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GAO

Report to Congressional Requesters

March 2011

DOE NUCLEAR WASTE

Better Information Needed on Waste Storage at DOE Sites as a Result of Yucca Mountain Shutdown

GAO-11-230

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GAO Highlights

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Highlights of GAO-11-230, a report to congressional requesters

Why GAO Did This Study

The Department of Energy's (DOE) Office of Environmental Management (EM) is responsible for storing and managing a total of about 13,000 metric tons of nuclear waste—spent nuclear fuel and high-level waste—at five DOE sites in Colorado, Idaho, New York, South Carolina, and Washington. Also, a joint DOE-Navy program stores spent nuclear fuel from warships at DOE's Idaho site. DOE and the Navy intended to permanently dispose of this nuclear waste at a repository planned for Yucca Mountain in Nevada. However, that plan is now in question because of actions taken to terminate the site. This report assesses (1) agreements DOE and the Navy have with states at the five sites and the effects a termination of the Yucca Mountain repository would have on their ability to fulfill these agreements; (2) the effects a termination would have on DOE's and the Navy's operations and costs for storing the waste; and (3) DOE's and the Navy's plans to mitigate these potential effects. GAO reviewed state agreements and DOE plans, visited waste facilities, and interviewed federal and state officials.

What GAO Recommends

GAO recommends that DOE (1) assess existing nuclear waste storage facilities and the resources and information needed to extend their useful lifetimes and (2) identify any additional research needed to address DOE's unique needs for long-term waste storage. DOE agreed with the recommendations, but objected to some of GAO's findings, which GAO continues to believe are sound.

View GAO-11-230 or key components.
For more information, contact Gene Aloise at (202) 512-3841 or aloisee@gao.gov.

What GAO Found

Five states have agreements with DOE, and in one case with the Navy, regarding the storage, treatment, or disposal of nuclear waste stored at DOE sites. Only agreements with Colorado and Idaho include deadlines, or milestones, for removing waste from sites that may be threatened by a termination of the Yucca Mountain repository program. Under the agreements, DOE and the Navy are expected to remove their spent nuclear fuel from Idaho, and DOE is to remove its fuel from Colorado, by January 1, 2035. If a repository is not available to accept the waste, however, DOE and the Navy could miss these milestones. As a result, the government could face significant penalties—$60,000 for each day the waste remains in Idaho and $15,000 for each day the waste remains in Colorado—after January 1, 2035. These penalties could total about $27.4 million annually. Navy officials told GAO, however, their greater concern is that Idaho might suspend Navy shipments of spent nuclear fuel to the state until the Navy meets its agreement to remove spent nuclear fuel, a suspension that would interfere with the Navy's ability to refuel its nuclear warships.

Terminating the Yucca Mountain repository would not affect DOE's or the Navy's nuclear waste operations on DOE sites in the near term, according to DOE and Navy officials. But it would likely extend on-site storage and increase storage costs, which could be substantial. For example, an EM analysis estimates that EM could need an additional $918 million to extend storage, assuming a 20-year delay in a repository's opening. Since it is not known when an alternative to Yucca Mountain will be available, it is difficult to estimate the total additional storage costs stemming from terminating the repository. Although EM officials told GAO that DOE can extend storage of nuclear waste on DOE sites for some time, additional information is needed to plan for longer storage. For instance, DOE does not know how long the lives of existing storage facilities can be extended beyond estimates in current site plans. In addition, although research is being planned for long-term storage of commercial spent nuclear fuel beyond 120 years, DOE has no plan for comparable research focusing on its unique long-term waste storage needs.

DOE and the Navy have not yet developed plans to mitigate the potential effects of longer storage resulting from a termination of the Yucca Mountain repository. EM and Navy officials said they are waiting for recommendations from a Blue Ribbon Commission that DOE created in 2010 to clarify future nuclear waste management alternatives. Even after the commission's recommendations are available, however, DOE could face difficulties in planning how to mitigate the impact of a termination of the repository. For example, because it is not clear how specific the commission's recommendations will be, it may take time to develop the recommendations into a new nuclear waste management policy. Further, some recommendations may not lead to a solution soon enough to meet existing waste removal milestones. DOE and the Navy said it was too early to change existing plans since no final disposition path for the waste has been determined.

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Abbreviations

CERCLA	Comprehensive Environmental Responsibility, Compensation, and Liability Act
DOE	Department of Energy
EM	Office of Environmental Management
EPA	Environmental Protection Agency
NRC	Nuclear Regulatory Commission
RCRA	Resource Conservation and Recovery Act of 1976

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United States Government Accountability Office
Washington, DC 20548

March 23, 2011

The Honorable Jason Chaffetz
Chairman
The Honorable John F. Tierney
Ranking Member
Subcommittee on National Security,
Homeland Defense and
Foreign Operations
Committee on Oversight and
Government Reform
House of Representatives

The Honorable Jeff Flake
House of Representatives

After decades of nuclear weapons production, the nation now faces the complex task of storing and eventually disposing of two types of highly radioactive waste.[1] The first type, called "spent nuclear fuel," is the fuel that has been used and then removed from nuclear reactors operated for weapons production. The Department of Energy (DOE) is responsible for managing the spent nuclear fuel primarily from weapons-related activities and other defense-related activities but also from certain nondefense activities. The second type of nuclear waste is "high-level waste," a by-product of weapons production and other defense-related activities—much of it currently stored in liquid or semiliquid form in large underground tanks. DOE's Office of Environmental Management (EM) is responsible for storing and managing a total of almost 13,000 metric tons[2] of nuclear waste at five sites: the Hanford Site in Washington state, the Savannah River Site in South Carolina, Idaho National Laboratory in

[1]For this report, we use the phrase "nuclear waste" to include both DOE's spent nuclear fuel and high-level radioactive waste, since both were planned for permanent disposal at Yucca Mountain. However, spent nuclear fuel is potentially a resource rather than simply a waste for disposal. Although spent nuclear fuel (also known as used nuclear fuel) is no longer efficient in generating power in a reactor, it can be reprocessed to separate uranium or plutonium that can be used to construct nuclear weapons or to again fuel a reactor. Moreover, according to EM officials, spent nuclear fuel on DOE sites is not managed under waste regulations.

[2]DOE's estimated quantity is based on the metric tons of spent nuclear fuel and an assumption that each canister of high-level waste contributes a half metric ton.

Idaho, the Fort St. Vrain Site in Colorado, and the West Valley Site in New York.

DOE has agreements with these states governing how the nuclear waste is managed. These agreements can include various dates by which DOE agrees to complete certain activities, such as processing high-level waste, transferring spent nuclear fuel and high-level waste to safer storage, and removing nuclear waste from the site. Some of these agreements include penalties if these dates, known as milestones, are not met. The Navy is also a party to agreements with Idaho, where it stores spent nuclear fuel from submarines and aircraft carriers at DOE's Idaho site.[3]

For decades, DOE has planned to permanently dispose of these nuclear wastes—some components of which remain dangerously radioactive for thousands of years—in a deep geological repository at Yucca Mountain in southwestern Nevada, but that plan is now in question. As amended in 1987, the Nuclear Waste Policy Act of 1982 directs DOE to study Yucca Mountain as the site for a repository to store both DOE's nuclear waste and spent nuclear fuel from commercial nuclear reactors.[4] The act, as amended, also identifies the Nuclear Regulatory Commission (NRC) as responsible for licensing the development, construction, and operation of a repository at Yucca Mountain. In June 2008, after spending more than $14 billion since 1983 to study potential repository sites and to develop the technical documents for a license, DOE submitted an application to the NRC seeking authorization to construct a repository at the Yucca Mountain site. DOE planned to open the repository in 2020.

In a budget submission to Congress in 2009, however, the administration stated its decision to terminate the Yucca Mountain program and proposed eliminating funding for the development of the Yucca Mountain repository. In March 2010, DOE filed a motion with NRC's Atomic Safety and Licensing Board—which is responsible for hearing legal and technical

[3]For this report, we refer to responses about the joint DOE and Navy managed Naval Nuclear Propulsion Program as responses from the Navy to distinguish the program from other DOE operations. Within DOE, this program is under the National Nuclear Security Administration, which is a separate organization from EM. EM is responsible for managing almost all of the spent nuclear fuel and high-level waste on DOE sites.

[4]The majority of waste intended for the Yucca Mountain repository is commercial spent nuclear fuel from electric power companies that is not in DOE's possession. We are preparing a separate report on the impacts of a possible termination of the Yucca Mountain repository on the storage of this fuel, stored at 75 commercial reactor sites in 33 states.

challenges to DOE's license application—to withdraw its application with prejudice. DOE stated it was seeking "this form of dismissal because it does not intend ever to refile an application to construct a permanent geological repository for spent fuel and high-level radioactive waste at Yucca Mountain" and it "will provide finality in ending the Yucca Mountain project." In June 2010, NRC's Atomic Safety and Licensing Board denied DOE's withdrawal motion, concluding that DOE lacks the authority under the Nuclear Waste Policy Act, as amended, to withdraw the license application. The ultimate outcome of DOE's plan to terminate the Yucca Mountain program remains unsettled. First, the commissioners who head the NRC can choose whether to review the board's decision to deny DOE's motion and can either uphold or reverse the board's decision. In addition, two states, a county, and private citizens sued DOE and NRC in federal court, arguing that DOE had no authority to terminate the proposed Yucca Mountain repository. As of mid-March 2011, the consolidated lawsuit for these parties has not been settled or decided.

To develop waste disposal alternatives, the administration directed DOE to establish the Blue Ribbon Commission on America's Nuclear Future. The commission, which was formed in January 2010, is to conduct a comprehensive review of policies and provide advice, evaluate alternatives, and make recommendations for managing the storage, processing, and disposal of spent nuclear fuel and high-level waste, among other things. Its final report is expected by January 29, 2012. For now, the decision to forgo Yucca Mountain leaves DOE without a pathway to permanently dispose of spent nuclear fuel and high-level waste. In the absence of a repository at Yucca Mountain, some affected states and communities are concerned that DOE may store waste at its sites indefinitely.

In this context, you asked us to assess the effect of a possible termination of the Yucca Mountain repository on nuclear waste stored at DOE sites. For this report, our objectives were to assess (1) agreements DOE and the Navy have with states concerning spent nuclear fuel and high-level waste at five DOE sites and the effects, if any, a termination of the Yucca Mountain repository would have on DOE's and the Navy's ability to fulfill these agreements; (2) the effects, if any, a termination of the Yucca Mountain repository would have on DOE's and the Navy's operations and costs for storing spent nuclear fuel and high-level waste; and (3) DOE's and the Navy's plans to mitigate these potential effects.

To address the first objective, we reviewed the statutory and regulatory frameworks, including agreements between DOE and states, regarding spent nuclear fuel and high-level waste at DOE sites. To address the second

objective, we reviewed documents, including waste treatment plans, program missions, EM's 5-year plan for fiscal years 2008 to 2012, DOE annual budget justifications, public statements of DOE and EM officials, recommendations of EM's citizen advisory boards, and DOE, Congressional Research Service, and GAO reports. We also analyzed EM's contingency planning for the costs that would arise from a hypothetical delayed opening of the Yucca Mountain repository in 2040 rather than 2020 and EM's cost modeling for extending on-site storage for up to 500 years, the latter of which was prepared at our request for a prior report.[5] To view storage and treatment facilities, we visited the three DOE sites—the Hanford Site, the Savannah River Site, and Idaho National Laboratory—that store most of the DOE-managed spent nuclear fuel and high-level waste. To address the third objective regarding EM's and the Navy's mitigation plans and other possible options, we examined presentation slides, statements, and transcripts for the Blue Ribbon Commission meetings and congressional hearings and other pertinent documents. To get additional information on our research objectives, we conducted interviews with DOE and contractor officials representing the five DOE sites, EM headquarters, EM's Office of Environmental Compliance, and DOE's Office of General Counsel. We attended EM conferences on managing nuclear materials in March and September 2010. We also interviewed officials from the Naval Nuclear Propulsion Program and its counsel and officials with the Defense Nuclear Facilities Safety Board, Nuclear Waste Technical Review Board, Environmental Protection Agency, Nuclear Regulatory Commission, and state agencies in Colorado, Idaho, New York, South Carolina, and Washington. We limited our review of the Department of Defense to only the Navy because Defense and Navy officials told us that the Navy was the only organization in the department with responsibilities for disposal of nuclear materials destined for the Yucca Mountain repository.

We conducted this performance audit from January 2010 to March 2011 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

[5]GAO, *Nuclear Waste Management: Key Attributes, Challenges, and Costs for the Yucca Mountain Repository and Two Potential Alternatives*, GAO-10-48 (Washington, D.C.: Nov. 4, 2009).

Background

From 1944 until the 1980s, the United States used nuclear reactors to produce plutonium and other materials for nuclear weapons. Plutonium was extracted from the fuels used by these reactors by a chemical process known as reprocessing.[6] As a result of these activities, after the shutdown of weapons production and of some reprocessing plants at the end of the Cold War, DOE retained an inventory of spent nuclear fuel that had not been reprocessed, as well as high-level waste—which is one of the byproducts of reprocessing. Weapons production and related defense activities—such as the reprocessing of the Navy's spent nuclear fuel to produce new fuel, which also created high-level waste—are the source of about 87 percent of DOE's inventory of spent nuclear fuel and almost its entire inventory of high-level waste. Because weapons production and reprocessing of the Navy's spent nuclear fuel have ended, DOE's inventories of this waste are largely fixed.

DOE is also responsible for managing other nuclear waste from a variety of sources, including some active programs that continue to add to DOE's inventory. For example, DOE is responsible for managing spent nuclear fuel from the Navy through the Naval Nuclear Propulsion Program, which is jointly operated by DOE and the Navy. The Navy uses nuclear-powered ships and submarines in carrying out its missions. The spent nuclear fuel removed from these vessels is the primary driver of increases in DOE's inventory, but it totals only 1 percent of DOE's spent nuclear fuel inventory. The remainder of DOE's inventory of nuclear waste comes from various nondefense sources, including spent nuclear fuel from its own test and experimental reactors, reactors at U.S. universities, and other government research reactors; commercial reactor fuel acquired by DOE for research and development; and fuel from foreign research reactors. For example, DOE stores fuel debris from the Three Mile Island accident that occurred in 1979 at a commercial nuclear power plant. It also stores spent nuclear fuel from three commercial power demonstration projects, including from the first commercial-scale high-temperature gas-cooled reactor plant in the United States, at the Fort St. Vrain site. In addition, the United States operates a program to take custody of spent nuclear fuel from foreign research reactors, which supports a U.S. policy to prevent the proliferation of nuclear weapons; this program is scheduled for completion in 2019.

[6]A reprocessing plant was used to dissolve the spent nuclear fuel in acid and then to extract the uranium and plutonium, leaving behind a highly radioactive liquid referred to as high-level waste.

DOE currently stores its inventories of nuclear waste at five DOE sites. In 1995, DOE decided to consolidate nearly all of its spent nuclear fuel from other sites at three primary locations—the Hanford Site, Idaho National Laboratory, and the Savannah River Site—for storage and preparation for permanent disposal. The exception to this consolidation decision is DOE's Fort St. Vrain site, which stores less than 1 percent of DOE's total inventory. In 1999, DOE decided to store its high-level waste where it was generated, at the same three primary sites. In addition, DOE manages a small amount of high-level waste that resulted from the relatively brief operation of the only commercial reprocessing plant ever run in the United States. This waste was generated between 1966 and 1972 from reprocessing spent nuclear fuel at a site near West Valley, New York, where DOE is now responsible for storing it.[7]

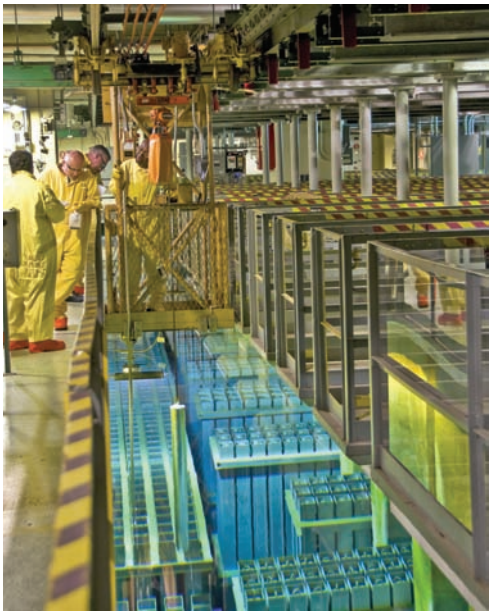
Some of the nuclear waste at these sites requires further processing and packaging before it can be safely stored over the long term or removed for final disposal. In the case of spent nuclear fuel, this generally means removing it from storage pools of water and packaging it in stainless steel canisters. The processing and packaging of high-level waste is vastly more complicated—a massive enterprise in which DOE is removing waste from storage tanks and transferring it to treatment facilities. For example, at the Savannah River Site, DOE is vitrifying high-level waste by mixing it with a glass-forming material, melting the mixture into glass, and pouring it into stainless-steel canisters to harden. Across all sites, DOE expects to eventually produce about 20,000 canisters of solidified high-level waste. Once the wastes are stabilized, removing them from the sites would require a destination where they could be stored or permanently disposed of and a decades-long shipping campaign to get them there. Appendix I describes how the sites are in different stages of preparing spent nuclear fuel and high-level waste for final disposal.

In the meantime, DOE manages many types of storage facilities, as illustrated in figure 1, of widely varying ages and conditions. For example, DOE has generally been moving spent nuclear fuel from wet storage in pools of water, designed to cool the fuel and provide radiation protection, to dry storage. Dry storage has numerous configurations, including underground storage vaults, only some of which are covered by a building, and casks on an outdoor pad or a railroad car. Overall, these storage facilities vary from aging to almost new; for instance, they range from a

[7]DOE now manages part of the West Valley site, but the state of New York owns the site.

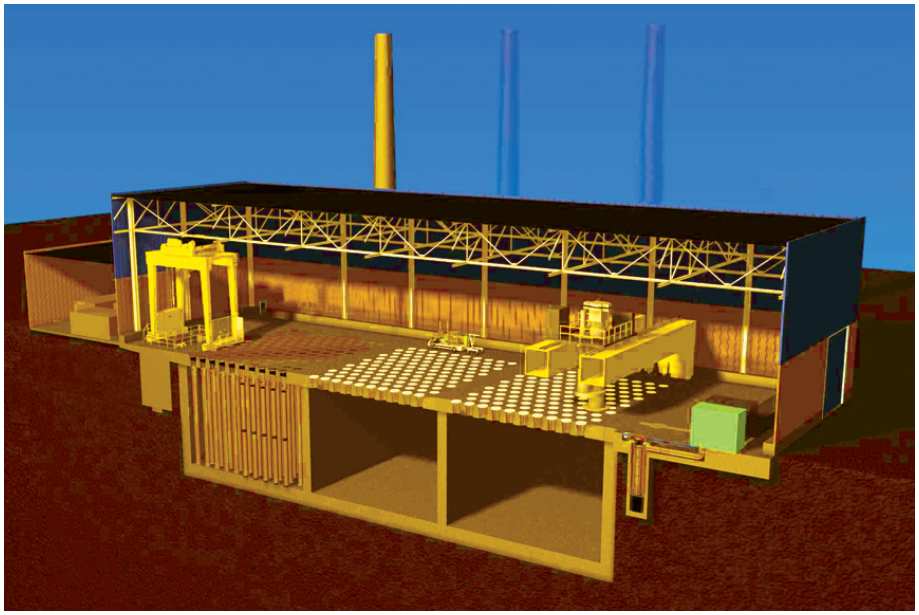
1950s building at the Idaho National Laboratory to a high-level waste canister building constructed in 2005 at the Savannah River Site.

Figure 1: Examples of Nuclear Waste Storage Systems at DOE Sites



Source: DOE.

Spent nuclear fuel being moved in a wet storage pool at the Savannah River Site.



Source: DOE.

Spent nuclear fuel canisters stored in undersurface tubes in a storage building at the Hanford Site.

Source: West Valley Demonstration Project.

High-level waste canisters in a shielded room at the West Valley Site (viewed through protective glass).

Source: Naval Nuclear Propulsion Program.

Navy's spent nuclear fuel canisters surrounded by protective concrete overpacks in a storage building at DOE's Idaho site.

DOE operates these five sites under a legal framework that includes self-regulation, as well as regulation by federal agencies and states. In contrast to the commercial nuclear industry's sites, which are regulated by NRC, DOE generally operates under its own regulations for nuclear safety at its sites.[8] In addition, DOE's treatment, storage, and disposal of radioactive and hazardous wastes are governed by a number of federal and state laws, including the Resource Conservation and Recovery Act of 1976 (RCRA), as amended, which regulates the management of hazardous waste from generation to disposal. The Federal Facility Compliance Act of 1992 amended RCRA to require federal agencies, including DOE, to develop waste treatment plans for their sites that contain mixed wastes—certain wastes with both radioactive and chemically hazardous materials. For example, high-level waste is sometimes considered a mixed waste because it contains highly corrosive, organic, or heavy metal components that may be regulated under RCRA. These plans are approved by states that the Environmental Protection Agency (EPA) has authorized to administer RCRA or by EPA in states that have not been so authorized.

Activities carried out under these plans are often governed by compliance agreements between DOE, EPA, and the states (state agreements), which regulate and oversee the activities. State agreements establish the scope of work to be performed at given sites, as well as "milestones"—specific dates by which these activities should be achieved. The agreements may also impose monetary or other penalties for missing milestones. Milestones may cover actions to treat, store, and dispose of hazardous wastes located at the DOE sites. Agreements differ by state. Some cover virtually all cleanup activities at a site, while others cover just a portion. These activities may include soil and groundwater remediation, low-level radioactive waste disposition, and special nuclear material consolidation; in this report, we focus on state agreement cleanup activities involving spent nuclear fuel and high-level waste. States and DOE can negotiate to amend or modify the agreements, including extending or eliminating milestones.

State agreements may be created in at least four ways. First, states may enter into Federal Facilities Agreements (also known as Tri-Party Agreements) with DOE and EPA, which implement the Comprehensive

[8]DOE operates some sites under NRC regulations, such as the NRC-licensed storage facilities at Idaho National Laboratory—for fuel debris from the Three Mile Island accident—and at Fort St. Vrain.

Environmental Responsibility, Compensation, and Liability Act of 1980 (CERCLA) and RCRA, as well as state hazardous waste law requirements to set the cleanup schedules at sites. CERCLA, among other things, authorizes EPA to compel responsible parties to initiate cleanup activities at hazardous waste sites. Second, states may take legal action against DOE seeking review of its compliance with the National Environmental Policy Act, which can result in settlement agreements between the parties and may outline activities and milestones. Third, Congress may address the management of wastes at a specific site. Finally, federal government officials may enter into agreements with states concerning DOE-managed radioactive waste, which may include specific cleanup milestones.

Termination of the Yucca Mountain Repository Could Threaten DOE's and the Navy's Ability to Fulfill Agreements with Colorado and Idaho

The five states with DOE sites storing nuclear waste have agreements with DOE, and in one case with the Navy, regarding how nuclear waste will be managed. However, only the agreements with Colorado and Idaho would be affected by a termination of the Yucca Mountain repository because only those agreements specify dates for removing the waste from the DOE sites.

All Five States Have Agreements Regarding the Management of Nuclear Waste at DOE Sites

Each DOE site falls under at least one state agreement that specifies certain treatment, storage, or disposal activities for high-level waste, spent nuclear fuel, or both. The agreements with four sites deal with the safe storage and treatment of high-level waste. (DOE's site in Colorado, does not store any high-level waste; it stores only spent nuclear fuel.) In addition, state agreements for some DOE sites focus on the storage of spent nuclear fuel or its removal from the states. Major state agreements at each site are as follows:

- *Idaho National Laboratory.* DOE and the Navy are party to a 1995 settlement agreement and consent decree (the Idaho Settlement Agreement), entered into the United States District Court for the District of Idaho, to settle a lawsuit brought by the state. The agreement commits DOE to prepare its high-level waste for shipment out of Idaho for disposal. The agreement also contains provisions for managing spent nuclear fuel. Specifically, it requires DOE and the Navy to move their spent nuclear fuel

from storage in pools of water to dry storage—given state concerns that the water pools might leak and radioactively contaminate the underlying groundwater—and later to move the spent nuclear fuel out of Idaho.

- *Fort St. Vrain Site.* In 1996 the Governor of Colorado signed an agreement with the Assistant Secretary for Environmental Management at DOE, referred to as the "Agreement Between the Department of Energy and the State of Colorado Regarding Shipping Spent Fuel Out of Colorado." The agreement states that DOE is committed to shipping its spent nuclear fuel stored at Fort St. Vrain out of Colorado.

- *Hanford Site.* The Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) of 1989, as amended, entered into by DOE, EPA, and the state of Washington's Department of Ecology, focuses on completing DOE's closure of tanks that store liquid waste and solidifying its high-level waste for safer storage. The agreement also requires DOE to develop a disposition plan for cesium and strontium capsules, which are managed as high-level waste, if vitrification is not planned.[9]

- *Savannah River Site.* The 1993 Federal Facility Agreement for the Savannah River Site and the Savannah River Site Treatment Plan of 1995 between DOE and the South Carolina Department of Health and Environmental Control focus on completing DOE's closure of tanks that store liquid waste and solidifying its high-level waste for safer storage.

- *West Valley Site.* The West Valley Demonstration Project Act, enacted in 1980, directs the Secretary of Energy to enter into a cooperative agreement with New York and to carry out a radioactive waste management demonstration project at the western New York Service Center in West Valley, New York. The project includes solidifying high-level waste, developing waste containers suitable for permanent disposal, and transporting the solidified waste to an appropriate federal repository for permanent disposal.

[9]In October 2010, a federal district court approved a consent decree that imposes a new, enforceable schedule for cleaning up the tank waste at Hanford. In addition, the Tri-Party Agreement was amended to revise milestones related to this cleanup.

Agreements with Idaho and Colorado Have Milestones for Waste Removal That Could Be Affected by Terminating the Yucca Mountain Repository

A termination of the Yucca Mountain repository may prevent DOE and the Navy from meeting agreements with Colorado and Idaho that establish milestones for shipping the spent nuclear fuel out the states. As shown in table 1, the other agreements do not set dates for removing spent nuclear fuel from DOE sites. No state agreement sets a date for removing high-level waste.

Table 1: Details of State Agreements Regarding Nuclear Waste at the Five DOE Sites

	High-level waste		Spent nuclear fuel	
DOE sites	**Stored at site**	**Milestones for removal**	**Stored at site**	**Milestones for removal**
Idaho site				
Idaho National Laboratory	Yes	No[a]	Yes	Jan. 1, 2035
Navy	No	Not applicable	Yes	Jan. 1, 2035
Fort St. Vrain in Colorado	No	Not applicable	Yes	Jan. 1, 2035
Hanford Site in Washington	Yes	No	Yes	No
Savannah River Site in South Carolina	Yes	No	Yes	No
West Valley Site in New York	Yes	No[b]	No[c]	Not applicable

Source: GAO analysis of state agreements.

[a]In the Idaho Settlement Agreement, DOE committed to a target date to have high-level waste prepared for shipment out of Idaho by 2035, but not to a milestone date for removal.

[b]The West Valley Demonstration Project Act commits DOE to "as soon as feasible, transport, in accordance with applicable provisions of law," the solidified high-level waste to a federal repository, but does not specify a milestone date for removal.

[c]A DOE official told us that DOE took title to some spent nuclear fuel from West Valley after the demonstration project began and shipped it to the Idaho National Laboratory for storage. Earlier during the commercial reprocessing efforts, a small amount of other spent nuclear fuel was disposed of in the NRC-Licensed Disposal Area at the site. The official said no decision has been made regarding removal and disposal of this material at a geological repository.

DOE and the Navy, under the 1995 Idaho Settlement Agreement, are required to remove from the state by January 1, 2035, spent nuclear fuel stored at Idaho National Laboratory. In addition, DOE's head of EM signed an agreement to remove the spent nuclear fuel stored at the Fort St. Vrain site from Colorado by the same date.[10] When the agreements were signed, DOE had intended to remove the spent nuclear fuel from these sites and

[10]The document is titled "Agreement Between the Department of Energy and the State of Colorado Regarding Shipping Spent Fuel Out of Colorado" and was signed February 13, 1996.

ship it to the Yucca Mountain repository for final disposition.[11] Similarly, the Navy had planned to transport its spent nuclear fuel from Idaho to the Yucca Mountain repository starting after 2020. If the Yucca Mountain repository is terminated, DOE and the Navy would lose their planned shipping destination for their spent nuclear fuel, which could cause them to miss the 2035 removal date they have committed to.

DOE and the Navy may be faced with significant penalties for missing these removal milestones. For example, under the Idaho Settlement Agreement, the federal government may be liable to pay the state $60,000 for each day past January 1, 2035, that DOE and the Navy have not removed their spent nuclear fuel from the state. Under the Colorado state agreement, DOE may be liable to pay the state $15,000 for each day after January 1, 2035, that DOE fails to remove its spent nuclear fuel. These penalties would total approximately $27.4 million per year, although both state agreements stipulate that any possible future payments of these penalties will be subject to the availability of appropriations specifically for that purpose.

Under the Idaho Settlement Agreement, the state may also have the ability to suspend any further DOE or Navy shipments of spent nuclear fuel to DOE's Idaho site until the agreement's obligation for removal of spent nuclear fuel is met. According to Navy officials, this would be of much greater concern than the financial penalties. After removing spent nuclear fuel from its warships as part of the refueling process, the Navy transports it to the Idaho site for examination and storage. No other sites are available for these critical activities. A Navy official told us that developing the infrastructure for these activities at a new site outside of Idaho would be time consuming and costly, and other states might oppose such a facility within their boundaries if there were no disposal pathway for the spent nuclear fuel. If Idaho were to suspend the Navy's shipments of spent nuclear fuel, the Navy would not be able to refuel its nuclear warships, which Navy officials said would raise national security concerns. In

[11]For the spent fuel from Fort St. Vrain, DOE intended to send it first to Idaho National Laboratory for further treatment, but the Idaho state agreement commits DOE to do so only if a permanent repository or alternative interim storage site outside of Idaho is open and is accepting spent nuclear fuel.

addition, suspension might effectively prevent the Navy from continuing to examine its spent nuclear fuel at the Idaho site after 2035.[12]

If DOE determines that it will not be able to meet the removal milestones in the Idaho and Colorado agreements, it is unclear when the department would approach these states or whether either state would be amenable to renegotiating the agreement milestones. For example, Idaho officials said they still expect DOE and the Navy to meet the milestones. They stated that the 25 years remaining to remove spent nuclear fuel from Idaho may not be enough time to establish an alternative repository, but they noted that the Idaho Settlement Agreement does not require the spent nuclear fuel to be sent to the Yucca Mountain repository, only that it be removed from Idaho. These officials also said Idaho might seek remedies in court if it becomes evident that DOE is not positioned to meet a future milestone.

Termination of the Yucca Mountain Repository Would Not Affect Near-Term Operations at DOE Sites but Would Likely Extend On-Site Storage of Nuclear Waste

According to DOE and Navy officials, a termination of the Yucca Mountain repository would not generally affect their nuclear waste operations in the near term. However, it would likely extend on-site storage of nuclear waste, which would lead to increased storage costs for the federal government. In addition, DOE officials said they will need additional information on storage facilities to plan storage beyond the time set forth in the current site plans.

Near-Term Operations at DOE Sites Generally Would Be Unaffected

According to EM officials, a termination of the Yucca Mountain repository is not expected to affect site operations in the near term because current DOE operations are primarily focused on treating high-level wastes and moving spent nuclear fuel from wet to dry storage—activities that do not depend on having a repository available. Operations at the primary DOE sites we reviewed—Hanford, Idaho, and Savannah River—are currently

[12]A 2008 addendum to the 1995 Idaho Settlement Agreement allowed the Navy to continue receiving and examining a limited volume of its spent nuclear fuel after 2035. By 2035, any Naval spent nuclear fuel that arrived at Idaho National Laboratory prior to 2026 must be removed from Idaho.

focused on treating high-level radioactive liquid tank waste or moving spent nuclear fuel from wet to dry storage. These efforts are intended to immobilize high-level waste and provide safer storage on site until disposal at a repository. Savannah River is vitrifying the site's high-level waste by combining it with glass-forming chemicals to make a glass that is poured into stainless steel canisters and sealed by welding; Hanford is building a $12.3 billion complex to do the same. Savannah River and Hanford officials said they intend to continue these operations through completion, regardless of the status of the Yucca Mountain repository, because of EM's mission to mitigate environmental risk and because the officials are trying to meet milestones in their state agreements for removing high-level waste from tanks. Idaho National Laboratory has treated much of its high-level waste[13] with a different process, called calcination, which turns the waste into a dry granular powder. In a 2009 record of decision, DOE decided to take additional steps to put the calcine waste into a monolithic form within canisters for permanent disposal, but according to EM officials, this work has not yet been started. Regarding spent nuclear fuel, Idaho is in the process of moving all of it from wet to dry storage, and Hanford has generally completed the process. According to EM officials, there are no plans at this time for the Savannah River Site to move spent nuclear fuel from wet to dry storage.

Furthermore, at a 2010 hearing, the head of the Naval Nuclear Propulsion Program stated that termination of the Yucca Mountain repository would have no near-term effect on its operations at Idaho. The Navy intends to continue moving its spent nuclear fuel out of wet storage and placing it into canisters that are ready for transport when an alternative to the Yucca Mountain repository is available. In the meantime, the Navy will store the canisters at the Idaho site, as it anticipated doing while waiting for the Yucca Mountain repository to open.

Some officials, such as those from the Washington State Department of Ecology, raised concerns that a termination of the Yucca Mountain repository could affect current operations if a replacement repository is selected with different requirements for accepting waste. Waste acceptance criteria govern aspects such as the waste canister's shape, size, and radioactive content. According to EM officials, however, continuing

[13]DOE is still making a decision about whether a radioactive liquid in tanks at Idaho National Laboratory, known as sodium bearing waste, should be classified as high-level waste or some other type of radioactive waste for disposal.

operations in accordance with the treatment and packaging requirements established for the Yucca Mountain repository license application likely does not raise any significant issues. They said that EM, in coordination with NRC and EPA, strives to develop waste forms and package designs that will likely be accepted at any geologic repository, and they expect that any new repository would be designed to safely hold the high-level waste and spent nuclear fuel that has already been packaged.

While the sites can generally continue with their operations and plans without the opening of a repository, a termination of the Yucca Mountain repository may change some plans related to disposal. For example, if a repository is not available, sites can delay building shipping facilities, which would need to be in place about 5 years before a repository is available.

Termination of the Yucca Mountain Repository Will Likely Extend On-Site Storage and Increase Costs

Without a Yucca Mountain repository, DOE will likely have to extend storage of nuclear wastes at DOE sites, which will increase its storage costs—although it is difficult to predict by how much. According to a 2009 Congressional Research Service report, halting the development of the Yucca Mountain repository would almost certainly require that nuclear waste remain at on-site storage facilities longer than currently planned. This is because a new repository to replace the Yucca Mountain repository would be unlikely to open by 2020.[14] Similarly, senior EM officials told us they understand that high-level waste and spent nuclear fuel may remain at DOE sites for a "considerable" period of time. On-site storage can be safe and secure for long periods, according to a National Research Council report, but it would require a continuing commitment of resources for the

[14]Congressional Research Service, *Nuclear Waste Disposal: Alternatives to Yucca Mountain* (Washington, D.C., Feb. 6, 2009).

storage to be continuously monitored, maintained, and periodically rebuilt.[15]

For our analysis, we used DOE's own estimate that the Yucca Mountain repository would be open in 2020. This 2008 estimate was made before DOE took steps to terminate the Yucca Mountain repository program. While we recognize the 2020 date was not certain, we know of no better assumption to meaningfully assess the impact of a termination of the Yucca Mountain repository. In a written comment to us, DOE officials stated that it is incorrect to conclude there will be a delay in moving the nuclear materials or disposing of them using an alternative strategy compared to pursuing the Yucca Mountain program. Specifically, they stated it is speculation to say a new strategy will take longer to implement than continuing with the Yucca Mountain program because there is no guarantee of when, if ever, the many significant steps for opening the Yucca Mountain repository would have occurred. Since the comment provides only a hypothetical bounding possibility—the Yucca Mountain repository might have never opened, even without DOE's current steps to terminate it—rather than a new estimate for when the repository might have opened, we note the DOE officials' position but do not analyze it further.

Longer storage would increase costs at DOE sites because it would require additional years of storage beyond current plans, which assumed shipments to the Yucca Mountain repository starting in 2020. These storage costs generally fall into three categories:[16]

[15]The National Research Council, *Disposition of High-Level Waste and Spent Nuclear Fuel: The Continuing Societal and Technical Challeng*es (Washington, D.C., 2001). However, the report recommends geological disposal for long-term storage because it is the only available alternative that does not require ongoing control and resource expenditures by future generations. Similarly, international experts conclude that nuclear waste will eventually need permanent disposal because the active controls required for storage cannot be guaranteed over the thousands of years that the wastes can remain radioactively hazardous. International Atomic Energy Agency, *The Long Term Storage of Radioactive Waste: Safety and Sustainability, A Position Paper of International Experts* (Vienna, 2003).

[16]Our framework of cost categories focuses on the costs of extended storage on DOE sites as a result of a termination of the Yucca Mountain repository. It does not consider the costs of a yet-to-be-determined alternative to shipping the nuclear waste to the Yucca Mountain repository or whether the alternative would be more or less costly than proceeding with the Yucca Mountain repository program.

- *Annual and recurring storage costs:* Annual costs include costs for operations, maintenance, surveillance, and security for the storage facilities. Recurrent costs are generally maintenance or repair costs that are not annual, such as the anticipated cost of replacing a storage building's roof every 25 to 30 years.

- *Increased storage capacity:* Beyond storage already available or planned, the Hanford Site, the Savannah River Site, and the Naval Reactor Facility at the Idaho site would have to build additional storage if their canister inventory cannot be reduced by sending canisters to the Yucca Mountain repository. This capacity can be expensive. For example, an EM analysis estimated that Hanford would need three additional storage facilities to accommodate all of the waste canisters. These facilities would be built as needed, at an estimated cost of $100 million (2010 dollars) each.

- *Replacement of storage facilities and containers.* Existing storage systems must be replaced once they exceed their useful lives. DOE has not yet determined the design of these replacement storage systems, and these costs could be incurred well into the future. For example, in a 2002 analysis, DOE assumed that the storage facilities would undergo complete replacement after the first 100 years and every 100 years thereafter.

  EM estimates that it could need an additional $918 million (2010 dollars) to extend storage if the opening of a permanent repository were delayed from 2020 to 2040.[17] About two-thirds of these costs would fall into the category of annual and recurring storage costs.[18] For example, costs for storing spent nuclear fuel at the Hanford Site were estimated at $6 million per year for an additional 20 years. The remaining one-third of the projected additional costs fall into the category of increased storage capacity beyond what would be needed if the Yucca Mountain repository

[17]These estimates were part of EM's analysis of its 2010 environmental liability. DOE uses such studies to develop its annual financial statement report. The estimate of EM's environmental liability is composed of expected costs arising from current planning assumptions and from contingency costs, which reflect uncertainties in future environmental costs if current planning assumptions—such as Yucca Mountain opening in 2020—are not met.

[18]This category would also include any relicensing costs for DOE's two NRC-licensed storage facilities.

had opened in 2020.[19] EM's estimate did not include any costs in the category of replacing storage facilities and containers because it assumed a delay of 20 years would not necessitate the replacement of any existing storage buildings or containers. If storage were extended well into the future, however, some buildings would need to be replaced. For instance, Savannah River Site officials said the high-level waste canister storage buildings at the site have a design life of 50 years,[20] but are expected to have a usable life of 100 years if properly maintained. According to the officials, if storage needs to be extended beyond the storage buildings' usable life, these buildings would have to be replaced at an estimated cost of about $75 million each, the cost when the last one was built in 2005.

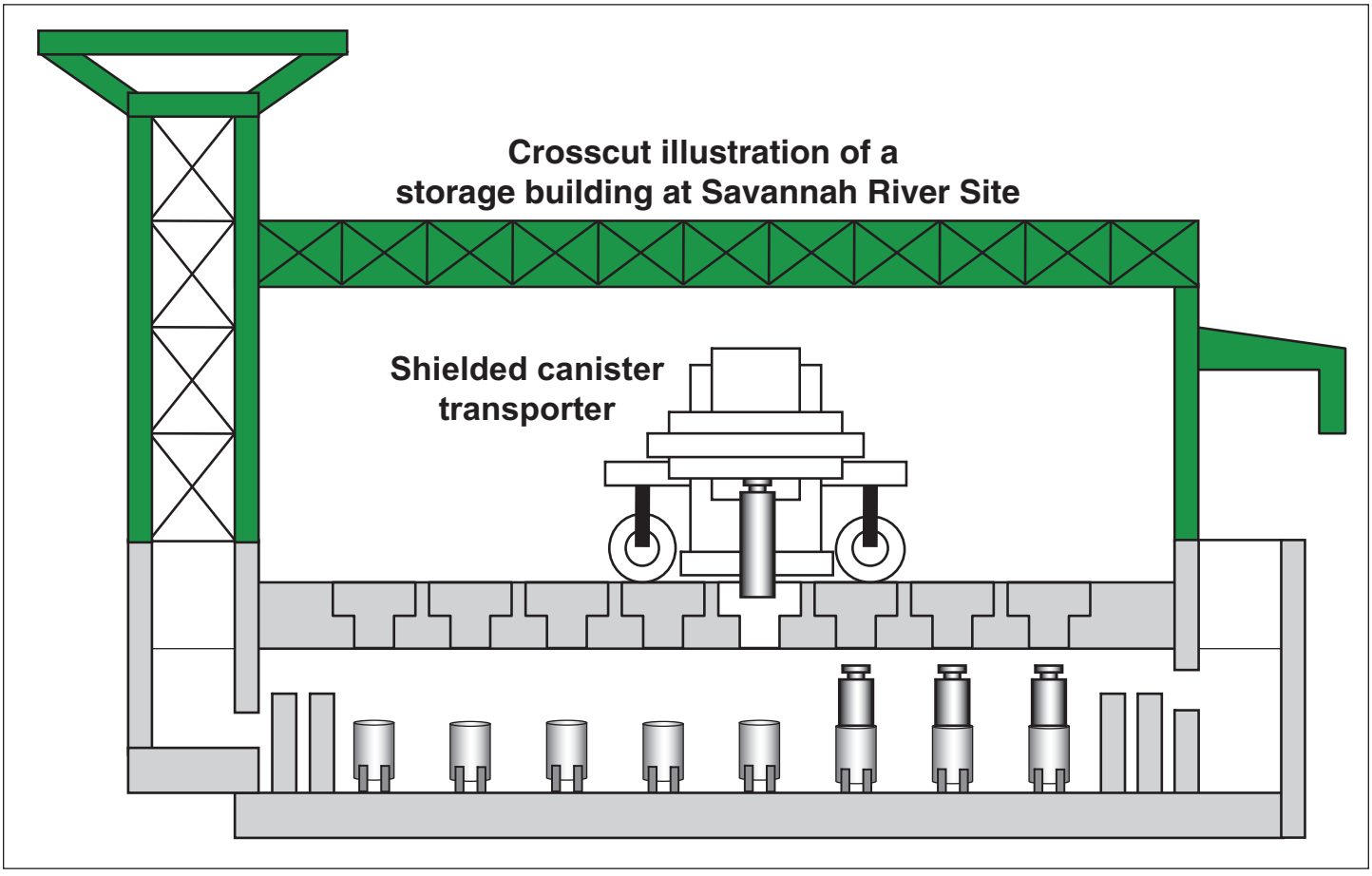
DOE may also have to replace or reinforce waste containers. Specifically, spent nuclear fuel canisters might need to be either repackaged or left in the original canister but then placed into a larger one, called a canister overpack. For the high-level waste canisters, which are not amenable to repackaging (which would involve the removal of the high-level waste glass from the original stainless steel canisters), Savannah River officials stated that they could likely be stored safely on site for a long time, perhaps 1,000 years, without the canisters breaching from corrosion. Problems could arise earlier for transport to a repository, however. After an estimated 200 years, DOE could face problems safely retrieving and moving the canisters from the on-site storage vault to the permanent repository because of potential corrosion at the neck of the canister. Savannah River officials explained that a transporter lifts the canister by its neck to move it in or out of storage in subsurface vaults, as illustrated in figure 2. If a corroded neck breaks when lifted, DOE would have difficulties retrieving the canister. Breaking the neck of the canister could also contaminate the vault, which would require cleanup. Because of these

[19]EM's liability estimate is sensitive to assumptions and scope. For example, although an EM official told us various scenarios are possible, the estimate assumes a decision to defer the packaging of Idaho calcine waste into canisters for 20 years, which avoids the costs for new on-site canister storage. It also assumes that the Savannah River Site will process spent nuclear fuel at a facility called H-Canyon. If this does not occur, the site may eventually have to build dry storage for the spent fuel. In addition, the EM analysis excludes Navy spent nuclear fuel because it is not managed by EM. According to a Navy official, if the spent nuclear fuel canisters are not shipped to a repository starting about the time of the expected opening of Yucca Mountain, then the Navy will have additional costs for more storage capacity and protective concrete overpacks, as well as additional annual costs for monitoring, maintaining, and operating the storage facility.

[20]Design life is an engineer's assessments of how long the concrete vaults in the storage building can last.

concerns, according to a site official and an EM expert, DOE might decide to overpack the high-level waste canisters, perhaps as early as after 100 to 150 years of storage. Moreover, if DOE did overpack the canisters, it would also need to design and construct new storage buildings because the new larger overpack would not fit into the storage positions in the existing buildings at Savannah River.

Figure 2: A Transporter Lifting a High-Level Waste Canister over the Concrete Storage Vault



Source: Savannah River Remediation.

It is difficult to accurately estimate these increased on-site storage costs because of three key factors. First, how long the wastes will remain on-site cannot be projected with certainty because it is unclear when an alternative to the Yucca Mountain repository will be available. Reflecting the degree of uncertainty, presenters at a March 2010 EM conference on

managing spent nuclear fuel considered a wide variety of possible periods of storage, from 40 to 300 years. Second, the actual configuration and cost of any future storage systems are not yet known. This is because DOE has not devised a plan for long-term storage and because DOE has yet to make certain decisions that could change the type of future storage and costs, according to EM officials. For example, because DOE has not decided whether to process spent nuclear fuel through Savannah River Site's H-Canyon facility, it does not know the final configuration of the waste storage system or the cost of storing it. Third, because DOE does not know how long current storage systems can be used safely, it does not know the appropriate timing for replacing them, EM officials said. They emphasized that the useful lives of existing storage systems are uncertain and will only be discovered over time through continuous surveillance to identify degradation.

Additional Information on Storage Facilities and Any Unique Storage Needs Would Be Required for DOE to Plan for Longer Storage

EM officials told us that DOE can extend storage of spent nuclear fuel and high-level waste on DOE sites for some time but will need additional information on storage facilities to plan storage beyond the time set forth in the current site plans. These officials said the current plans generally assume that the nuclear waste will be shipped to a repository by about 2050, and the sites' facilities are designed to last approximately until then. A major exception is that Idaho National Laboratory had planned to use its spent nuclear fuel storage facilities only through 2035, a date chosen because of the Idaho Settlement Agreement's milestone.

One option for extending on-site storage would be to extend the lives of existing storage facilities when they reach the end of their design lives. EM officials said they do not know how long a storage facility may last because long-term storage at sites is unprecedented. In addition, they said they know of no studies that verify the estimates of facilities' useful lives beyond their design lives. It is also unclear how long the canisters or the spent nuclear fuel can be stored without degradation, which would interfere with safe retrieval and transport to another location. Such degradation could necessitate repackaging or overpacking to meet NRC transportation requirements before sending the canisters to a disposal site.

Although EM officials told us EM has not yet planned for extending the lives of storage buildings, an official at Idaho National Laboratory told us that studies could be designed to provide confidence that storage buildings will last for an additional 20 or 30 years. Specifically, these longevity studies could identify components of the storage facility that are at risk for failure and repairs that could extend storage. For example, a

longevity study may conclude that Idaho National Laboratory needs to shore up a particular wall in a storage area for spent nuclear fuel in order to assure that the area will last for another 30 years. Such information would be useful to EM in budgeting for the maintenance and repairs that are needed to extend the lives of existing facilities or for their replacement at the end of their useful lives. Similarly, to assess how to manage aging facilities for the long term, EM officials told us about some internal proposals for research and development on spent nuclear fuel storage, including ways to monitor wet and dry storage for degradation. However, it is uncertain how much information this intended effort will ultimately provide, since EM officials said that EM has not budgeted any funds for this work.

A second option would be to build new storage facilities for very long-term storage—such as beyond 120 years—that may exceed the useful lives of existing facilities. However, to plan for very long-term storage, DOE may need to conduct research to get information about its sites' unique storage needs. EM officials said EM currently has no research plan for very long-term storage for the wastes at DOE sites. An NRC official stated that NRC and other groups are planning to research the technical basis for the very long-term storage of commercial spent nuclear fuel beyond 120 years. However, it is unclear whether this research will address all of DOE's waste storage needs since EM officials said DOE storage systems generally differ from those used for commercial waste. NRC is not evaluating DOE spent nuclear fuel because it generally does not have authority over DOE, according to an NRC official. According to NRC officials, NRC also is not yet looking at long-term storage of spent nuclear fuel in the two NRC-licensed storage facilities at DOE's Idaho and Colorado sites. Because this spent nuclear fuel also differs from commercial spent nuclear fuel, it will require a unique analysis that NRC is not likely to undertake soon, NRC officials said.

More information would also be needed for DOE and the Navy to decide between these two options. New facilities might increase the cost-effectiveness of storage over the long term and be better designed to monitor deterioration and address security issues. However, DOE and the Navy cannot determine the resulting benefit without knowing the costs and time periods involved for each of the two options. For example, EM officials said DOE would not want to invest in costly new storage facilities that could last hundreds of years, only to discover that a shorter period of storage was needed. Furthermore, DOE may need more information about state and local support for the two options. Based on our discussions and review of documents, some states and communities may oppose any signs

that DOE is planning long-term storage at the sites. As New York officials told us, for instance, the local community may react negatively to a new storage facility at the West Valley site because it would be a visible sign that the nuclear waste is not moving.[21] On the other hand, some states and communities may favor building robust storage facilities to help ensure safety.

DOE and the Navy Have Not Developed Plans to Mitigate the Impact of Termination of the Yucca Mountain Repository on Nuclear Waste Storage

EM and Navy officials told us they will not make any mitigation plans until those plans can be informed by the Blue Ribbon Commission's recommendations, which are expected by January 29, 2012. EM officials told us that it is too early for EM to jettison its current plans because of the uncertainties about the possible alternatives to the Yucca Mountain repository. In addition, according to EM management, EM will not make any plans for extended storage before the Blue Ribbon Commission has made its recommendations because it does not want to preclude any strategies or options the Blue Ribbon Commission might recommend.

For some years after the commission's recommendations are available, however, DOE and the Navy could experience difficulties planning how to mitigate the impact of a termination because uncertainties about the alternative to the Yucca Mountain repository may take time to resolve. Establishing an alternative site for a repository, for example, would likely require new legislation, according the officials at DOE's Office of General Counsel. This might reopen lengthy and contentious political debates over repository siting. It took almost 4 years of congressional effort to pass the Nuclear Waste Policy Act of 1982, followed by about 5 years of additional effort, before Congress narrowed the evaluation of possible repository sites to Yucca Mountain. In addition, because it is not clear how specific the Blue Ribbon Commission's recommendations will be, it may take DOE additional work and time to use these recommendations to develop a new nuclear waste management policy. For example, it may take time to reassess whether to use the same procedures in siting a repository for DOE and Navy materials and commercial spent nuclear fuel. According to

[21]The community's reaction to the new facility occurs in the context of a potential termination of Yucca Mountain. However, EM officials stated this new storage facility is needed to support the cleanup of the West Valley site and is not the direct result of a termination of the Yucca Mountain program.

a 1982 Office of Technology Assessment report, this issue was a major obstacle to passing nuclear waste legislation in 1979 and 1980.[22]

With a termination of the Yucca Mountain repository, both DOE and the Navy recognize they will need to devise alternative strategies to meet state commitments for removing spent nuclear fuel from both Colorado and Idaho, and both are waiting for the Blue Ribbon Commission recommendations before planning a strategy. Navy officials said they expect that the Blue Ribbon Commission recommendations will define a potential alternate path for defense waste that will allow it to comply with the Idaho Settlement Agreement and to continue operations at DOE's Idaho site. EM officials believe it is too early to talk with states about renegotiating agreements and told us that they plan to wait until alternative plans to the Yucca Mountain repository can be made. In any event, they stated, DOE intends to remain in compliance with milestones and requirements in agreements with the states of Colorado and Idaho.

A termination of Yucca Mountain, however, may threaten DOE's and the Navy's ability to meet state commitments. Specifically, some alternatives that the Blue Ribbon Commission might consider may not provide a solution soon enough—in the less than 25 years remaining before the 2035 milestones—or may not be applicable to DOE's and the Navy's spent nuclear fuel. Although the commission has not indicated what it plans to recommend, it has heard testimony on alternatives that have previously been discussed and that might allow for removal of nuclear waste from DOE sites. One of these alternatives is to establish one or more new permanent repositories to replace the Yucca Mountain repository. However, establishing another repository may not allow enough time to meet the 2035 milestones unless the process is more expeditious for a new repository than it was for Yucca Mountain. For the Yucca Mountain repository, in 2008 this process was projected to ultimately last at least 37 years—from the beginning of the siting process in 1983 to the earliest possible start of operations, in 2020. The commission is also considering changes to the way nuclear waste is stored prior to final disposal. One alternative that DOE previously studied for commercial spent nuclear fuel is storing it at a centralized site. For our November 2009 report on alternatives to the Yucca Mountain repository, an expert in centralized storage estimated that opening a centralized facility could take between 17

[22]Office of Technology Assessment, *Managing Commercial High-Level Radioactive Waste: Summary* (Washington, D.C., 1982).

and 33 years from site selection until the facility began accepting waste.[23] A third alternative, which DOE has also previously considered, is for the United States to reprocess spent nuclear fuel to create new fuel for reactors. However, current reprocessing technology may not be cost-effective and, if not managed properly, creates proliferation concerns because the resulting materials could be used in a nuclear weapon. Transitioning the nuclear industry to new technologies to address these concerns could take 50 to 100 years, according to a 2010 report from the Massachusetts Institute of Technology.[24] Even then, this solution might apply mainly to commercial spent nuclear fuel, rather than the fuel stored at DOE sites, because it may be impractical or uneconomical to reprocess the relatively small quantities and many different types of spent nuclear fuels stored at DOE sites, according to DOE documents and Navy officials.

Conclusions

For decades, the United States has been struggling with the issue of what to do with the nuclear waste from weapons production and several other sources. With the possible termination of the Yucca Mountain repository, it may be about to restart this potentially time-consuming and contentious process. In the short term, this is unlikely to affect nuclear waste operations for DOE or the Navy. However, long-term storage costs at sites are likely to increase since DOE would need to store waste for longer periods prior to permanent disposal. Furthermore, as a result of the potential termination, DOE and the Navy may fail to meet commitments they have made with Colorado and Idaho to remove spent nuclear fuel by 2035.

The fate of the Yucca Mountain repository is still uncertain, and DOE's Blue Ribbon Commission may not provide recommendations on a new direction for nuclear waste management until January 2012. Given this situation, DOE and the Navy cannot yet easily plan or wisely invest in long-term storage since they will not know how long they will have to store waste at DOE sites. Nevertheless, it seems likely that some extension of on-site storage will be needed, and additional information about storage systems will be needed to even start planning for extended storage. For example, it is not known how long the lives of existing facilities can be extended or what will happen to the waste or the storage containers

[23]GAO-10-48.

[24]Massachusetts Institute of Technology, *The Future of the Nuclear Fuel Cycle: An Interdisciplinary MIT Study, Summary Report* (2010).

during long-term on-site storage. EM officials told us that EM currently has no plan for developing information on extending the lives of existing facilities, but longevity studies could identify components of the storage facilities that are at risk for failure and repairs that could extend storage. Moreover, although NRC and other groups are planning to research the long-term storage of commercial spent nuclear fuel, DOE does not have comparable research planned for somewhat different storage systems at its sites. Thus, without taking some preliminary steps to assess the information necessary to plan for long-term storage, DOE and the Navy will not have the understanding needed to proceed with such planning when the future direction becomes clearer. The alternative is to wait until there is further clarity about national and departmental policy, which may take years after the Blue Ribbon Commission provides recommendations.

Recommendations for Executive Action

To help prepare for longer storage of nuclear waste at DOE sites, we recommend the Secretary of Energy direct the Assistant Secretary for Environmental Management, and other DOE officials as appropriate, to take the following two actions:

- Assess the condition of existing nuclear waste storage facilities and the resources and information needed to extend the facilities' useful lifetimes.
- Identify any gap between past and ongoing research into long-term nuclear waste storage and any additional actions needed to address DOE's unique waste storage needs.

Agency Comments and Our Evaluation

We provided DOE and the Navy with a draft of this report for their review and comment. The Navy chose not to provide formal comments. DOE provided written comments on March 11, 2011, which are summarized below and reproduced in appendix II. DOE stated that it agreed with our recommendations but disagreed with two aspects of our report—that (1) there would likely be delay and increased costs due to DOE's decision to terminate a repository at Yucca Mountain and (2) DOE may not meet its commitments to the states of Idaho and Colorado. After reviewing DOE's comments, we believe that our findings are adequately supported and that any assumptions upon which those findings are based are appropriately acknowledged.

We are encouraged that DOE agrees that it needs better information on the condition of existing nuclear waste storage facilities as well as research on very long-term storage to meet its unique needs. DOE recognizes that the

waste may remain on its sites for a considerable period of time. This will likely require DOE to revise the target date in its current plans, which assume that a repository will be available in 2020.

DOE disagreed with parts of the draft report that stated there would likely be a delay in removing waste from DOE sites and increased costs as a result of DOE's decision to terminate the proposed repository at Yucca Mountain. DOE stated that there was no "certain" date for opening the Yucca Mountain repository and that any opening was subject to contingencies beyond DOE's control. DOE characterized our finding of a likely delay as speculation. DOE also stated that the Blue Ribbon Commission could propose options that will lead to more rapid disposal of waste than the Yucca Mountain approach.

We believe that using 2020 as an opening date for the Yucca Mountain repository was a reasonable assumption for analyzing the effects of a possible termination of the program. In 2008, DOE itself established this target date for opening the planned Yucca Mountain repository, before it took steps to terminate the program. DOE did not provide an alternative target or any basis for one in its comments, which would be necessary for conducting a meaningful analysis. We agree that the opening date for the Yucca Mountain repository was uncertain, and therefore we have made clear in the report that our analysis is based on DOE's own assumption of a 2020 opening. Regarding DOE's assertion that the Blue Ribbon Commission could propose options for more rapid disposal, this also provides no new basis for analysis. It is unclear how specific the commission's recommendations will be, whether DOE will choose to implement them, or how quickly they can be implemented. Key alternatives to Yucca Mountain that we reviewed—centralized storage, reprocessing, or a new repository—could take decades to implement. Therefore, the Yucca Mountain repository could have opened many years after 2020 and still possibly have been available sooner than these alternatives. Such uncertainties for both the availability of the Yucca Mountain repository and for any alternative led us to report a "likely" lengthening of the duration of on-site storage. DOE's comments provide no basis for revising our finding.

Second, DOE objected to the suggestion that DOE may not meet its commitments to the states of Idaho and Colorado. DOE stated in its comments that it intends to meet its commitments to remove spent nuclear fuel from those states by 2035, and that there is no factual basis to support that the commitments will not be met. However, we disagree with DOE's representation of our findings and supporting facts. Although our

report does conclude that DOE may not meet it commitments, it does not state that DOE "will not" meet them. Instead, we highlight some challenges to meeting these commitments if the Yucca Mountain repository program were terminated. Without the Yucca Mountain repository, DOE currently has no planned shipping destination for its spent nuclear fuel, and it is not clear when a new destination will be available. We also reported that some alternatives that the Blue Ribbon Commission might consider may not provide a solution soon enough—in the less than 25 years remaining before the 2035 milestones—or may not be applicable to DOE's spent nuclear fuel. We are unable to say more because, as we reported, DOE has yet to announce a new plan for meeting its commitments. Its likelihood of meeting them will be clearer after DOE specifies how it plans to establish a new destination and ship its spent nuclear fuel there by 2035.

DOE and the Navy also provided technical comments, which we incorporated into the report as appropriate.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to the appropriate congressional committees, the Secretaries of Energy and Defense, and other interested parties. In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staffs have any questions about this report, please contact me at (202) 512-3841 or aloisee@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made major contributions to this report are listed in appendix III.

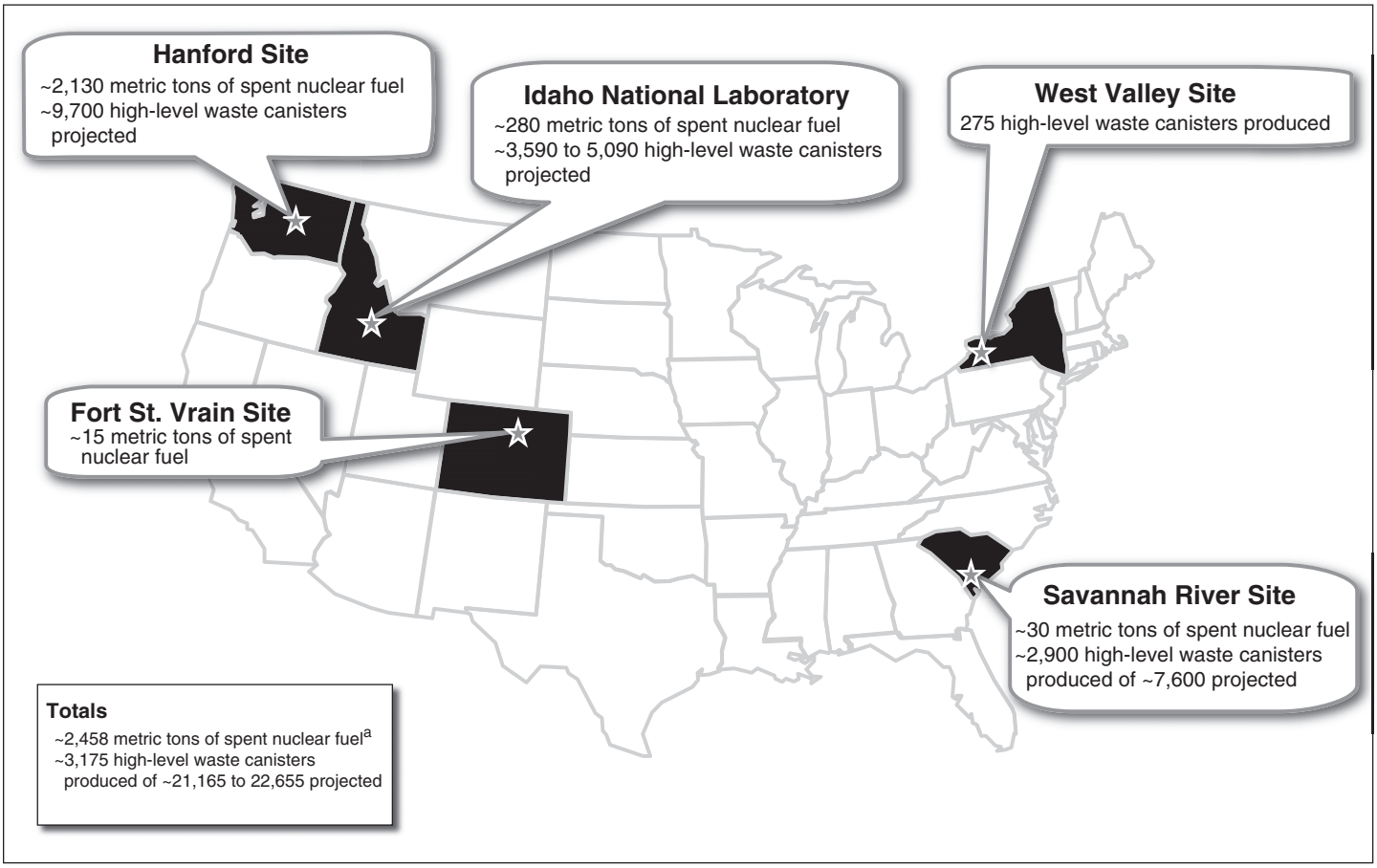
Gene Aloise
Director, Natural Resources
and Environment

Appendix I: Status of DOE's Preparation of Spent Nuclear Fuel and High-Level Waste for Disposal

The five Department of Energy (DOE) sites manage very different amounts of spent nuclear fuel and high-level waste, all of which will have to be prepared for disposal in a repository. The inventories differ in terms of metric tons of heavy metal for spent nuclear fuel and in terms of the number of canisters of high-level waste that will be produced (see figure 3).[1] The Hanford Site has about 85 percent of the spent nuclear fuel by weight and is projected to have about 45 percent of the canisters of high-level waste.

[1]Quantities of spent nuclear fuel are expressed in terms of metric tons of heavy metal (MTHM), which refers to the weight of the heavy metal, typically uranium, excluding other materials such as cladding around the fuel. The relative quantities of high-level waste are only roughly captured by the number of projected canisters, partly since the size of the canisters is not uniform across all sites. In addition, EM officials said the amount of high-level waste in each individual canister is not uniform in terms of heavy metal, because of the different compositions of waste in various storage tanks and differences in the amount of waste loaded into canisters over time and across sites.

Figure 3: 2010 Inventories of Spent Nuclear Fuel and High-Level Waste at DOE's Sites



Source: GAO analysis of DOE data.

[a]The total includes an approximate two metric tons of spent nuclear fuel located at other domestic sites. In addition to this total, about 25 metric tons of the Navy's spent nuclear fuel is at DOE's Idaho site.

Sites are in very different stages of preparing spent nuclear fuel and high-level waste for final disposal. Preparation generally involves loading and sealing the materials into stainless steel canisters suitable for permanent disposal in a repository. For spent nuclear fuel, the Hanford Site has placed almost all of its spent nuclear fuel in multicanister overpacks for placement in a repository. DOE has planned to place the remaining Hanford inventory of spent nuclear fuel—less than 1 percent of Hanford's total—and most of the spent nuclear fuel inventory at Idaho National

Laboratory into DOE standard canisters. DOE, however, has not yet built the needed canister packaging facilities.[2] At DOE's Idaho site, the Navy's spent nuclear fuel is being placed into a different type of canister for disposal. DOE also intends to ship the spent nuclear fuel from the Fort St. Vrain facility to Idaho National Laboratory for packaging into DOE standard canisters shortly before shipping it to a repository. For the Savannah River Site, DOE has planned to ship its non-aluminum-based spent nuclear fuel to Idaho National Laboratory and, in exchange, receive the laboratory's aluminum-based spent nuclear fuel to add to its own inventory.[3] The Savannah River Site would process the aluminum-based spent nuclear fuel at its H-Canyon facility, where uranium would be extracted for fuel production and a resulting liquid waste stream would be vitrified for final disposal as high-level waste in canisters. To date, the spent nuclear fuel exchange has not occurred between Idaho National Laboratory and the Savannah River Site, and DOE is still considering whether to proceed with processing the aluminum-based spent nuclear fuel at the H-Canyon facility.

To prepare high-level waste for shipment to a repository, DOE has been converting it to a solid glass form and sealing it in stainless steel canisters. Depending on the stage of the processing for disposal, high-level radioactive waste can be in a liquid, sludge, or crystallized form in waste tanks; a solid glass form in a canister; a solid granular form (calcine); or a solid ceramic form in a canister. DOE initially prepares high-level radioactive waste for disposal by transferring the radioactive waste from storage tanks to a treatment facility. Treatment can include separation of the waste into high- and low-radioactive streams, followed by vitrification that combines the high-level waste with glass-forming chemicals to make a glass that is poured into stainless steel canisters and sealed by welding.[4] Instead of using vitrification at Idaho National Laboratory, DOE first solidified the high-level waste into a granular form, known as calcine, and

[2]Because of concerns that metallic sodium creates risks for corrosion and explosions in a repository, Idaho National Laboratory is processing a portion of its spent nuclear fuel, a type known as sodium-bonded, with an electrometallurgical treatment that results in high-level waste for disposal.

[3]Spent nuclear fuel may differ in many ways, including the cladding around the fuel that may be aluminum or other types of material such as stainless steel or zirconium.

[4]Some other radioactive materials may be disposed of by adding them to the high-level waste stream for vitrification. For example, DOE is considering vitrifying a portion of surplus plutonium at the Savannah River Site and has considered vitrifying strontium and cesium that were extracted from tank waste and placed in capsules at the Hanford Site.

placed it in stainless steel storage bins within concrete vaults. To prepare it for transportation and disposal, DOE decided in 2009 to next process the calcine into a monolithic, possibly ceramic, form within a canister. Both the solidified, immobilized glass and ceramic forms are designed to keep the waste stable, confined, and isolated from the environment. DOE has planned to store the solidified high-level waste canisters on site until they are shipped to a repository.

DOE sites are in markedly different stages of preparing high-level waste for final disposition, and, overall, DOE has produced about 15 percent of the projected number of canisters. By early 2010, the Hanford Site and Idaho National Laboratory had not yet produced canisters of immobilized high-level waste. The Savannah River Site was approaching completion of almost 40 percent of its projected number of canisters, after starting vitrification operations in 1996. Similarly, the West Valley Site began vitrifying waste in 1996 but completed production in 2002. Preparing the many remaining canisters of waste is expected to be a lengthy process. For example, the Hanford waste treatment plant currently being built is not scheduled to begin operations until 2019 and then is expected to take almost three decades to produce about 10,000 canisters of waste.

Appendix II: Comments from the Department of Energy

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

Department of Energy
Washington, DC 20585

March 11, 2011

Mr. Gene Aloise
Director of Natural Resources and Environment
United States Government Accountability Office
Washington, DC 20548

Dear Mr. Aloise:

Thank you for the opportunity to review the draft report entitled "DOE Nuclear Waste: Better Information Needed on Waste Storage at DOE Sites as a Result of Yucca Mountain Shutdown."

Now on p. 16.

The Department of Energy (DOE) agrees with the draft report's conclusion that the termination of the Yucca Mountain repository will not affect near-term nuclear waste operations at DOE sites. However, DOE disagrees with, and objects to, statements in the draft report that there would likely be delay and increased costs due to DOE's decision to terminate a repository at Yucca Mountain. As the report itself concedes (at page 20), there was no "certain" date for opening the Yucca Mountain repository, and any opening was always subject to contingencies beyond DOE's control. By the same token, the report disregards the fact that the Blue Ribbon Commission is currently considering these matters and could propose options that will lead to more rapid disposal of waste than the Yucca Mountain approach. Indeed, after DOE highlighted these and other points, the U.S. Court of Appeals for the D.C. Circuit determined that DOE's decisions with regard to Yucca Mountain created no irreparable injury. While the U.S. Government Accountability Office may view there is increased risk of a delay in repository operation, it should not base its analysis (as it currently does) on speculation that there will be a delay.

DOE also objects to the suggestion that DOE may not meet its commitments to the States of Idaho and Colorado in 2035. DOE intends to meet these commitments, and there is no factual basis, and certainly nothing in the report, that would support that they will not be met at this time.

That said, we do agree with the two recommendations made in the report. The first recommendation suggests that the Office of Environmental Management (EM) assess the condition of existing nuclear waste storage facilities and of the resources and information needed to extend their useful lifetimes. EM has already initiated activities to implement the first recommendation (to assess the condition of existing nuclear waste storage facilities and of the resources and information needed to extend their useful lifetimes). In this regard, while we agree that EM is responsible for most of DOE's nuclear waste management activities, other Departmental elements have responsibilities with respect to nuclear waste and this should be acknowledged in this recommendation.

See comment.

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The second recommendation suggests that EM identify any gap between past and ongoing research into very long-term nuclear waste storage and any additional research needed to address DOE's unique waste storage needs. EM has identified innovative technologies and strategies needed for long-term storage of high-level waste (HLW) and spent nuclear fuel (SNF) (also referred to as used nuclear fuel) (Reference: Science and Technology to Reduce the Life Cycle Cost of Closure, January 2011). EM is also actively collaborating with other Departmental elements to identify other research and development activities that address efforts needed to assure safe storage capabilities for the very long-term, should that be necessary. Examples of these research and development activities include: (1) aging management studies to assure fuel and storage system integrity in wet or dry storage systems such as remote corrosion characterization; repairing aging concrete; and the effects of water chemistries on concrete and fuel corrosion; and (2) improving technologies for preparing and packaging SNF for disposal over a broad range of future scenarios. We will continue to evaluate and adapt our research efforts in light of new plans and information regarding nuclear waste management requirements.

Thank you for providing us an opportunity to review your draft report and your assistance in strengthening our HLW and SNF management programs. We also appreciate the opportunity for direct dialogue with you on these important issues prior to receiving the draft report. We have enclosed specific comments for your consideration.

If you have any questions, please contact me or Mr. Frank Marcinowski, Deputy Assistant Secretary for Technical and Regulatory Support, at (202) 586-0370.

Sincerely,

Inés R. Triay
Assistant Secretary for
Environmental Management

Enclosure

cc: D. Chung, EM-2
C. Anderson, EM-3
F. Marcinowski, Acting EM-4
K. Picha, Acting EM-20
Y. Collazo, EM-30

The following is GAO's comment on the Department of Energy's letter dated March 11, 2011.

GAO Comment

We acknowledged in our recommendations that they may need to be directed to other DOE officials, as appropriate.

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Gene Aloise, (202) 512-3841 or aloisee@gao.gov

Staff Acknowledgments

In addition to the contact named above, the following staff members made key contributions to this report: Janet Frisch, Assistant Director; Arkelga Braxton; Kevin Bray; Penney Harwell-Caramia; Scott Fletcher; Eugene Gray; Terry Hanford; Jonathan Kelly; Anne Rhodes-Kline; Mehrzad Nadji; Ben Shouse; and Vasiliki Theodoropoulos.

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