all Class A, B and C low-level waste from most states. The Barnwell facility had stopped accepting waste from outside the Southeast Compact at the end of June 1994. The Southeast Compact Commission in May 1995 twice rejected a South Carolina proposal to open the Barnwell site to waste generators outside the Southeast and to bar access to North Carolina until that state opened a new regional disposal facility, as required by the compact. The rejection of those proposals led the South Carolina General Assembly to vote in 1995 to withdraw from the Southeast Compact and begin accepting waste at Barnwell from all states but North Carolina. North

Carolina withdrew from the Southeast Compact July 26, 1999, a move that prompted a lawsuit from the compact on July 10, 2000.

South Carolina joined the Atlantic Compact (formerly the Northeast Compact) with Connecticut and New Jersey on July 1, 2000. Under the compact, South Carolina can limit the use of the Barnwell facility to the three compact members. A state law enacted in June 2000 phases out acceptance of non-compact waste through 2008.

The only other existing disposal facility for all three major classes of low-level waste is at Hanford, Washington. Controlled by the Northwest Compact, the Hanford site will continue taking waste from the neighboring Rocky Mountain Compact under a contract. States barred from access to existing disposal facilities are likely to require low-level waste generators to store their waste on site until new disposal sites are available, particularly for Class B and C waste.

Regulatory Requirements. Licensing of commercial low-level waste facilities is carried out under the Atomic Energy Act by NRC or by "agreement states" with regulatory programs approved by NRC. NRC regulations governing low-level waste licenses must conform to general environmental protection standards and radiation protection guidelines issued by EPA. Transportation of low-level waste is jointly regulated by NRC and the Department of Transportation.

Most states considering new or expanded low-level waste disposal facilities, including Texas and Utah, are agreement states. Most states, both agreement and non-agreement, have established substantially stricter technical requirements for low-level waste disposal than NRC's, such as banning shallow land burial and requiring concrete bunkers and other engineered barriers. NRC would issue the licenses in non-agreement states.

LEGISLATION

H.R. 526 (Berkley)

Redirects the Nuclear Waste Fund established under the Nuclear Waste Policy Act of 1982 into research, development, and utilization of risk-decreasing technologies for the onsite storage and eventual reduction of radiation levels of nuclear waste. Introduced February 2, 2005; referred to Committees on Energy and Commerce; Science; and Ways and Means.

H.R. 895 (Berkley)

Provides for interagency planning for preparing for, defending against, and responding to the consequences of terrorist attacks against the Yucca Mountain Project. Introduced February 17, 2005; referred to Committees on Energy and Commerce and Homeland Security.

H.R. 2419 (Hobson)

Energy and Water Development Appropriations for FY2006. Provides funding for DOE nuclear waste program. Reported as an original measure by the House Committee on Appropriations and introduced May 18, 2005 (H.Rept. 109-86). Passed House May 24,

2005, by vote of 416-13. Passed Senate July 1, 2005, by vote of 92-3 (S.Rept. 109-84). Signed by the President November 19, 2005 (H.Rept. 109-275, P.L. 109-103).

CONGRESSIONAL HEARINGS, REPORTS, AND DOCUMENTS

U.S. Congress. House. Committee on Energy and Commerce. Subcommittee on Energy and Air Quality. *A Review of the President's Recommendation to Develop a Nuclear Waste Repository at Yucca Mountain, Nevada*. Hearing, 107th Congress, 2nd session. April 18, 2002. Washington: GPO, 2002. 294 p. "Serial no. 107-99."

U.S. Congress. Senate. Committee on Energy and Natural Resources. *Low-Level Radioactive Waste*. Hearing, 108th Congress, 2nd session. September 30, 2004. Washington: GPO, 2005. 62 p.

U.S. Congress. Senate. *Yucca Mountain Repository Development*. Hearings, 107th Congress, 1st session. May 16, 22, and 23, 2002. Washington: GPO, 2002. 240 p. S. Hrg. 107-483.

FOR ADDITIONAL READING

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Harvard University. John F. Kennedy School of Government. Belfer Center for Science and International Affairs. *The Economics of Reprocessing vs. Direct Disposal of Spent Nuclear Fuel*. DE-FG26-99FT4028. December 2003.

Nuclear Waste Technical Review Board. *Report to the U.S. Congress and the U.S. Secretary of Energy*. May 2004. 152 p.

U.S. Department of Energy. *Office of Civilian Radioactive Waste Management home page*; covers DOE activities for disposal, transportation, and other management of civilian nuclear waste. [http://www.ocrwm.doe.gov]

U.S. General Accounting Office. *Low-Level Radioactive Waste: Disposal Availability Adequate in the Short Term, but Oversight Needed to Identify Any Future Shortfalls.* GAO-04-604. June 2004. 53 p.