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NUCLEAR WASTE

Challenges and Savings Opportunities in DOE's High-Level Waste Cleanup Program

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Highlights

Highlights of GAO-03-930T, a testimony before the Subcommittee on Oversight and Investigations, Committee on Energy and Commerce, House of Representatives

Why GAO Did This Study

The Department of Energy (DOE) oversees the treatment and disposal of 94 million gallons of highly radioactive nuclear waste from the nation's nuclear weapons program, currently at DOE sites in Washington, Idaho, and South Carolina. In 2002, DOE began an initiative to reduce the estimated $105-billion cost and 70-year time frame of this cleanup. GAO was asked to testify on the status of this initiative, the legal and technical challenges DOE faces in implementation, and any further opportunities to reduce costs or improve program management. GAO's testimony is based on a report (GAO-03-593) released at the hearing.

What GAO Recommends

GAO made recommendations in the report on which this testimony is based. In commenting on the report, DOE agreed to consider seeking clarification from the Congress about its authority to decide that waste with low concentrations of radioactivity could be treated and disposed of on-site. DOE disagreed with the need to conduct integrated testing of the Hanford waste separation technology and argued that its existing actions are sufficient to support decision making with rigorous analysis, test new technology before incorporating it into projects, and pursue concurrent design/construction of complex facilities. GAO disagrees and continues to believe that its recommendations are warranted.

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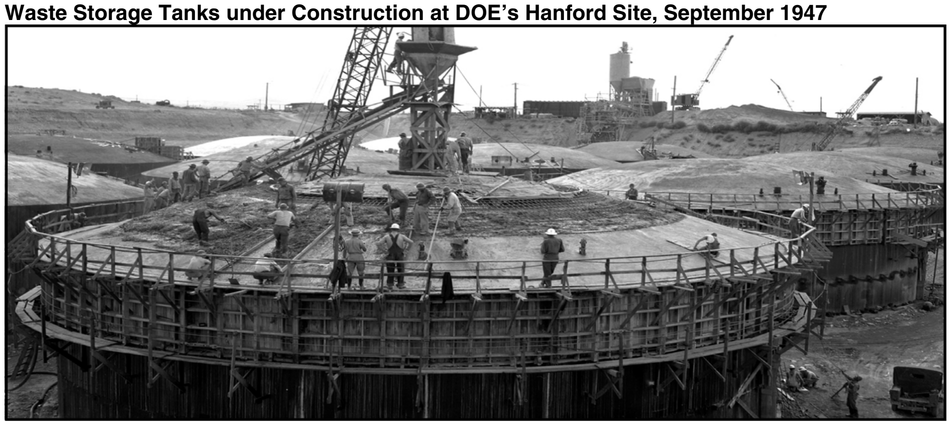
What GAO Found

DOE's initiative for reducing the costs and time required for cleanup of high-level wastes is still evolving. DOE's main strategy for treating high-level waste continues to include separating and concentrating much of the radioactivity into a smaller volume for disposal in a geologic repository. Under the initiative, DOE sites are evaluating other approaches, such as disposing of more waste on site. DOE's current savings estimate for these approaches is $29 billion, but the estimate may not be reliable or complete. For example, the savings estimate does not adequately reflect uncertainties or take into account the timing of when savings will be realized.

DOE faces significant legal and technical challenges to realize these savings. A key legal challenge involves DOE's process for deciding that some waste with relatively low concentrations of radioactivity can be treated and disposed of on-site. A recent court ruling invalidated this process, putting the accelerated schedule and potential savings in jeopardy. A key technical challenge is that DOE's approach relies on laboratory testing to confirm separation of the waste into high-level and low-activity portions. At the Hanford Site in Washington State, DOE plans to build a facility before conducting integrated testing of the waste separation technology—an approach that failed on a prior major project.

DOE is exploring proposals, such as increasing the amount of high-level waste in each disposal canister, that if successful could save billions of dollars more than the current $29 billion estimate. However, considerable evaluation remains to be done. DOE also has opportunities to improve program management by fully addressing recurring weaknesses GAO has identified in DOE's management of cleanup projects, including the practice of incorporating technology into projects before it is sufficiently tested.

Waste Storage Tanks under Construction at DOE's Hanford Site, September 1947



Source: DOE.

Many of the waste storage tanks, such as those above, were built in the 1940s to 1960s. These tanks, now underground, are used to store high-level waste and have exceeded their design life of 10-40 years. Some have leaked waste into the soil.

Mr. Chairman and Members of the Subcommittee:

We are pleased to be here today to discuss the Department of Energy's (DOE) high-level waste cleanup program. DOE has about 94 million gallons of highly radioactive nuclear waste from the nation's nuclear weapons program. This waste is currently in temporary storage at DOE sites in Washington, South Carolina, and Idaho. After investing more than 20 years and about $18 billion, DOE acknowledged in February 2002 that the program to clean up its high-level waste was far behind schedule, far over budget, and in need of major change. In 2002, DOE began an initiative to reduce the program's nearly $105-billion estimated cost and 70-year time frame to finish permanent disposal of this waste. Our testimony, based on work included in the report being released by the Subcommittee today,[1] discusses (1) the components of DOE's high-level waste and the process involved in preparing the waste for disposal, (2) the status of DOE's accelerated cleanup initiative for high-level waste, (3) legal and technical challenges DOE faces in implementing the initiative, and (4) further opportunities to reduce costs beyond those identified in DOE's current cost-savings proposal or to improve program management.

In summary, we found the following:

- DOE's high-level waste has many components, ranging from radioactive isotopes and corrosive chemicals to the water in which much of this material was initially discharged. The radioactive components vary greatly; a small portion will remain dangerously radioactive for millions of years, while the vast majority will lose much of their radioactivity more quickly, so that more than 90 percent of the current radioactivity will be gone within 100 years. To prepare the waste for permanent disposal, DOE plans to separate the waste into two waste streams: one with high levels of radioactivity and the other with lower concentrations of radioactivity. DOE expects that this process will concentrate at least 90 percent of the radioactivity into a volume that is significantly smaller than the current total volume of waste. DOE plans to immobilize and bury the highly radioactive portion in a permanent underground repository. The remaining waste will be immobilized and disposed of at the location where it is currently stored or at some other location.

[1] U.S. General Accounting Office, *Nuclear Waste: Challenges to Achieving Potential Savings in DOE's High-Level Waste Cleanup Program*, GAO-03-593 (Washington, D.C.: June 17, 2003).

- DOE's initiative to accelerate the cleanup is evolving, and while its savings estimates are changing accordingly, we have ongoing concerns about the reliability of those estimates. As of April 2003, DOE estimated it could shorten the waste cleanup schedule by 20-35 years and save up to $29 billion. To help achieve these schedule and cost reductions, DOE has identified alternative treatment and disposal strategies, such as developing ways to permanently dispose of more of the radioactive waste at current sites rather than moving it to the planned underground repository. However, our assessment of DOE's savings estimate indicates that it may not be reliable. For example, the savings analysis does not take into account all costs associated with alternative treatment strategies. Also, the estimate of savings does not compare costs on the basis of "present value," where dollars to be saved in future years are discounted to a common year to reflect the time value of money. At DOE's Savannah River Site in South Carolina, such an adjustment would lower the savings estimate for accelerated waste processing by $2.6 billion—from $5.4 billion to $2.8 billion (in 2003 dollars).

- DOE faces significant legal and technical challenges to realize the estimated savings. A key legal challenge involves DOE's authority to apply a designation other than high-level waste to some waste with relatively low concentrations of radioactivity, so that this portion can be treated less expensively than highly radioactive waste. A recent court ruling invalidated this redesignation process, thus precluding DOE from proceeding with this element of its accelerated initiative. If DOE cannot meet its accelerated schedules, then potential savings are in jeopardy. A key technical challenge is that DOE's approach relies primarily on laboratory testing to confirm that separating waste into high-level and low-activity portions will be successful. At the Hanford Site in Washington State, DOE is planning to construct full-scale facilities before fully testing the technologies on an integrated basis—an approach that has failed on another project in the past, resulting in significant cost increases and schedule delays.

- DOE is exploring additional cost savings beyond those identified in its current cost-saving proposals. The proposals that offer significant potential are being developed by the Hanford and Savannah River sites. These proposals call for increasing the amount of waste that can be concentrated into the canisters destined for the permanent underground repository. DOE's data indicates that these proposals, if successful, could save several billion dollars. Considerable evaluation of these proposals remains to be done and cost-saving estimates have not yet been fully developed, according to DOE officials. DOE also has opportunities to improve its management of the cleanup program by addressing management weaknesses that we and others have identified in the past. Although DOE has taken steps to improve program management, we have continuing concerns about management weaknesses in several areas. These include making key decisions without rigorous supporting analysis, incorporating technology into projects before it is sufficiently tested, and pursuing a “fast-track” approach of launching into facility construction before completing sufficient design work. It does not appear that DOE’s current management efforts will fully address these weaknesses.

Our report makes several recommendations to DOE that, if implemented, will help to manage or reduce legal and technical risks to the program, avoid costly delays, and strengthen overall program management. DOE agreed to consider our recommendation to seek clarification from the Congress regarding its authority to determine that some waste can be treated and disposed of as other than high-level waste. However, regarding our recommendations that the department conduct integrated pilot testing of its waste separation processes at Hanford, and take steps to improve the management of high-level waste projects, such as by conducting more rigorous analyses to support key project decisions, DOE believes that its current approach is adequate. We do not agree with DOE’s views and continue to believe that all of our recommendations are warranted.

Background

DOE has a vast complex of sites across the nation dedicated to the nuclear weapons program. DOE largely ceased production of plutonium and enriched uranium by 1992, but the waste remains at the sites. Most of the tanks in which the waste is stored have already exceeded their design life. For example, many of Hanford’s and Savannah River’s tanks were built in the 1940s to 1960s and were designed to last 10-40 years. Leaks from some of these tanks were first detected at Hanford in 1956 and at Savannah River in 1959. Given the age and deteriorating condition of some of the tanks, there is concern that some of them will leak additional waste into the soil, where it may migrate to the water table and, in the case of the Hanford Site, to the Columbia River.

Responsibility for the high-level waste produced at DOE facilities is governed primarily by federal laws, including the Atomic Energy Act of 1954. These laws established responsibility for the regulatory control of radioactive materials including DOE’s high-level waste and assigned the Nuclear Regulatory Commission (NRC) the function of licensing facilities that are expressly authorized for long-term storage of high-level radioactive waste generated by DOE. In addition, the Nuclear Waste Policy Act of 1982 defined high-level radioactive waste. Various other federal laws, including the Resource Conservation and Recovery Act of 1976, guide how DOE must carry out its cleanup program. The high-level waste cleanup program is under the leadership of the Assistant Secretary for Environmental Management. It involves consultation with a variety of stakeholders, including the Environmental Protection Agency, state environmental agencies where DOE sites are located, county and local governmental agencies, citizen groups, advisory groups, and Native American tribes.

DOE's High-Level Waste Is a Complex Mixture That Requires a Multi-Step Process to Prepare for Disposal

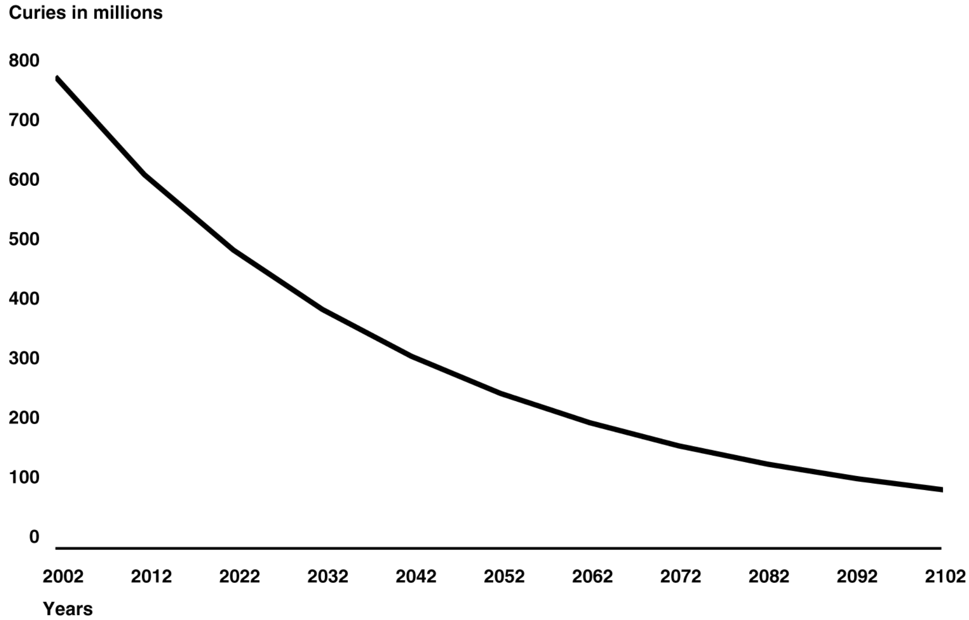
The waste in the tanks at the Hanford and Savannah River sites and the Idaho National Laboratory near Idaho Falls is a complex mixture of radioactive and hazardous components. DOE's process for preparing it for disposal is designed to separate much of the radioactive material from other waste components.

Much of the Radioactivity Declines Relatively Quickly

Nearly all the radioactivity in the waste originates from radionuclides with half-lives[2] of about 30 years or less. The relatively short half-lives of most of the radionuclides in the waste means that within 30 years, about 50 percent of the current radioactivity will have decayed away, and within 100 years this figure will rise to more than 90 percent. Figure 1 shows the pattern of decay, using 2002 to 2102 as the 100-year period. Extending the analysis beyond the 100-year period shown in the figure, in 300 years, 99.8 percent of the radioactivity will have decayed, leaving 0.2 percent of the current radioactivity remaining.

[2]Each radioactive component, or radionuclide, in high-level waste loses its radioactivity at a rate that differs for each component. This rate of decay, which cannot be changed, is measured in "half-lives"—that is, the length of time required for half of the unstable atoms to decay and release their radiation.

Figure 1: Natural Decay of Radionuclides in DOE's Untreated High-Level Waste from 2002 to 2102



Source: GAO analysis of DOE data.

Note: Radioactivity is measured in a unit called a curie. One curie equals 37 billion atomic disintegrations per second.

Despite the relatively rapid decay of most of the current radioactivity, some radionuclides have half-lives in the hundreds of thousands of years and will remain dangerously radioactive for millions of years. Some of these long-lived radionuclides are potentially very mobile in the environment and therefore must remain permanently isolated. If these highly mobile radionuclides leak out or are released into the environment, they can contaminate the soil and water.

Processing Can Concentrate the Radioactivity into a Much Smaller Volume of Waste

DOE plans to isolate the radioactive components and prepare the waste for disposal through a multi-step treatment process. DOE expects this process to concentrate at least 90 percent of the radioactivity into a much smaller volume that can be permanently isolated for at least 10,000 years in a geologic repository. The portion of the waste not sent to the geologic repository will have relatively small amounts of radioactivity and long-lived radionuclides. Based on current disposal standards used by the NRC, if the radioactivity of this remaining waste is sufficiently low, it can be disposed of on site near the surface of the ground, using less complex and expensive techniques than those required for the highly radioactive portion. DOE plans to dispose of this waste on site in vaults or canisters, or at other designated disposal facilities.

DOE has successfully applied this process in a demonstration project at the West Valley site in New York State. At West Valley, separation of the low-activity portion from the high-level portion of the waste reduced by 90 percent the quantity of waste requiring permanent isolation and disposal at a geologic repository. The high-level portion was stabilized in a glass material (vitrified) and remains stored at the site pending completion of the high-level waste geologic repository and resolution of other issues associated with disposal costs.[3] The remaining low-activity portion was mixed with cement-forming materials, poured into drums where it solidified into grout (a cement-like material), and remains stored on site, awaiting shipment to an off-site disposal facility.

DOE's Initiative for Accelerating Cleanup Is Still Evolving, with the Extent of Savings Uncertain

DOE's new initiative, implemented in 2002, attempts to address the schedule delays and increasing costs DOE has encountered in its efforts to treat and dispose of high-level waste. This initiative is still evolving. As of April 2003, DOE had identified several strategies to help reduce the time needed to treat and dispose of the waste. Based on these strategies, DOE estimated that it could reduce the waste cleanup schedule by about 20 to 35 years at its high-level waste sites and save about $29 billion compared to the existing program baseline.[4] While some degree of savings is likely if the strategies are successfully implemented, the extent of the savings is still uncertain.

[3]At Savannah River, high-level sludge from the tanks has also been stabilized in glass material and is currently stored on site pending completion of the geologic repository. As of August 30, 2002, Savannah River had produced 1,331 canisters of this stabilized waste.

[4]Unless otherwise noted, all dollar estimates are as reported by DOE and are in current dollars.

Initiative Centers on Ways to Speed Disposal and Save Money

Many of DOE's proposals to speed cleanup and reduce environmental risk involve ways to do one or more of the following:

- Deal with some tank waste as low-level or transuranic[5] waste, rather than as high-level waste. Doing so would eliminate the need to vitrify the waste for off-site disposal in the geologic repository for high-level waste.

- Complete the waste treatment more quickly by using additional or supplemental technologies. For example, DOE's Hanford Site is considering using up to four supplemental technologies, in addition to vitrification, to process its low-activity waste. DOE believes these technologies are needed to help it meet a schedule milestone date of 2028 agreed to with regulators to complete waste processing. Without these technologies, DOE believes waste treatment would not be completed before 2048.

- Segregate the waste more fully than initially planned and tailor waste treatment to each of the waste types. By doing so, DOE plans to apply less costly treatment methods to waste with lower concentrations of radioactivity.

- Close waste storage tanks earlier than expected, thereby avoiding the operating costs involved in maintaining the tanks and monitoring the wastes.

Table 1 summarizes the estimated cost savings for each DOE site if accelerated proposals for cleaning up high-level waste are successfully implemented.

[5]Low-level radioactive waste is defined as radioactive material that is not high-level radioactive waste, spent nuclear fuel, transuranic waste, or certain by-product material (the tailings or wastes produced by the extraction or concentration or uranium or thorium from any ore processed primarily for its source material content). 42 U.S.C. 10101(16). Transuranic wastes come primarily from reprocessing of spent nuclear fuel and from fabrication of nuclear weapons. Transuranic waste is defined as waste with radionuclides with atomic numbers greater than 92 (that is, uranium) and having half-lives greater than 20 years in concentrations greater than 100 nanocuries per gram.

Table 1: DOE's Estimated Cost Savings from Proposals to Accelerate Cleanup of High-Level Waste

Amounts are in billions of current dollars, fiscal year 2003 to the end of cleanup

Site	Current baseline lifecycle cost estimate	Accelerated lifecycle cost estimate	Estimated savings from accelerated initiatives
Idaho National Laboratory	$10.07	$ 3.10	$ 6.97
Hanford	56.19	41.67	14.52
Savannah River	18.82	11.49	7.33
Totals	$85.08	$56.26	$28.82

Source: DOE.

Note: West Valley is not included in this table because high-level waste cleanup at the site was essentially completed in September 2002.

Savings Estimate May Not Be Reliable

Our review indicates that DOE's current estimate of $29 billion may not yet be reliable and that the actual amount to be saved if DOE successfully implements the alternative waste treatment and disposal strategies may be substantially different from what DOE is projecting. We have several concerns about the reliability and completeness of the estimate. These concerns include the accuracy of baseline cost estimates from which savings are calculated, whether all appropriate costs are included in the analysis, and whether the savings estimates properly reflect the timing of the savings or uncertainties.

Baseline Costs Are Not Fully Reliable

DOE's current lifecycle cost baseline is used as the base cost from which potential savings associated with any improvements are measured. However, in recent years, we and others have raised concerns about the reliability of DOE's baseline cost estimates. In a 1999 report, we noted that DOE lacked a standard methodology for sites to use in developing their lifecycle cost baseline, raising a concern about the reliability of data used to develop these cost estimates.[6] DOE's Office of Inspector General also raised a concern in a 1999 review of DOE project estimates, noting that several project cost estimates examined were not supported or complete. DOE acknowledged in its February 2002 review of the cleanup program

[6]U.S. General Accounting Office, *Nuclear Waste: DOE's Accelerated Cleanup Strategy Has Benefits but Faces Uncertainties*, GAO/RCED-99-129 (Washington, D.C.: Apr. 30, 1999).

that baseline cost estimates do not provide a reliable picture of project costs.[7]

Estimates of Project Costs May Be Incomplete

Some of DOE's savings may be based on incomplete estimates of the costs for the accelerated proposals. According to Office of Management and Budget (OMB) guidance on developing cost estimates, agencies should ensure that all appropriate costs are addressed in the estimate. However, DOE has not always done so. For example, the Idaho National Laboratory's estimated savings of up to $7 billion is based, in large part, on eliminating the need to build a vitrification facility to treat its waste. However, the waste may have to undergo an alternative treatment method before it can be accepted at a geological repository, and the Idaho National Laboratory is considering four different technologies for doing so. Nevertheless, DOE's current savings estimate reflects the potential cost of only one of those technologies. DOE has not yet developed the costs of using any of the other waste treatment approaches. DOE noted that the accelerated lifecycle estimate could likely change depending on which one of the technologies is selected and the associated costs of treating the waste are developed.

Savings Estimates Do Not Reflect Timing, Uncertainty, or Nonbudgetary Impacts

According to OMB guidance, agencies should ensure that the timing of when the savings will occur is accounted for, that uncertainties are recognized and quantified where possible, and that nonbudgetary impacts, such as a change in the level of risk to workers, are quantified, or at least described. We found problems in all three areas.

- Regarding the time value of money, applying OMB guidance would mean that estimates of savings in DOE's accelerated plans should reflect a comparison of its baseline cost estimate with the alternative, expressed in a "present value," where the dollars are discounted to a common year to reflect the time value of money. Instead, DOE's savings estimates generally measure savings by comparing dollars in different years. For example, the Savannah River Site estimates a savings of nearly $5.4 billion by reducing by 8 years (from 2027 to 2019) the time required to process its high-level waste. Adjusting the savings estimate to present value in 2003 results in a savings of $2.8 billion in 2003 dollars.

[7]U.S. Department of Energy, *A Review of the Environmental Management Program* (Washington, D.C.: Feb. 4, 2002).

- Regarding uncertainties, in contrast to OMB guidance, the DOE savings estimates generally do not consider uncertainties. For example, the savings projected in the Idaho National Laboratory's accelerated plan reflect the proposal to no longer build the vitrification facility and an associated reduction in operations costs. However, the savings do not account for uncertainties such as whether alternatives to vitrification will succeed and at what cost. Rather than reflecting uncertainties by providing a range of savings, DOE's savings estimate is a single point estimate of $7 billion.

- Regarding nonbudgetary impacts, DOE's savings estimates generally do not fully assess the value of potential nonbudgetary impacts, such as a change in the level of risk to workers or potential effects on the environment. OMB guidelines recommend identification and, where possible, quantification of other expected benefits and costs to society when evaluating alternative plans. For example, the Idaho National Laboratory's accelerated plan does not assess potential increases in environmental risk, if any, from disposing of the waste without stabilizing it into a vitrified form. By not assessing these benefits and risks to workers and the environment, DOE leaves unclear how important these risks and trade-offs are to choosing an alternative treatment approach.

Key Legal and Technical Challenges Could Limit Potential Savings from DOE's Accelerated Cleanup Initiative

DOE faces significant legal and technical challenges in achieving the cost and schedule reductions proposed in its new initiative. On the legal side, DOE's proposals depend heavily on the agency's authority to apply a designation other than "high-level waste" to the low-activity portion of the waste stream, so that this low-activity portion does not have to be disposed of more expensively as high-level waste. The portion of DOE's order setting out criteria for making such determinations has been invalidated in a recent court ruling. On the technical side, DOE's proposals rest heavily on the successful application of waste separation methods that are still under development and will not be fully tested before being put in place. DOE's track record in this regard has not been strong; it has had to abandon past projects that were also based on promising—but not fully tested—technologies. Either or both of these challenges could limit the potential savings from DOE's accelerated cleanup initiative.

DOE's Accelerated Initiative Relies on a Process for Reclassifying Waste That the Court Has Ruled Invalid

DOE has traditionally managed all of the wastes in its tanks as high-level waste because the waste resulted primarily from the reprocessing of spent nuclear fuel and contains significant amounts of radioactivity. However, by separating the waste into high-level and low-activity portions and managing the low-activity portion as something other than high-level waste, DOE could use less costly and less complicated treatment approaches. DOE has developed guidelines for deciding when waste in the tanks should not be considered high-level waste. In 1999, under Order 435.1, DOE formalized its process for determining which waste is incidental to reprocessing ("incidental waste"), not high level waste, and therefore will not be sent to a geological repository for high-level waste disposal. This process provides a basis for DOE to treat and dispose of some portion of its wastes less expensively as low-level or transuranic wastes.

DOE's ability to define some waste as incidental to reprocessing, and to then follow a different set of treatment and disposal requirements for that waste, is central to its overall strategy for addressing its tank waste. For example, DOE planned to use its incidental waste process to manage about 90 percent of its 54 million gallons of tank waste at the Hanford Site as low-level waste, rather than process it through a high-level waste vitrification facility. Using that approach, most of the waste would be eligible for treatment and disposal on site. Such an approach would save billions compared to treating all of the waste as high-level waste and sending it for disposal in a high-level waste geologic repository.

A recent court ruling precludes DOE from reclassifying some of its waste as other than high-level waste. In March 2002, the Natural Resources Defense Council and others filed a lawsuit challenging DOE's authority to manage its wastes through its incidental waste process.[8] The plaintiffs alleged that DOE arbitrarily established the incidental waste determination process without proper regard for the law or properly establishing a justification for this process. A primary concern of the plaintiffs was that DOE would use its incidental waste process to permanently leave intensely radioactive waste sediments in the tanks with only minimal

[8] *Natural Resources Defense Council, Inc. v. Abraham,* No. 01-CV-413 (D. Idaho, filed Mar. 5, 2002). The lawsuit was originally filed in January 2000 in the 9th Circuit Court of Appeals and was subsequently transferred to the federal district court in Idaho. The other parties to the lawsuit are the Snake River Alliance, the Confederated Tribes and Bands of the Yakama Nation, and the Shoshone Bannock Tribes. In addition, the states of Washington, Idaho, Oregon and South Carolina are participating as *amicus curiae.*

treatment. The lawsuit alleged that DOE's incidental waste process improperly allows DOE to reclassify high-level waste as incidental waste that does not need to be treated in the same way as high-level waste. According to the plaintiffs, the Nuclear Waste Policy Act defines all waste originating from a given source—that is, from reprocessing of spent nuclear fuel—as high-level waste and requires that such waste be managed as high-level waste, yet DOE has chosen to differentiate its wastes according to the level of radioactivity and manage them accordingly. In a July 3, 2003 ruling on the lawsuit, the court agreed with the plaintiffs, stating that the portion of DOE's Order 435.1 setting out its incidental waste determination process violates the Nuclear Waste Policy Act and thus is invalid.

The court's ruling could seriously hinder DOE's efforts to implement its accelerated treatment and disposal strategies. Under the ruling, DOE's incidental waste determinations cannot be implemented. Since the start of the lawsuit, DOE had not implemented any of its approved incidental waste determinations and had not yet decided whether to defer or proceed with its pending incidental waste determinations—such as those for closing tanks at the Savannah River Site and Idaho National Laboratory.

If DOE appeals the court ruling, a lengthy legal process could follow. A lengthy legal process will also likely delay treatment plans for this waste and delay closing tanks on an accelerated schedule. For example, the Idaho National Laboratory planned to begin closing tanks in the spring of 2003, pending approval of an incidental waste determination that would allow DOE to close the tanks by managing tank waste residuals as low-level waste.[9] A DOE official at the Idaho National Laboratory told us that while a delay of several months would not immediately threaten schedule dates, a delay beyond 24 months would seriously affect the site's ability to meet its accelerated 2012 date to close all of the tanks.

If the court's ruling invalidating DOE's incidental waste determination process is upheld, DOE may need to find an alternative that would allow it to treat waste with lower concentrations of radioactivity less expensively. Searching for such an alternative could delay progress at all three of DOE's high-level waste sites that rely on incidental waste determinations. If DOE cannot meet its accelerated schedules, then potential savings are

[9]Tank closure at the Idaho National Laboratory is also pending completion of its National Environmental Policy Act process.

in jeopardy. At this point, the department does not appear to have a strategy to avoid the potential effects of challenges to its incidental waste determination authority, either from the current court ruling or future challenges. At the time of our report, DOE officials told us that they believed the department would prevail in the legal challenge. DOE believed it would be premature to explore alternative strategies to overcome potentially significant delays to the program that could result from a protracted legal conflict or from an adverse decision. Such strategies could range from exploring alternative approaches for establishing an incidental waste regulation to asking that the Congress provide legislative authority for DOE to implement an incidental waste policy.

Accelerated Initiative Also Relies on Waste Separation Approaches That Will Not Be Fully Tested

Like the ability to determine that some waste is incidental to reprocessing, the ability to separate the waste components is important to meet waste cleanup schedule and cost goals. If the waste is not separated, all of it—about 94 million gallons—may have to be treated as high-level waste and disposed of in the geological repository. Doing so would require a much larger repository than currently planned, and drive up disposal costs by billions of dollars. Successful separation will substantially reduce the volume of waste needing disposal at the planned repository, as well as the time and cost required to prepare it for disposal, and allow less expensive methods to be used in treating and disposing of the remaining low-activity waste. The waste separation process is complicated, difficult, and unique in scope at each site. The waste differs among sites not only in volume but also in the way it has been generated, managed, and stored over the years.

The challenge to successfully separate the waste is significant at the Hanford Site, where DOE intends to build a facility for separating the waste before fully testing the separation processes that will be used. The planned laboratory testing includes a combination of pilot-scale testing of major individual processes and use of operational data for certain of those processes for which DOE officials said they had extensive experience. However, integrated testing will not be performed until full-scale facilities are constructed. DOE plans to fully test the processes for the first time during the operational tests of the newly constructed facilities.

This approach does not fully reflect DOE guidance, which calls for ensuring that new or complex technology is mature before integrating it into a project. Specifically, DOE's Project Management Order 413.3 requires DOE to assess the risks associated with technology at various phases of a project's development. For projects with significant technical uncertainties that could affect cost and schedule, corrective action plans to address these uncertainties are required before the projects can proceed. In addition, DOE's supplementary project management guidance suggests that technologies be developed to a reasonable level of maturity before a project progresses to full implementation to reduce risks and avoid cost increases and schedule delays. The guidance suggests that DOE avoid the risk of designing facilities concurrently with technology development.

The laboratories working to develop Hanford's waste separation process have identified several technical uncertainties, which they are working to address. These uncertainties or critical technology risks include problems with separating waste solids through an elaborate filtration system, problems associated with mixing the waste during separation processes, and various problems associated with the low-activity waste evaporator.

Given these and other uncertainties, Hanford's construction contractor and outside experts have seen Hanford's approach as having high technical risk and have proposed integrated testing during project development. However, DOE and the construction contractor eventually decided not to construct an integrated pilot facility and instead to accept a higher-risk approach. DOE officials said they wanted to avoid increasing project costs and schedule delays, which they believe will result from building a testing facility. Instead, Hanford officials said that they will continue to conduct pilot-scale tests of major separation processes. DOE officials said they believe this testing will provide assurance that the separation processes will function in an integrated manner. After the full-scale treatment facilities are constructed, DOE plans to fully test and demonstrate the separation process during facility startup operations.

The consequences of not adhering to sound technology development guidelines can be severe. At the Savannah River Site, for example, DOE invested nearly $500 million over nearly 15 years to develop a waste separation process, called in-tank precipitation, to treat Savannah River's high-level waste. While laboratory tests of this process were viewed as successful, DOE did not adequately test the components until it started full-scale operations. DOE followed this approach, in part, because the technology was commercially available and considered "mature." However, when DOE started full-scale operations, major problems occurred. Benzene, a dangerously flammable byproduct, was produced in large quantities. Operations were stopped after DOE spent about $500 million because experts could not explain how or why benzene was being produced and could not determine how to economically reconfigure the facility to minimize it. Consequences of this technology failure included significant cost increases, schedule delays, a full-scale waste separation process that did not work, and a less-than-optimum waste treatment operation. Savannah River is now developing and implementing a new separation technology at an additional cost of about $1.8 billion and a delay of about 7 years.[10]

Subsequent assessments of the problems that developed at Savannah River found that DOE (1) relied on laboratory-scale tests to demonstrate separation processes, (2) believed that technical problems could be resolved later during facility construction and startup, and (3) decided to scale up the technology from lab tests to full-scale without the benefit of using additional testing facilities to confirm that processes would work at a larger scale. Officials at Hanford are following a similar approach. Several experts with whom we talked cautioned that if separation processes at Hanford do not work as planned, facilities will have to be retrofitted, and potential cost increases and schedule delays would be much greater than any associated with integrated process testing in a pilot facility.

Opportunities Exist to Explore Additional Cost Savings and to Strengthen Program Management

In addition to the potential cost savings identified in the accelerated site cleanup plans, DOE continues to develop and evaluate other proposals to reduce costs but is still assessing them. Although the potential cost savings have not been fully developed, they could be in the range of several billion dollars, if the proposals are successfully implemented. At the Savannah River and Hanford sites, for example, DOE is identifying ways to increase the amount of waste that can be placed in its high-level waste canisters to reduce treatment and disposal costs. DOE also has a number of initiatives under way to improve overall program management. However, we are concerned that the initiatives may not be adequate. In our examinations of problems that have plagued DOE's project management over the years, three contributing factors often emerged—making key project decisions without rigorous analysis, incorporating new technology before it has received sufficient testing, and using a "fast-track" approach (concurrent design and construction) on complex projects.

[10]U.S. General Accounting Office, *Nuclear Waste: Process to Remove Radioactive Waste From Savannah River Tanks Fails to Work*, GAO/RCED-99-69 (Washington, D.C.: Apr. 30, 1999).

Ensuring that these weaknesses are addressed as part of its program management initiatives would further improve the management of the program and increase the chances for success.

DOE Is Considering Additional Potential Opportunities to Reduce Costs

DOE is continuing to identify other proposals for reducing costs under its accelerated cleanup initiative. Among the proposals that DOE is considering, the ones that appear to offer significant cost savings opportunities would increase the amount of waste placed in each disposal canister. The amount of waste that can be placed into a canister depends on a complex set of factors, including the specific mix of radioactive material combined with other chemicals in the waste, such as chromium and sulfate, that affect the processing and quality of the immobilized product. These factors affect the percentage of waste than can be placed in each canister because they indicate the likelihood that radioactive constituents could move out of the immobilizing glass medium and into the environment. The greater the potential for the waste to become mobile, the lower the allowable percentage of waste and the higher the percentage of glass material that must be used.

Savannah River officials believe they can increase the amount of waste loaded in each canister from 28 percent to about 35 percent, and for at least one waste batch, to nearly 50 percent. In June 2003, Savannah River began to implement this new process to increase the amount of waste in each canister. If successful, Savannah River's improved approach could reduce the number of canisters needed by about 1,000 canisters and save about $2.7 billion, based on preliminary estimates. Other efforts to increase waste loading of the canisters are also under way that, if successful, may permit further cost savings of about $1.7 billion. The Hanford Site is also exploring ways to decrease the numbers of waste canisters that will be needed by using waste forms other than the standard borosilicate glass. This effort is in a very early stage of development and cost-savings estimates have not been fully developed.

DOE Has Opportunities to Improve Management of the Program by Addressing Previously Identified Weaknesses

In addition to site-specific proposals for saving time and money, DOE is also undertaking management improvements using teams to study individual issues. Nine teams are currently in place, while other teams to address issues such as improving the environmental review process to better support decision making have not yet been formed. Each team has a disciplined management process to follow,[11] and even after the teams' work is completed, any implementation will take time. These efforts are in the early stages, and therefore it is unclear if they will correct the performance problems DOE and others have identified.

We are concerned that these management reforms may not go far enough in addressing performance problems with the high-level waste program. Our concerns stem from our review of initiatives under way in the management teams, our discussions with DOE officials, and our past and current work, as well as work by others inside and outside DOE. We have identified three recurring weaknesses in DOE's management of cleanup projects that we believe need to be addressed as part of DOE's overall review. These weaknesses cut across the various issues that the teams are working on and are often at the center of problems that have been identified. Two of these weaknesses have been raised earlier in this testimony—lack of rigor in the analysis supporting key decisions, and incorporating technology into projects before it is sufficiently mature. The final area of weakness involves using "fast-track" methods to begin construction of complex facilities before sufficient planning and design have taken place.

Key Decisions Not Always Supported by Rigorous Current Analysis

DOE's project management guidance emphasizes the importance of rigorous and current analysis to support decision making during the development of DOE projects. Similarly, OMB guidance states that agencies should validate earlier planning decisions with updated information before finalizing decisions to construct facilities. This validation is particularly important where early cost comparisons are susceptible to uncertainties and change.

DOE does not always follow this guidance, yet no DOE management team appears to be addressing this weakness. Proceeding without rigorous review has been a recurring cause of many of the problems we have

[11]Under DOE's project management principles, for example, teams must define project requirements, conduct preliminary risk assessments, and prepare a risk mitigation plan prior to developing a baseline cost estimate of proposed alternatives.

identified in past DOE projects. For example, the decision at Hanford to construct a vitrification plant to treat Hanford's low-activity waste has not been validated with updated information. Hanford's primary analysis justifying the cost of this approach was prepared in 1999 and was based on technical performance data, disposal assumptions, and cost data developed in the early to mid-1990s—conditions that are no longer applicable. Subsequent analyses have continued to rely on this data. However, since that time conditions have changed, including the performance capabilities of alternative technologies such as grout, the relative cost of different technologies, and the amount of waste DOE intends to process through a vitrification facility.

DOE officials disagree with our assessment of their analysis, stating that a comprehensive analysis was conducted in the spring of 2003. However, DOE's high-level waste project team agreed that the DOE officials at Hanford had not performed a current, rigorous analysis of low-activity waste treatment options including the use of grout as an alternative to vitrification, and the team encouraged the Hanford site to update its analysis based on current waste treatment and disposal assumptions. DOE officials at Hanford told us they do not plan to reassess the decision to construct a low-activity vitrification facility because their compliance agreement with the state of Washington calls for vitrification of this waste. They also stated that vitrification is a technology needed for destroying hazardous constituents in a portion of the waste.

New Technology Is Incorporated before It Is Sufficiently Mature

Our work on Department of Defense acquisitions has documented a set of "best practices" used by industry for integrating new technology into major projects. We reported in July 1999 that the maturity of a technology at the start of a project is an important determinant of success.[12] As technology develops from preconceptual design through preliminary design and testing, the maturity of the technology increases and the risks associated with incorporating that technology into a project decrease. Waiting until technology is well-developed and tested before integrating it into a project will greatly increase the chances of meeting cost, schedule, and technical baselines. On the other hand, integrating technology that is not fully mature into a project greatly increases the risk of cost increases and schedule delays. According to industry experts, correcting problems

[12]U.S. General Accounting Office, *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999).

after a project has begun can cost 10 times as much as resolving technology problems beforehand.

DOE's project management guidance issued in October 2000 is consistent with these best practices. The guidance discusses technology development and sets out suggested steps to ensure that new technology is brought to a sufficient level of maturity at each decision point in a project. For example, during the conceptual design phase of a project, "proof of concept" testing should be performed before approval to proceed to the preliminary design phase. Furthermore, the guidance states that attempting to concurrently develop the technology and design the facility for a project poses ill-defined risks to the project.

Nevertheless, as we discussed earlier, DOE sites continue to integrate immature technologies into their projects. For example, as discussed earlier, DOE is constructing a facility at the Hanford Site to separate high-level waste components, although integrated testing of the many steps in the separations process has not occurred and will not occur until after the facility is completed. DOE, trying to keep the project on schedule and within budget, has decided the risks associated with this approach are acceptable. However, there are many projects for which this approach created schedule delays and unexpected costs. The continued reliance on this approach in the face of so many past problems is a signal of an area that needs careful attention as DOE proceeds with its management reform efforts. At present, no DOE management team is addressing this issue.

Facility Construction Starts before Design Is Sufficiently Developed

Finally, we have concerns about DOE's practice of launching into construction of complex, one-of-a-kind facilities well before their final design is sufficiently developed, again in an effort to save time and money. Both DOE guidance and external reviews stress the importance of adequate upfront planning before beginning project construction. DOE's project management guidance identifies a series of well-defined steps before construction begins and suggests that complex projects with treatment processes that have never before been combined into a facility do not lend themselves to being expedited. However, DOE guidance does not explicitly prohibit a fast-track—or concurrent design and construction—approach to complex, one-of-a-kind projects, and DOE often follows this approach. For example, at the Hanford Site, DOE is concurrently designing and constructing facilities for the largest, most complex environmental cleanup job in the United States. Problems are already surfacing. Only 24 months after the contract was awarded, the project was 10 months behind schedule dates, construction activities have outpaced design work causing inefficient work sequencing, and DOE has withheld performance fee from the design/construction contractor because of these problems.

DOE experienced similar problems in concurrent design and construction activities on other waste treatment facilities. Both the spent nuclear fuel project at Hanford and the waste separations facility at the Savannah River Site encountered schedule delays and cost increases in part because the concurrent approach led to mistakes and rework, and required extra time and money to address the problems.[13] In its 2001 follow-up report on DOE project management, the National Research Council noted that inadequate pre-construction planning and definition of project scope led to cost and schedule overruns on DOE's cleanup projects.[14] The Council reported that research studies suggest that inadequate project definition accounts for 50 percent of the cost increases for environmental remediation projects. Again, no DOE team is specifically examining the "fast-track" approach, yet it frequently contributed to past problems and DOE continues to use this approach.

Conclusions

DOE's efforts to improve its high-level waste cleanup program and to rein in the uncontrolled growth in project costs and schedules are important and necessary. The accelerated cleanup initiative represents at least the hope of treating and disposing of the waste in a more economical and timely way, although the actual savings are unknown at this time. Furthermore, specific components of this initiative face key legal and technical challenges. Much of the potential for success rested on DOE's ability to dispose of large quantities of waste with relatively low concentrations of radioactivity on site by applying its incidental waste process. Recently, a court ruled that the portion of DOE's order setting out its incidental waste determination process violates the Nuclear Waste Policy Act and is invalid. Thus, DOE is precluded from implementing this element of its accelerated initiative. Success in accelerating cleanup also rests on DOE's ability to obtain successful technical performance from its

[13]For a discussion of the problems associated with the fast track design/build approach on these projects, see U.S. General Accounting Office, *Nuclear Waste: DOE's Hanford Spent Nuclear Fuel Storage Project—Cost, Schedule, and Management Issues*, GAO/RCED-99-267 (Washington, D.C.: Sept. 20, 1999) and *Nuclear Waste: Process to Remove Radioactive Waste From Savannah River Tanks Fails to Work*, GAO-RCED-99-69 (Washington, D.C.: Apr. 30, 1999).

[14]National Research Council, *Progress in Improving Project Management at the Department of Energy* (Washington, D.C.: Nov. 2001).

as-yet unproven waste separation processes. Any technical problems with these processes will likely result in costly delays. At DOE's Hanford Site, we believe the potential for such problems warrants reconsidering the need for more thorough testing of the processes, before completing construction of the full-scale waste separation facility.

DOE's accelerated cleanup initiative should mark the beginning, not the end, of DOE's efforts to identify other opportunities to improve the program by accomplishing the work more quickly, more effectively, or at less cost. As DOE continues to pursue other management improvements, it should reassess certain aspects of its current management approach, including the quality of the analysis underlying key decisions, the adequacy of its approach to incorporating new technologies into projects, and the merits of a fast-track approach to designing and building complex nuclear facilities. Although the challenges are great, the opportunities for program improvements are even greater. Therefore, DOE must continue its efforts to clean up its high-level waste while demonstrating tangible, measurable program improvements.

In the report being released today, we made several recommendations to help DOE manage or reduce the legal and technical risks faced by the program as well as to strengthen DOE's overall program management. DOE agreed to consider seeking clarification from Congress regarding its authority to define some waste as incidental to reprocessing, if the legal challenge to its authority significantly affected DOE's ability to achieve savings under the accelerated initiative. Regarding our recommendations to conduct integrated pilot-scale testing of the separations facility at Hanford before construction is completed, and to make other management improvements to address the weaknesses I just discussed, DOE's position is that it has already taken appropriate steps to manage the technology risks and strengthen its management practices. We disagree and believe that implementing all of our recommendations would help reduce the risk of costly delays and improve overall management of DOE's entire high-level waste program.

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Thank you, Mr. Chairman and Members of the Subcommittee. That concludes my testimony. I would be pleased to respond to any questions that you may have.

Contacts and Acknowledgements

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