United States Government Accountability Office

GAO

Report to the Subcommittee on Energy and Water Development, Committee on Appropriations, House of Representatives

June 2008

NUCLEAR WASTE

DOE Lacks Critical Information Needed to Assess Its Tank Management Strategy at Hanford

GAO

Accountability * Integrity * Reliability

GAO-08-793

GAO

Accountability • Integrity • Reliability

Highlights

Highlights of GAO-08-793, a report to the Subcommittee on Energy and Water Development, Committee on Appropriations, House of Representatives

June 2008

NUCLEAR WASTE

DOE Lacks Critical Information Needed to Assess Its Tank Management Strategy at Hanford

Why GAO Did This Study

The Department of Energy (DOE) manages more than 56 million gallons of radioactive and hazardous waste stored in 149 single-shell and 28 double-shell underground tanks at its Hanford Site in Washington State. Many of these aging tanks have already leaked waste into the soil. Meanwhile, DOE's planned process for emptying the tanks and treating the waste—mixing it with molten glass and solidifying it in canisters for storage—has experienced delays, lengthening the time the tanks will store waste and intensifying concerns about the tanks' viability during a long cleanup process.

This report addresses (1) the condition, contents, and long-term viability of Hanford's underground tanks; (2) DOE's strategy for managing the tanks; and (3) the extent to which DOE has weighed the risks and benefits of its tank management strategy against the growing costs of that strategy. GAO analyzed numerous studies and reports on the tanks and interviewed DOE officials and other experts on relevant issues.

What GAO Recommends

GAO recommends that DOE (1) give priority to assessing single-shell tank integrity, (2) quantify specific risks in light of continued tank use, and (3) work with state and federal agencies on realistic cleanup milestones. DOE disagreed with GAO's conclusions and viewed the recommendations as consistent with its present and planned activities.

To view the full product, including the scope and methodology, click on GAO-08-793. For more information, contact Gene Aloise at (202) 512-3841 or aloisee@gao.gov.

What GAO Found

DOE lacks comprehensive information about the condition, contents, and long-term viability of Hanford's waste tanks. Although recent work indicates that the newer, double-shell tanks are generally sound structurally, the condition of the older, single-shell tanks is less certain. All the tanks contain a complex mix of radioactive elements and chemicals, making the proportions of constituents in any tank uncertain and emptying the tanks technically challenging. DOE officials acknowledged the lack of information about the condition of the single-shell tanks and are in early stages of a study to assess these tanks' structural integrity. The uncertainties over tank condition, especially as the time frames for emptying tanks are extended and the tanks age, raise serious questions about the tanks' long-term viability.

DOE's tank management strategy involves continuing to use Hanford's aging tanks to store waste until they can be emptied, the waste treated, and the tanks closed. As work proceeds, however, DOE's time frames for completion are lengthening by decades, and the agency appears to be operating under more than one schedule. For example, DOE's internal milestone for emptying single-shell tanks is 19 years later than the date agreed to with its regulators. Although DOE and its regulators have been discussing new tank waste management milestones, as of June 2008, no decisions had been reached. Moreover, DOE's tank management strategy relies on assumptions that may be overly optimistic, such as assuming that emptying single-shell tanks will proceed significantly faster than it has to date.

DOE lacks comprehensive risk information needed to weigh the benefits of pursuing its tank waste removal and closure strategy against growing costs. In particular, DOE has not assessed the risks posed by continuing to store waste in the aging tanks until the waste is removed and cannot demonstrate that benefits are commensurate with the costs of its tank management strategy. DOE is nevertheless moving forward with negotiating new tank waste milestones with its regulators.

Double-Shell Tank Farm under Construction at Hanford

Source: DOE.

Contents

Abbreviations

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	Department of Energy
EPA	Environmental Protection Agency
RCRA	Resource Conservation and Recovery Act

United States Government Accountability Office
Washington, DC 20548

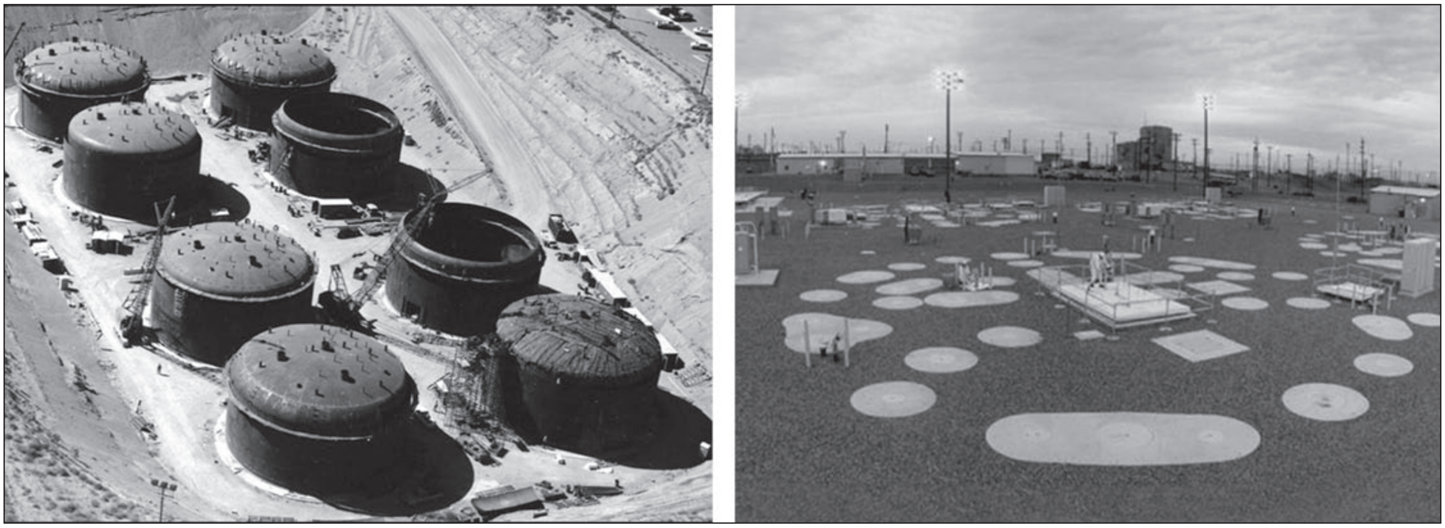
June 30, 2008

The Honorable Peter J. Visclosky
Chairman
The Honorable David L. Hobson
Ranking Member
Subcommittee on Energy and Water Development
Committee on Appropriations
House of Representatives

The Department of Energy (DOE) is responsible for one of the world's largest environmental cleanup programs—the treatment and disposal of wastes created by the production of materials for nuclear weapons. From 1943 to 1989, DOE and its predecessor agencies[1] produced nuclear materials at the Hanford Site, which lies along the Columbia River in southeastern Washington State. The site occupies 586 square miles upriver from the cities of Richland, Pasco, and Kennewick, whose combined population exceeds 200,000 people. Four decades of nuclear weapons production have left a legacy of chemical, hazardous, and radioactive waste, making Hanford one of the most contaminated places on Earth. During production, some of the waste was deposited directly into the soil; some was encased in drums or other containers and buried; and some was stored in 177 large, underground tanks. All told, these tanks, clustered together in 18 locations called tank farms, store more than 56 million gallons of waste—enough to cover an entire football field to a depth of over 150 feet, or the height of a 15-story building (see fig. 1).

[1]DOE has managed the Hanford Site since 1977. Before then, the site was managed by the U.S. Army Corps of Engineers (1943–47), the Atomic Energy Commission (1947–75), and the Energy Research and Development Administration (1975–77).

Figure 1: Double-Shell Waste Tanks under Construction and Completed Tank Farm at DOE's Hanford Site



Source: DOE.

Since plutonium production ended at Hanford in the late 1980s, DOE has established an approach for stabilizing, treating, and disposing of the site's tank waste. Its planned cleanup process involves removing, or retrieving, waste from the tanks; treating the waste on site; and ultimately disposing of the lower-radioactive waste on site and sending the highly radioactive waste to a geologic repository for disposal. As cleanup has unfolded, however, the schedule has slipped, and the costs have mounted. According to DOE's latest estimate, treatment of the waste is not expected to begin until late 2019 and could continue until 2050 or longer.[2] Meanwhile, 67 of Hanford's tanks are confirmed or presumed to have already leaked about 1 million gallons of waste into the ground,[3] and as a result, experts, including representatives from the National Academy of Sciences, have expressed concern about the integrity and usability of the tanks during what is likely to be a long treatment process.

[2]We have reported several times on progress at Hanford's waste treatment plant. The most recent of these reports is GAO, *Hanford Waste Treatment Plant: Contractor and DOE Management Problems Have Led to Higher Costs, Construction Delays, and Safety Concerns*, GAO-06-602T (Washington, D.C.: Apr. 6, 2006). See "Related GAO Products" at the end of this report.

[3]Some documents we reviewed indicate that 1 million or more gallons have leaked from these tanks. DOE's estimate ranges from about 500,000 to 1 million gallons.

Cleanup, treatment, and disposal of waste produced at DOE facilities are governed by a number of federal laws and implemented under the leadership of the Assistant Secretary for Environmental Management. DOE is to conduct its cleanup activities in accordance with a number of federal and state environmental laws, primarily the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, and the Resource Conservation and Recovery Act of 1976 (RCRA), as amended. In addition, most of the cleanup activities at Hanford, including emptying of the underground tanks, are carried out under the Hanford Federal Facility Agreement and Consent Order among DOE, Washington State's Department of Ecology (Ecology), and the federal Environmental Protection Agency (EPA). Commonly called the Tri-Party Agreement, this accord was signed in May 1989 and has been amended a number of times since then. The agreement lays out legally binding milestones for completing the major steps of Hanford's waste treatment and cleanup process. A variety of local and regional stakeholders, including county and local governmental agencies, citizen and advisory groups, and Native American tribes, also have long-standing interests in Hanford cleanup issues. Like nearly all of DOE's missions, work at Hanford is performed by private firms under contract to DOE.

In this context, this report addresses (1) the condition, contents, and long-term viability of Hanford's underground tanks; (2) DOE's strategy for managing the tanks and the waste they contain; and (3) the extent to which DOE has weighed the risks and benefits of its tank management strategy against the growing costs of that strategy.

To address these objectives, we gathered and reviewed information on the tanks and their contents, and we interviewed DOE and contractor officials and outside experts. Specifically, we reviewed available documentation on the condition of the tanks, including their expected life span (which engineers call design life), age, structural integrity, and contents. We reviewed DOE's strategy for managing and monitoring the tanks' contents, as well as regulatory requirements and milestones governing tanks. In addition, we reviewed a 2007 DOE tank waste management plan to identify potential problems facing Hanford's aging tanks and the possible effects of such problems on DOE's strategy for dealing effectively with the tanks. We examined risk studies and technical reviews to identify the challenges DOE faces in managing Hanford's underground tanks. We also determined the extent to which costs and risks to workers, public health, and the environment that are associated with DOE's tank management strategy have been quantified. We discussed our findings with, and obtained the views of, DOE and contractor officials responsible for the tank farms and with representatives of federal and state environmental agencies, as well as with outside experts. Appendix I describes our scope and methodology in more detail. We conducted this performance audit from July 2007 through June 2008 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.

Results in Brief

DOE and its contractors lack comprehensive information about the condition, contents, and long-term viability of Hanford's aging underground waste tanks. While recent studies indicate that the newer, double-shell tanks are generally sound structurally, the condition of the older, single-shell tanks—nearly half of which are confirmed or presumed to have already leaked—is much less certain. The double-shell tanks were designed to allow workers to "see" between the inner and outer shells, monitor tank condition, and find leaks; in contrast, the single-shell tanks were constructed in such a way that visibility of and access to the deepest portions of the tanks are obstructed when waste is present, and monitoring is therefore difficult. DOE tank management officials acknowledged the lack of information about the overall condition of the single-shell tanks and are in early stages of a study to determine the tanks' structural integrity. To ascertain the tanks' contents, DOE has sampled and analyzed the waste and believes it has identified the major waste constituents, which include highly radioactive or very long-lived radioactive elements, hazardous chemicals, and some discarded equipment. All the tanks contain a complex variety of radioactive elements and chemicals that have been extensively mixed and commingled over the years. As a result, the contents of each tank are unique, and DOE and its contractors are uncertain of the specific proportions of constituents in any tank, uncertainty that may exacerbate the technical challenges of retrieving the waste. The lingering uncertainties over tank condition and contents, combined with the tanks' advancing age—many of the tanks have already exceeded their expected design life—raise serious questions about the tanks' long-term viability.

DOE's tank management strategy involves continuing to use Hanford's tanks to store waste until the waste is removed and disposed of and the tanks are permanently closed, a period measured in decades. Specifically, the strategy entails gradually emptying waste from the single-shell tanks into the double-shell tanks and continuing to use selected double-shell tanks to store waste until it can be treated and the tanks closed. While DOE's overall tank management approach has remained unchanged for nearly 2 decades, the department has been lengthening its implementation time frames and appears to be operating according to more than one schedule. For example, because of delays in beginning waste treatment, DOE's internal milestone for emptying single-shell tanks is 19 years later than the date agreed to with its regulators. Although DOE and its regulators are discussing new tank management milestones, as of June 2008 no decisions had been reached. Meanwhile, only 7 of the 177 tanks have been emptied, and none of the waste has been treated. Moreover, DOE is basing its tank management strategy on assumptions that may be overly optimistic. For example, the department assumes that the tanks will remain viable throughout what has become a protracted waste treatment process. It also assumes that emptying single-shell tanks will proceed significantly faster than it has to date.

DOE lacks comprehensive risk information critical for weighing the benefits of pursuing its tank management strategy against growing costs. Although DOE has conducted some studies that assessed potential health and environmental risks posed by the waste, the department has not evaluated the risks posed by continuing to store waste in aging tanks. In addition to planning a study of the single-shell tanks' structural integrity, DOE is preparing an environmental impact statement of tank closure, which is expected to address some tank waste risks. This study will not, however, be completed until 2009, and the extent to which it will weigh the benefits against costs is uncertain. Without such an analysis, DOE cannot demonstrate that benefits are commensurate with the costs of its tank management strategy, which have grown significantly. DOE is nevertheless moving forward with negotiating new tank waste milestones.

We are recommending that DOE give priority to carrying out the department's assessment of the structural integrity of Hanford's single-shell tanks—in early planning stages as of 2008—and ensure that this assessment includes examining key attributes such as the corrosion of the tanks' inner steel shells. We are also recommending that on a routine basis, such as every 3 to 5 years, DOE quantify the risks posed by the tank waste and by DOE's tank management strategy in light of the tanks' uncertain viability and that, using this information, DOE work with Ecology and EPA to reassess its tank management strategy and develop and agree to realistic schedule and cost milestones.

We provided a draft of this report to the Secretary of Energy for review and comment. In a written response, the department stated it does not agree that it lacks the necessary information to make informed decisions regarding tank integrity, waste retrieval, and treatment. DOE also stated it believes that it has adequate knowledge to make decisions and cited work performed by the Defense Nuclear Facilities Safety Board in 1993 and the National Academy of Sciences in 2006 as support that it had conducted extensive characterization of tank contents and resolved safety issues. However, neither of these efforts addressed the extent to which the aging single-shell waste tanks—about half of which are confirmed or presumed to have leaked—will remain viable during a treatment schedule that may be extended by decades. While DOE has made some progress in gathering data about the condition of the tanks and their general contents, DOE still has limited information about the actual condition of the single-shell tanks and their long-term viability. Moreover, DOE is in the early planning stages of a study to assess single-shell tank integrity, which represents the department's own acknowledgment of the need for more information. In our view, the department's current knowledge is not adequate to assess the appropriateness of its management strategy, which involves continuing to store waste in these tanks under lengthening time frames. Although DOE stated that our recommendations are consistent with its present and planned tank management activities in tank integrity, risk management, and regulatory negotiations, we are not convinced. We continue to believe that the evidence in this report shows the need for our recommendations and that, without action on each one, DOE can not ensure that its tank management strategy is appropriate in light of its lengthening treatment schedules and escalating costs. DOE also provided technical comments, which we incorporated throughout the report as appropriate.

Background

Established in 1943, the Hanford Site produced the plutonium used in developing the world's first nuclear device. At the time, little attention was given to the resulting by-products—massive amounts of radioactive and chemically hazardous waste.[4] From 1944 through 1988, about 525 million gallons of radioactive tank waste was generated by Hanford's plutonium-processing plants.[5] The federal government initially managed this waste by building underground tanks to store it until it could be treated and

[4]Hanford's tanks contain mixed waste, which consists of both radioactive components, as defined by the Low Level Radioactive Waste Policy Act and the Nuclear Waste Policy Act, and hazardous components, as defined by RCRA, as amended, respectively.

[5]Roy E. Gephart, *Hanford: A Conversation about Nuclear Waste and Cleanup* (Columbus, Ohio: Battelle Press, 2003).

permanently disposed of; intentionally discharging it into the ground;[6] and reducing its volume through various waste concentration methods,[7] such as evaporating off the liquids.

From the 1940s through the mid-1960s, 149 storage tanks were built at Hanford. Originally designed to last 10 to 20 years until a permanent disposal solution could be found, each of these tanks consisted of an outer concrete wall lined with one layer of carbon steel. Clustered into 12 tank farms[8] and buried some 6 to 11 feet beneath the surface, most of these single-shell tanks measure roughly 75 feet in diameter, range from 30 to 49 feet high, and have a capacity between 530,000 gallons and 1 million gallons of waste.[9] Together, the single-shell tanks contain almost 30 million gallons of waste; about 27 million gallons are in solid or semisolid form, and about 3 million gallons are liquid. As early as 1948, concerns arose about the use and viability of these tanks over the long term. By 1961, leakage of waste from one single-shell tank into the underlying soil was confirmed. Later, by the mid-1990s, 67 of the single-shell tanks had leaked or were presumed to have leaked about 1 million gallons of waste into the soil. To address concerns with the design of the single-shell tanks, a new tank design with two carbon-steel shells was adopted in the late 1960s. From 1968 through 1986, 28 of these double-shell tanks, each with storage capacities of 1 million gallons or more (see fig. 2), were built and sited in 6 more tank farms at Hanford; together, these double-shell tanks contain about 27 million gallons of waste.

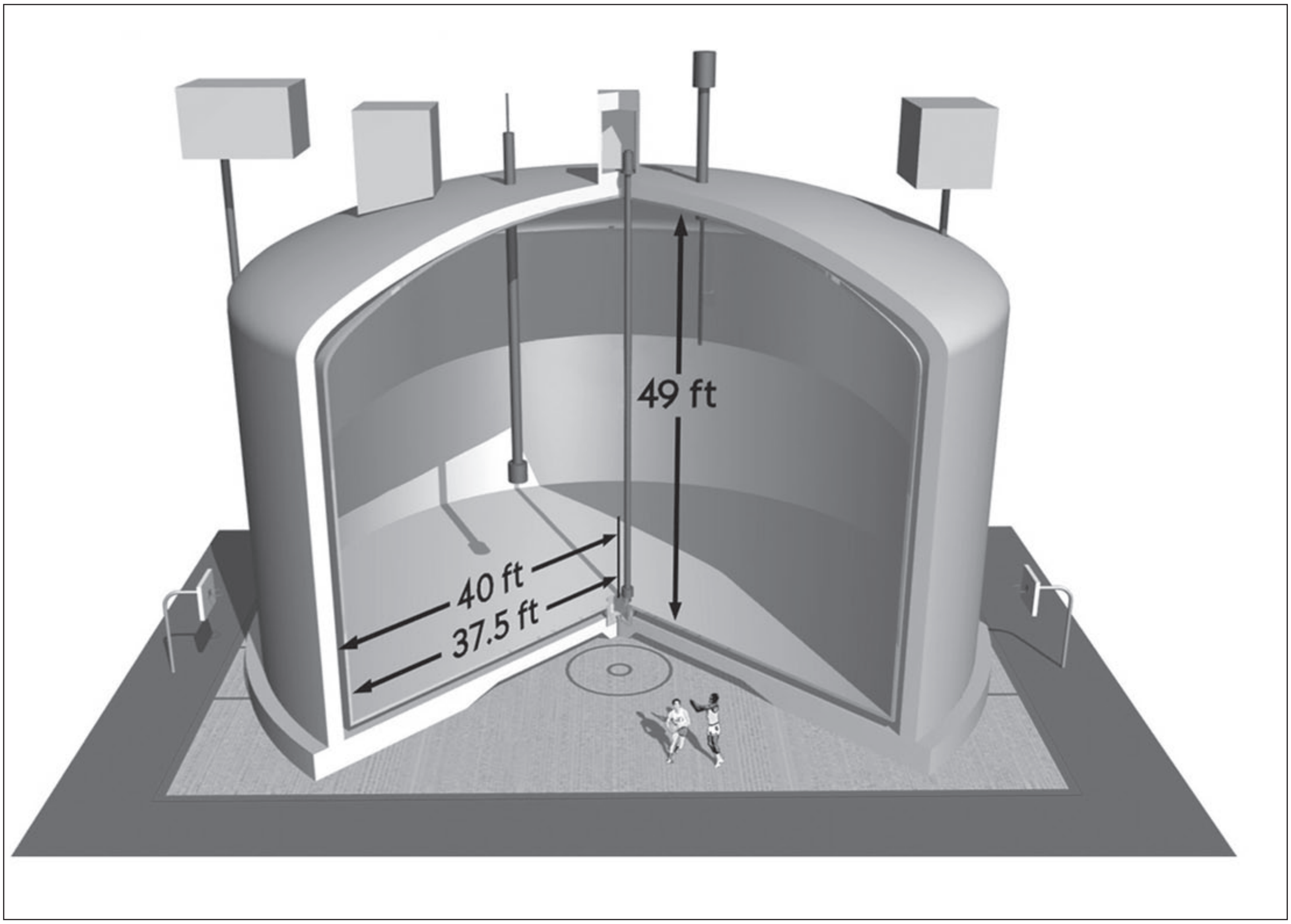
[6]DOE documents indicate that from 1946 to 1966, the agency intentionally discharged about 121 million gallons of radioactive liquid tank waste directly into the ground at Hanford.

[7]One such waste concentration method involved extracting cesium and strontium from the tanks to reduce the heat the waste generated. These highly radioactive elements were concentrated and placed in about 2,000 small stainless-steel canisters, which are currently stored in a secure on-site facility. This concentrated material is not part of Hanford's tank waste cleanup project.

[8]At Hanford, a group of 2 to 18 tanks buried side by side in the ground constitutes a tank farm. Besides the tanks themselves, tank farms also contain equipment such as lines and pumps for transferring waste between tanks, equipment for monitoring heat and chemical reactions inside the tanks, instruments to measure temperature and tank waste levels, and other support facilities.

[9]Sixteen of Hanford's original 149 tanks are much smaller, with a storage capacity of 55,000 gallons.

Figure 2: Dimensions and Relative Size of a Hanford Double-Shell Waste Storage Tank



Source: DOE.

Note: All of Hanford's double-shell tanks have a capacity of 1 million gallons or more.

In the late 1980s, DOE stopped producing nuclear materials and shifted its mission to treating and disposing of the decades of accumulated nuclear waste. At Hanford, DOE's planned cleanup process entails retrieving waste from the tanks;[10] mixing this waste with molten glass through a process known as vitrification; and pouring the waste into steel canisters, where it will cool and solidify. As part of this process, DOE has been constructing the Hanford Waste Treatment and Immobilization Plant, a large complex including waste-processing facilities; an analytical laboratory; and more than 20 smaller, supporting facilities to treat and package the waste. The waste treatment plant is designed to separate tank waste into high- and low-radioactivity portions, often referred to as high-level and low-activity waste, respectively. The high-level fraction (which amounts to less than 10 percent of the total waste volume) is to be stabilized at the Hanford Site and then sent to a geologic repository for permanent disposal. DOE plans to stabilize the low-radioactivity fraction (more than 90 percent of the total waste volume) and dispose of it permanently in an on-site facility.

Over the years, the waste contained in these tanks has settled; today it exists in four main forms or layers:

- *Vapor:* Gases produced from chemical reactions and radioactive decay occupy tank space above the waste.
- *Liquid:* Fluids (supernatant) may float above a layer of settled solids or under a floating layer of crust; fluids may also seep into pore spaces or cavities of settled solids, crust, or sludge.
- *Saltcake:* Water-soluble compounds, such as sodium salts, can crystallize or solidify out of wastes to form a moist saltlike or crusty material.
- *Sludge:* Denser, water-insoluble or solid components generally settle to the bottom of a tank to form a thick layer having the consistency of peanut butter.

To carry out its missions, DOE relies almost entirely on private firms under contract with the department. Accordingly, DOE manages Hanford's tanks and tank waste through two main contracts: a tank farm operations contract with CH2M Hill Hanford Group Inc., which employs about 1,100

[10]Hanford's waste tanks were not designed with specific waste retrieval features. Waste must be retrieved through openings, called risers, in the top of the tanks. For example, technicians must insert specially designed pumps into the tanks to pump the waste up about 45 to 60 feet to ground level. Removing waste from the tanks that have already leaked without releasing still more material into the soil also poses a challenge, which DOE is trying to address with new retrieval technologies.

workers, to store the waste safely and prepare it for retrieval from the tanks[11] and a construction contract with Bechtel National Inc., which employs approximately 3,500 workers, to design, construct, and commission the waste treatment plant. DOE oversees these contractors through its Office of River Protection, which was established in 1998 as required by Congress. As of May 2008, the office had a staff of 108 DOE employees and a fiscal year 2008 budget of about $1 billion.

Uncertainties Raise Questions about Tanks' Long-Term Viability

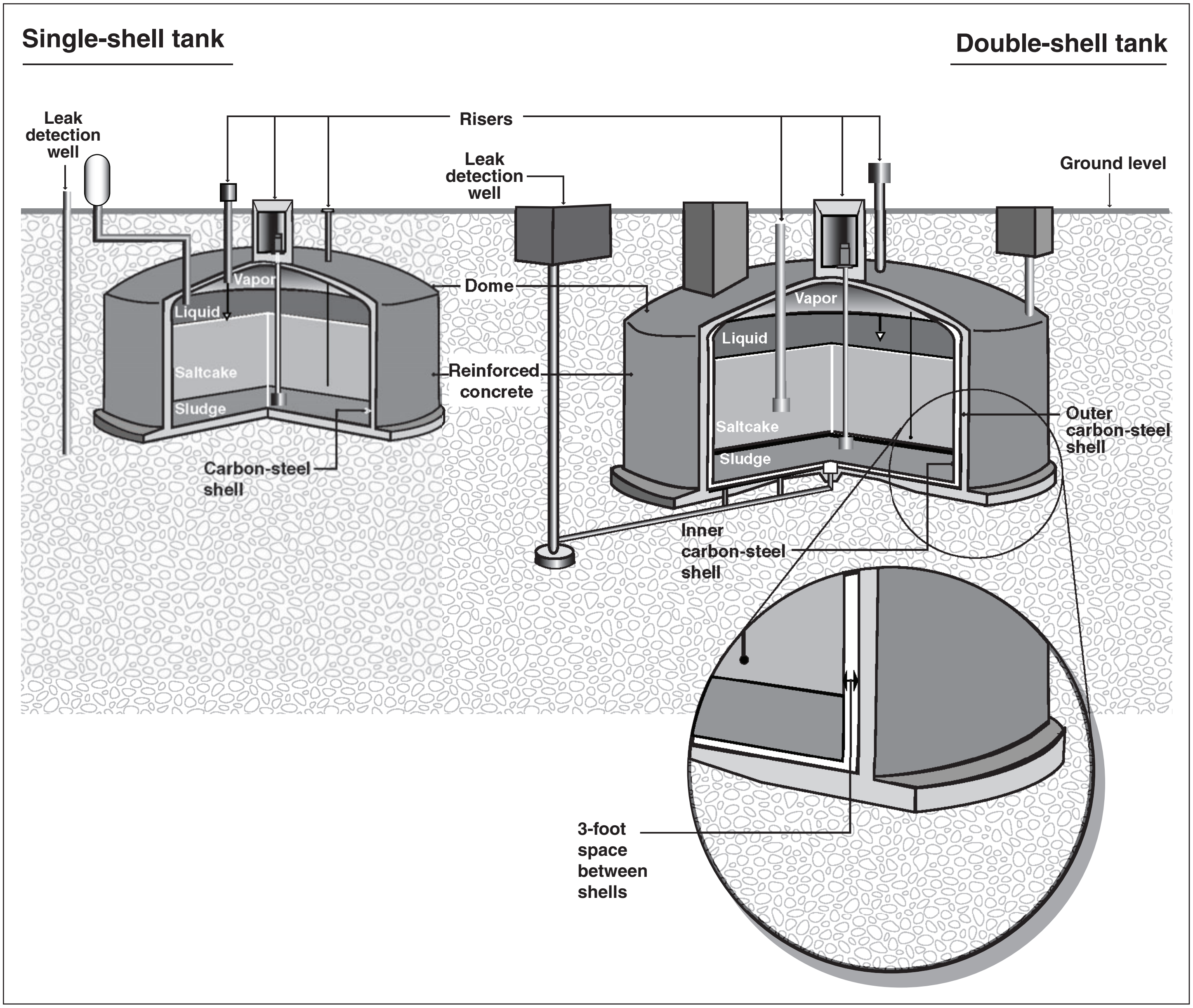
Neither DOE nor its contractors have comprehensive information about the overall integrity or contents of Hanford's underground waste tanks; as a result, they cannot predict the tanks' long-term viability with any degree of certainty. Although recent studies indicate that the newer, double-shell tanks are generally sound, the integrity of many single-shell tanks has been compromised in the past, and the condition of the rest is difficult to ascertain. Further, although DOE has identified the major waste constituents in the tanks, the specific proportions of the constituents contained in individual tanks remain uncertain, as does their combined effect, if any, on the tanks' integrity. The only certainty is that the tanks are aging, and at DOE's present rate of progress, all will have exceeded their design life—many significantly—by the time the tanks are finally emptied and closed.

[11]On July 1, 2008, this contract will transition to a new contractor—Washington River Protection Solutions LLC—and on October 1, 2008, the new contractor will assume responsibility for the tank waste mission until September 2013.

Integrity of Double-Shell Tanks Is Considered Sound, but Condition of Single-Shell Tanks Is Difficult to Ascertain

The primary design difference between Hanford's single- and double-shell underground waste storage tanks—a second carbon-steel lining, or shell, within the outer concrete housing to provide secondary containment of the waste (see fig. 3)—has improved DOE's ability to monitor and assess the tanks' integrity and contents. The two shells in the double-shell tanks are separated by about 3 feet of space, which enables workers to use remote leak detection sensors and remotely operated cameras to "see" between the inner and outer shells, thereby making it possible to find signs of corrosion or leaks before waste breaches the outer shell and leaches outside the tank structure. Using remote cameras, ultrasonic equipment, and structural analyses, DOE examines about three to five tanks each year and to date has found no evidence of leakage from the double-shell tanks or of degradation that could lead to leakage during approximately the next 10 years.

Figure 3: Hanford Waste Storage Tanks with Ancillary Parts



Sources:GAO and DOE.

In contrast, the condition of single-shell tanks is much harder to ascertain. Although DOE knows that about half the single-shell tanks are confirmed or presumed to have leaked, indicating some kind of liner failure, it has limited means to assess the leak integrity of the remaining single-shell tanks. DOE uses three primary methods to monitor waste and determine if leaks have occurred, although each of these methods has limitations.

- First, DOE periodically compares waste levels in each tank with prior waste records to detect major fluctuations in waste level, which may have been caused by leaks. This method has limitations because in many tanks, especially those with single shells, thick layers of waste can obscure the liquid sandwiched between them. To monitor liquid levels, DOE has placed liquid observation devices that extend below the layers of waste in about half of the single-shell tanks. Nevertheless, it is difficult, and in some cases nearly impossible, to determine if the waste level in a tank has changed. In tanks with liquid trapped between layers of waste, even if the overall waste level does not appear to have changed, liquid waste could still have leaked out.

- Second, DOE can monitor the waste in a tank using a remotely operated camera lowered into the tank's interior. The camera can be used only in the space above the waste, however, because the waste obscures the rest of the tank from the camera's view (see fig. 4). Although this method is useful for monitoring certain conditions, it is not effective for detecting tank leaks, which do not produce a visible change or a visible loss of liquid, because only a breach of the steel lining covered by or adjacent to the waste would cause a leak.

- Third, to help address these in-tank monitoring limitations, DOE has built numerous wells around the tanks, which contain monitoring equipment for detecting leaks. Even so, because many of the single-shell tanks have already leaked waste into the soil, detecting further leaks can be difficult, depending on the location of the leak relative to the monitoring well and the waste's radioactivity. DOE tank waste management and Ecology officials told us that unless significant quantities of waste—4,000 gallons or more—leaked near one of the wells, they would be unlikely to detect it.

Figure 4: Waste Inside a Single-Shell Tank at Hanford

Source: DOE.

DOE tank management officials acknowledge that the integrity of the single-shell tanks is a continuing uncertainty—with potentially significant effects on DOE's tank management strategy—and have taken steps, such as limited examination of the tanks' external structure and in-tank observations and analysis, to learn more about the condition of the single-shell tanks. In 2002, DOE attempted to assess the condition of the single-shell tanks to ensure that the tanks would not experience a catastrophic structural failure before tank waste cleanup activities were completed.[12] Using photographs, video cameras, and leak-monitoring results, DOE studied the structural characteristics of the reinforced concrete exterior; the condition of the tanks' concrete tops, or domes; and the visible portion

[12]CH2M Hill Hanford Group, *Single-Shell Tank System Integrity Assessment Report*, RPP-10435 (Richland, Washington, June 2002).

of the tank shells' interior. The waste in the tanks, and the tanks' location several feet below ground level, however, prevented DOE from studying the concrete exterior of most of the tanks or the bottom and concrete foundation of any of the tanks. Despite these limitations and the fact that many tanks had already leaked, the study concluded that the single-shell tanks' overall structural integrity was sound and that the tanks were structurally adequate for continuing to store the waste.

The department lacks conclusive information about the emptied tanks' condition, which might offer insights into the condition of other single-shell tanks that have yet to be emptied. DOE has used surveillance cameras to make limited observations of the seven single-shell tanks that have been emptied; DOE has not, however, thoroughly examined any of the seven emptied tanks. From the surveillance camera views, DOE tank management officials told us that the inner shells in these tanks, including the four tanks that leaked waste in the 1980s, show signs of corrosion, but despite long-term immersion in waste, the tanks' sides and bottoms generally appeared in good condition. Still, these officials acknowledged that such surveillance work cannot reveal a complete picture of the tanks' integrity because small corrosion leaks are very difficult, if not impossible, to detect with a surveillance camera; these preliminary observations are thus inconclusive at best. Further, although DOE completed waste retrieval from the first tank in 2003, it has yet to perform a comprehensive study of this tank's interior. DOE officials told us that they were in early stages of planning to further study the single-shell tanks. According to the manager of Hanford's River Protection office, this study is expected to take several years to complete. DOE plans to spend about $800,000 in fiscal year 2008 to plan how to proceed with the study and has projected expenditures of about $2.5 million for fiscal year 2009 to begin it.

DOE Knows the General Composition of Hanford's Tank Waste but Not the Specific Constituents in Each Tank

DOE believes that it has an adequate understanding of the tank waste's general composition but acknowledges it has limited information on the specific proportions of constituents in each tank. Routine sampling and analysis over more than 2 decades[13] show that the tanks contain millions of gallons of highly radioactive or long-lived radioactive materials; tons of hazardous chemicals; and a variety of miscellaneous materials, such as discarded equipment.

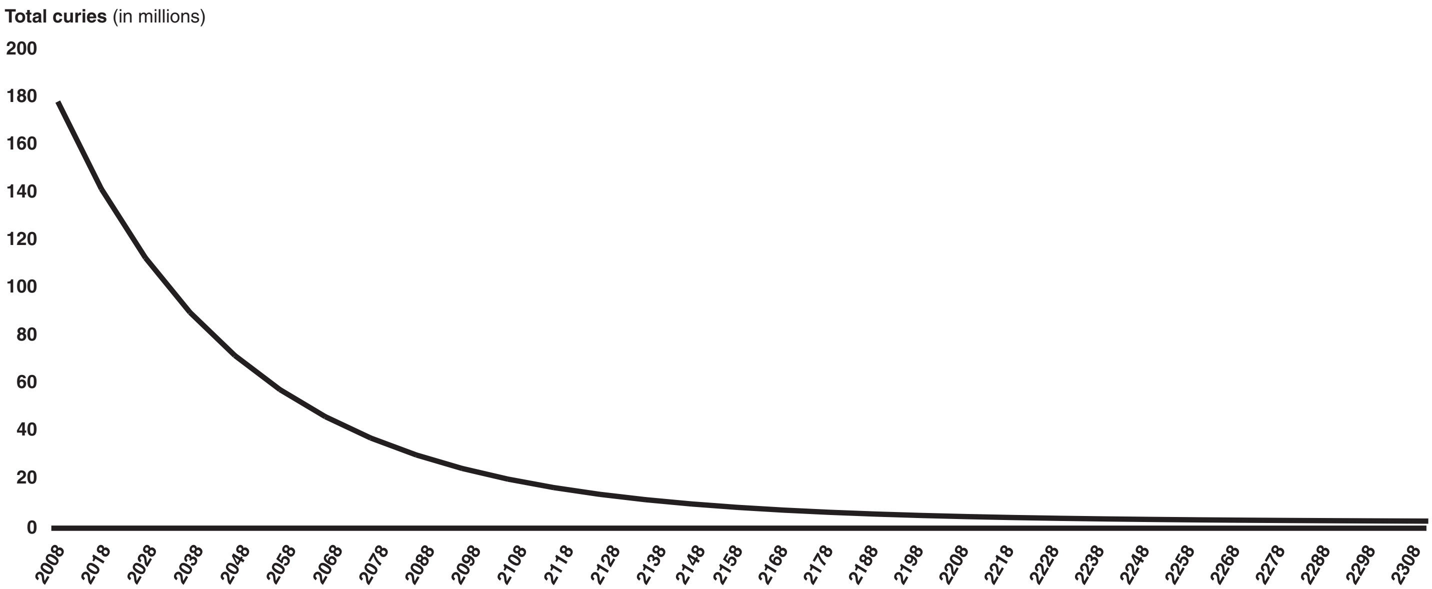
About 46 different radioactive elements—by-products of chemically separating plutonium from uranium during weapons production—represent the majority of the radioactivity currently residing in the tanks. Some of these elements lose most of their radioactivity in relatively short periods of time, while others remain radioactive for millions of years. The rate of radioactive decay is measured in half-lives, that is, the time required for half the atoms in a radioactive substance to disintegrate, or decay, and release their radiation. The half-lives of major radioactive tank constituents differ widely. The vast majority (98 percent) of the tank waste's radioactivity comes from two elements, strontium-90 and cesium-137, which have half-lives of about 29 and 30 years, respectively. The remaining radioactive elements, which account for about 2 percent of the waste's total radioactivity, have much longer half-lives. For example, the half-life of technetium-99 is 213,000 years, and that of iodine-129 is 15.7 million years.

Although some of the tanks once contained radioactive materials "hot" enough that the tanks self-boiled—that is, the temperature resulting from the radioactive decay reached 280 to 320 degrees Fahrenheit and stayed high for a decade or more—the waste's overall radioactivity is decaying over time (see fig. 5), thus lowering the risk of exposure to radioactivity for humans and the environment. As we reported in 2003 on the basis of radioactive levels measured as of August 2002, within 100 years, more than

[13]Schedule milestones for characterizing Hanford's tank waste were required under the Tri-Party Agreement beginning in 1989 and under a recommendation by the Defense Nuclear Facilities Safety Board in 1994. For more information about DOE's sampling and analysis activities, see GAO, *Nuclear Waste: Problems and Delays with Characterizing Hanford's Single-Shell Tank Waste*, GAO/RCED-91-118 (Washington, D.C.: Apr. 23, 1991), and GAO, *Nuclear Waste: Management and Technical Problems Continue to Delay Characterizing Hanford's Tank Waste*, GAO/RCED-96-56 (Washington, D.C.: Jan. 26, 1996).

90 percent of the radioactivity in the tanks will have dissipated, and within 300 years, 99.8 percent will disappear.[14]

Figure 5: Declining Radioactivity in Tank Waste at the Hanford Site, 2008 to 2308



Source: GAO and DOE.

Note: A curie is a measure of radioactivity equivalent to 37 billion atomic disintegrations per second.

The tanks also contain large volumes of hazardous chemical waste, including various metal hydroxides, oxides, and carbonates. Similar to the radioactive by-products of plutonium production, some of these chemicals—including acids, caustic sodas, solvents, and toxic heavy metals such as chromium—came from chemically reprocessing spent nuclear fuel to extract weapons-grade plutonium. A 1997 tank waste characterization study stated that "Hanford waste tanks are, in effect, slow chemical reactors in which an unknown but large number of chemical and radiochemical reactions are running simultaneously."[15] Altogether, DOE added about 240,000 tons of chemicals to the tanks from the 1940s to the

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

[15]Pacific Northwest National Laboratory, *A Risk-Based Focused Decision-Management Approach for Justifying Characterization of Hanford Tank Waste*, PNNL-11231, rev. 2 (Richland, Washington, April 1997).

mid-1980s. A majority of the chemicals (caustics, such as sodium hydroxide) were added to neutralize toxic reprocessing acids in the waste; other chemicals, such as solvents, ferrocyanide, and several organic compounds, were added during various waste extraction operations to help recover selected radioactive elements (uranium, cesium, and strontium) for reuse. These hazardous chemicals are dangerous to human health, and they can remain dangerous for thousands of years.

Finally, the tanks contain a variety of miscellaneous material, such as discarded equipment, cement to soak up liquids, casks of experimental fuel elements, and plastic bottles containing plutonium and uranium. These items were placed in the tanks during operations or in some cases, intentionally discarded. Although these items may not add significantly to the danger of materials already in the tanks, they may further complicate waste retrieval activities.

Beyond the general characterization of tank wastes, DOE lacks knowledge of the specific proportions of constituents in each tank. The radioactive elements, chemicals, and miscellaneous materials have been extensively mixed and commingled over the years. Wastes were mixed as they initially went into the tanks and were transferred extensively between tanks. Such waste transfers compounded existing uncertainties about waste composition because of the department's poor record keeping, which, as we reported in 1991 and again in 1996, was incomplete and often inaccurate.[16] Despite DOE's sampling efforts, the viscous and layered consistency of the waste has challenged measurement of physical and chemical properties. For example, given the multitude of waste constituents in a tank, taking 1- to 3-inch-wide samples that extend from the surface of the waste to the bottom of a tank that is 75 feet wide may not always produce representative results. DOE contractors acknowledged that they do not know the specific proportions of wastes in any given tank, and they continue to characterize tank wastes to mitigate corrosion; understand future waste delivery, treatment, and disposal needs; and support future waste retrieval and closure activities. Still, understanding the types and quantity of waste constituents in each tank and the effect, if any, this waste has on the tanks' integrity may be critical to predict how long they can be safely used. Recognizing this concern, DOE plans to further study the long-term integrity of the single-shell tanks

[16] GAO/RCED-91-118 and GAO/RCED-96-56.

and, in an effort to extend tank life span, has tried to control the acidity of the waste in the double-shell tanks to minimize its corrosive effects.

Many Tanks Have Exceeded Their Expected Life Spans, Raising Questions about Continued Viability

While uncertainties about the tanks' structural integrity and contents persist, the aging of the tanks goes without question. By 1987, all the single-shell tanks had already lasted beyond their estimated design life of 10 to 20 years. Some of these tanks may be more than 80 years old by the time they are emptied and the tank farms are closed (see app. II). Although none of the double-shell tanks have yet exceeded their estimated design life of 25 to 50 years, all will have done so by the time waste treatment is complete and the last of them has been emptied and closed (see app. III).

While a tank's design life is not a firm deadline beyond which a tank is no longer usable, site engineers considered design life a reasonable estimate of how long a tank could be expected to contain the radioactive and hazardous wastes and did not regard the tanks as a permanent solution to DOE's weapons production legacy. In the 1940s and 1950s, site contractors viewed tank failures as inevitable and assumed that as the tanks failed, new tanks would be constructed to store the waste until a more permanent disposal solution could be developed.[17] DOE and its contractor acknowledge that aging equipment is subject to more frequent failure. The likelihood of a major failure of a tank increases with time.[18] The conclusions of a 2007 Ecology study on the single-shell tanks seem to agree with this position. From an evaluation of the tanks' leak history, this study concluded that the probability of a single-shell tank's leaking may double about every 10 years. The study estimated that about half (41 tanks) of the single-shell tanks designated as sound could leak waste into the ground by the time they are emptied.[19]

[17]Gephart, *Hanford: A Conversation about Nuclear Waste and Cleanup.*

[18]CH2M Hill Hanford Group, *Risk Management Plan*, TFC-PNL-39, rev. B (Richland, Washington, July 7, 2006).

[19]Because all but about 3 million gallons of liquid waste has been pumped from the single-shell tanks, DOE believes it is unlikely that significant amounts of additional waste could leak into the ground. Nevertheless, in May 2008, DOE began investigating the possibility that a single-shell tank suspected to have leaked in the past may have recently leaked more waste. This tank contains nearly 48,000 gallons of liquid trapped within hardened saltcake layers. DOE officials also acknowledged that when liquids are introduced into tanks to help remove waste, additional leaks may occur.

Regardless of whether the tanks have exceeded their design life, their long-term viability remains unknown. Given the uncertainties over the bottom portions and foundations of the single-shell tanks uncovered by DOE's 2002 study, and that 67 tanks have leaked or are presumed to have already leaked and additional tanks are likely to leak in the future, these tanks' viability is both questionable and unpredictable. Furthermore, according to independent experts, DOE has never controlled the chemical composition of the wastes in the single-shell tanks to reduce corrosion of the tanks' steel liners, as required for the double-shell tanks.[20] It also remains unclear to what extent the single-shell tank study being planned will evaluate the expected viability of these tanks throughout the remainder of the treatment process. As for the double-shell tanks, DOE has taken steps to try to assess whether they will remain usable until they are emptied.[21] An independent panel of experts, including engineers, chemists, and corrosion experts from DOE sites, academia, and industry analyzed actual corrosion rates of the inner carbon-steel linings of the 28 double-shell tanks. Using these corrosion rates, the experts projected when future leaks in the tanks were likely to occur. They concluded that in a worst-case scenario—as when the waste is highly corrosive—assuming corrosion rates continue as observed, as many as 7 double-shell tanks may develop leaks in their inner steel shells between 2037 and 2043.[22] Another study conducted by an independent professional engineer for DOE's contractor used laboratory corrosion rate data, rather than rates from in-tank corrosion monitoring. Assuming that tank shell corrosion rates would not necessarily remain constant, this study concluded that the inner steel shell of all the double-shell tanks would be capable of containing the waste without developing corrosion leaks until about 2083.[23] Given these conflicting conclusions, DOE tank management officials continue to study

[20]The failure to control the chemical composition of the waste in the single-shell tanks may raise the potential for corrosion in the double-shell tanks when this waste is transferred to them. For more information, see CH2M Hill Hanford Group, *Expert Panel Workshop for Hanford Site Double-Shell Tank Waste Chemistry Optimization*, RPP-RPT-22126, rev. 0 (Richland, Washington, October 2004).

[21]According to DOE officials, the double-shell tanks have gone through a process to certify the tanks' readiness for use for an additional 10 years.

[22]CH2M Hill Hanford Group, *Expert Panel Workshop.*

[23]CH2M Hill Hanford Group, *Double-Shell Tank System Integrity Assessment*, HFFACO M-48-14, RPP-28538, rev. 4, prepared for the Department of Energy (Richland, Washington, September 2007).

the condition of the double-shell tanks and believe that they will remain sound during an extended waste storage schedule.

DOE's Tank Management Strategy Involves Continued Use of the Aging Tanks, Perhaps for Decades

DOE's strategy for managing Hanford's tanks involves transferring waste from the single- to the double-shell tanks and using the latter to store the waste until it can be treated and the tanks closed. With Hanford's waste treatment plant still under construction, DOE is carrying out this strategy under lengthening and seemingly disparate time frames. DOE's strategy and schedule also appear to rely on overly optimistic assumptions, in particular, that the aging tanks will remain viable throughout the treatment process and that sufficient double-shell tank space will be available to hold waste retrieved from the single-shell tanks.

DOE's Tank Management Strategy Calls for Using the Aging Tanks Until They Can Be Emptied and Closed

DOE has been gradually emptying the liquid waste from the single-shell tanks into the double-shell tanks. Beginning in the 1970s, DOE transferred as much liquid as possible from the single-shell tanks, a process called interim stabilization, to minimize or prevent further leaks of waste from these aging tanks to the soil below. By May 2005, DOE had completed the interim stabilization of all single-shell tanks. Because of the layered nature of tank waste, however, DOE was unable to remove all the liquid. As of February 2008 (the latest date for which data were available for this report), DOE reported that about 3 million gallons of liquid waste remains in these tanks, most of it unpumpable. Of this remaining liquid waste, about one-third, or 1 million gallons, resides in tanks known or presumed to have already leaked.

In 1998, DOE began emptying the single-shell tanks of their remaining waste, mostly saltcake and sludge, and transferring it to double-shell tanks, where it will be temporarily stored until the waste treatment plant becomes operational. To loosen and retrieve the waste from tanks, DOE has used a variety of technologies, including sprays of acid or water to help break up the waste and a vacuumlike system to suck up and remove waste through openings, called risers, in the top of the tank (see fig. 3). Under the Tri-Party Agreement, DOE has agreed to remove as much waste from the tanks as technically possible and the volume of waste remaining may generally not exceed specified volumes.[24] According to a DOE official, these volume limits were set to ensure that at least 99 percent of the waste was removed from the single-shell tanks.

As all the tanks are emptied of as much waste as practical, DOE expects to first close the single-shell and then the double-shell tanks, along with ancillary piping and other instruments. To date, the department has not yet reached agreement with its regulators on final closure of the tanks. Regulatory alternatives for closing the tanks are either "clean closure," a regulatory concept under which the tanks themselves, ancillary equipment, and contaminated soil would be exhumed, treated, and disposed of as radioactive waste, or "closure as a landfill," in which DOE would leave a small amount of waste in the each tank; fill each with grout, a cementlike material; and monitor tank conditions in perpetuity. As of May 2008, DOE was preparing an environmental impact statement that evaluates alternatives for closing the tanks, including how much waste can be left in the tanks at closing. DOE does not expect to issue the final statement before late 2009, with a decision about tank closure to follow later.

DOE Appears to Be Operating under More Than One Schedule

Within DOE's general strategy for addressing the aging tanks, time frames for completing specific actions, such as emptying the tanks and closing them, remain in flux. Under the existing Tri-Party Agreement, DOE agreed to empty all 149 single-shell tanks by September 2018 and to close them by 2024.[25] These milestones were tied to waste treatment operations, which were scheduled to be complete by December 31, 2028.[26] As of May 2008, however, the startup of Hanford's waste treatment plant had been delayed by at least 8 years, and it was unclear when waste treatment operations would be complete. Moreover, DOE has made limited progress in actually

[24]Under the Tri-Party Agreement, DOE is required to retrieve as much tank waste as technically possible, with tank waste residues not to exceed 360 cubic feet in the so-called "100" series of tanks, 30 cubic feet in the "200" series of tanks, or the limit of waste retrieval technology capability, whichever is less (app. D, milestone M-045-00N). According to the agreement, the goal is 99 percent waste retrieval, as defined by these criteria. If DOE believes that waste retrieval to these levels is not possible for individual tanks, DOE may request an exception to the criteria.

[25]The Tri-Party Agreement does not specify a date by which the double-shell tanks must be closed.

[26]The Tri-Party Agreement (milestone M-062-00A) specifies that DOE should complete treatment of no less than 10 percent (by mass) and 25 percent (by radioactivity) of Hanford's waste by February 2018, with the remainder to be processed by December 2028.

emptying the tanks, and at its present rate of progress, it will not achieve the milestones it agreed to.

In contrast to its Tri-Party Agreement commitments, DOE's own internal project baseline schedule[27] (approved in mid-2007) for emptying and closing the tanks reflects time frames almost 2 decades later. For example, according to this baseline, emptying the single-shell tanks will be completed 19 years later than agreed to in the Tri-Party Agreement. DOE officials told us that this baseline schedule reflects a 5-year delay in the start of waste treatment operations and a lengthened waste treatment period. Since the baseline schedule was developed, however, DOE has acknowledged that the start of waste treatment operations will be delayed at least 8 years (from 2011 to 2019), not 5, most likely making DOE's approved baseline schedule for emptying the tanks unachievable. In February 2008, DOE prepared an internal single-shell tank waste retrieval analysis that reflects this 8-year delay.[28] Under this new scenario, DOE postpones emptying all single-shell tanks from 2018 to at least 2047, a delay of 29 years from the agreed-to Tri-Party Agreement date, with tank closure to follow. Although DOE officials said this analysis was not a schedule to which the agency was working, they acknowledged that the time frames in the analysis more accurately reflect what the agency believes it can achieve given the waste treatment plant delay.[29]

DOE has been negotiating with Ecology and EPA since May 2007 to extend the Tri-Party Agreement milestones, including dates for emptying and closing the tanks. DOE acknowledged that it could not meet the current Tri-Party Agreement and instead proposed to regulators that it empty the single-shell tanks by 2040—a delay of 22 years. Given the delays in starting

[27]DOE Order 413.3A. Before a DOE project may begin, the sponsoring DOE program office must develop and obtain departmental approval for the project's "performance baseline." This baseline represents the organization's commitment to completing a project at a certain cost and by a specific date.

[28]CH2M Hill Hanford Group, *Single-Shell Tank Retrieval Selection and Sequence*, RPP-21216, rev. 3 (Richland, Washington, Feb. 28, 2008). This document also acknowledged that completion of waste treatment operations would be delayed about 20 years (to 2049) beyond the Tri-Party Agreement date of 2028.

[29]In May 2008, DOE publicly released the February 2008 schedule in a document describing its plan to complete its mission of retrieving and treating tank waste and closing the tank farms. This document, called the system plan, explains how DOE believes it can carry out its mission. (CH2M Hill Hanford Group, *River Protection Project System Plan*, RPP-11242, rev. 3, prepared for the Department of Energy (Richland, Washington, May 2008).

waste treatment plant operations and DOE's February 2008 single-shell tank waste retrieval analysis, however, it is unclear whether the proposed changes to the Tri-Party Agreement dates are realistic.

DOE's Lengthening Time Frames Incorporate Assumptions That Seem Overly Optimistic

In carrying out its tank management strategy under successively lengthening time frames, DOE is relying on some key assumptions that may be overly optimistic.

- *The aging tanks will remain viable until they can be emptied and closed.* At the foundation of DOE's strategy lies the department's assumption that the tanks will remain viable throughout what has become a protracted waste treatment process. At the time they were built, the single-shell tanks were intended to be in service for 10 to 20 years, but under DOE's current plan, some of these tanks will be more than 80 years old by the time they are emptied. Concerns have been raised over the years about the risk of tank failure, most recently in an internal analysis assessing management risks associated with tank farm activities, where the responsible contractor said that the likelihood of a major tank failure or failure of ancillary systems increases over time.

- *Double-shell tank space will be sufficient to receive all the waste retrieved from single-shell tanks until waste treatment operations can begin.* DOE also assumes that the 28 double-shell tanks will have enough space to hold waste transferred from single-shell tanks until the waste treatment plant begins operating. The double-shell tanks have an estimated capacity of slightly over 32 million gallons and, as of February 2008, contained nearly 27 million gallons of waste. To fit the expected volume of single-shell tank waste, plus liquids added in emptying these tanks, DOE plans to evaporate off as much liquid as possible, concentrating it for storage in the double-shell tanks. But DOE's evaporator facility is 31 years old, and an internal DOE 2006 document identified evaporator reliability as a critical challenge to meeting project goals.[30] Unplanned evaporator maintenance could in the worst case result in delays of a year or more. In addition, any failure of a double-shell tank would further reduce available space. Although DOE officials told us they believe that sufficient double-shell tank space will remain available, the 2006 DOE document noted that management of double-shell tank space remains critical to successful completion of the entire waste treatment operation.

[30]CH2M Hill Hanford Group, *Risk Management Plan* (2006).

- *Emptying single-shell tanks will proceed two to three times faster than it has to date.* DOE's tank management strategy assumes that the department can progress with waste retrieval from the single-shell tanks at a rate that contrasts with experience so far. In its February 2008 single-shell retrieval analysis, DOE shows completion of single-shell tank retrieval in 2047 if a total of 33 tanks are emptied through 2019—a waste retrieval pace averaging more than 3 tanks per year.[31] Since 1998, however, DOE has emptied only 7 tanks and is in the process of emptying 3 more—a rate of about 1 tank per year. Further, 4 of the 7 emptied tanks are among the smallest, at 55,000 gallons of capacity, and contain relatively small amounts of residual waste. The other 3 tanks range in capacity from 530,000 to 758,000 gallons, and each took almost a year or more to empty. Moreover, a 2007 tank spill illustrates that a relatively small spill can halt retrieval activities, further complicating schedules. On July 27, 2007, during retrieval of radioactive mixed waste from a 758,000-gallon single-shell tank, a pump failed, spilling 85 gallons of highly radioactive waste to the ground. At least two workers were exposed to chemical vapors, and later several workers reported health effects they believed to be related to the spill. Retrieval operations for all single-shell tanks were suspended after the accident, and DOE did not resume operations until June 2008, a delay of 11 months. In addition, the accident added at least $8 million to the retrieval cost for that tank. Hanford project management officials acknowledged that such an ambitious retrieval schedule might not be achievable. DOE's site manager for the Office of River Protection told us that she believed DOE could achieve a retrieval rate of about 1.7 tanks per year until 2019. In its fiscal year 2009 budget submitted to Congress, however, DOE indicated that it could achieve retrieval of waste from only 1 tank.

[31]These 33 tanks include several whose waste DOE assumes can be removed and treated using alternative treatment technologies, without first transferring the waste to double-shell tanks. DOE's February 2008 single-shell tank waste retrieval analysis shows that if these alternative treatment options were unavailable, emptying the single-shell tanks would be delayed to 2062.

DOE Cannot Weigh the Benefits of Pursuing Its Tank Management Strategy against Growing Costs Because It Lacks Critical Information

Without a comprehensive analysis that quantifies the risks of tank waste and the proposed strategies to address them, DOE lacks critical information to weigh the benefits of pursuing its present strategy against costs that continue to climb. DOE has undertaken some studies that assess general tank waste risks, but these studies lack detailed, tank-farm-specific information, not only about the tanks' long-term viability but also about incremental changes in risks associated with remediation actions. As a result, DOE, Congress, and the public cannot be assured that DOE's present strategy appropriately balances risk reduction with cost.

DOE's Past and Present Risk Studies Have Not Explicitly Considered Health and Environmental Risks Associated with Extended Use of the Tanks

DOE has taken the position that using a risk-based approach to managing its tank waste is a top priority. In addressing the progress of cleaning up Hanford's underground tanks in its fiscal year 2009 congressional budget request, DOE stated that it is pursuing a risk-based approach that focuses first on the greatest contributors to risk. In April 2008, the Assistant Secretary for Environmental Management reemphasized that the department would follow a risk-based approach and announced that DOE would give top priority to retrieving and treating the radioactive waste in the tanks. In addition, DOE's own project management order and implementing guidance calls for the department to consider programmatic risk before proceeding with a project.[32] In actual practice, DOE's main tank risk studies have looked at the long-term health and environmental risks of the waste in the tanks, but none of the studies has explicitly investigated such risks in association with using the tanks for an extended period of time:

- DOE's 1996 environmental impact statement documented and analyzed potential environmental consequences related to 10 proposed alternative

[32]Federal laws also allow for assessing risk associated with various actions. For example, CERCLA and RCRA—both of which govern the Hanford cleanup—authorize an assessment of the risks to human health and the environment from contamination before determining a cleanup remedy. Similarly, under the National Environmental Policy Act, federal agencies evaluate the likely effects of significant actions they are proposing using an environmental assessment or, if the projects will significantly affect the quality of the human environment, a more detailed environmental impact statement.

approaches to cleanup of the tank waste at the Hanford Site.[33] The environmental impact statement evaluated the short- and long-term effects of these alternatives on site workers, the public, and the environment; it also compared the costs and technical and regulatory feasibility associated with each alternative, although the study did not make clear how DOE compared these factors to arrive at its preferred alternative for cleanup. The study did not purport to analyze the tanks' condition or long-term viability or the risks posed by leaving the waste in the tanks for several more decades. Rather, DOE assumed that no further waste leaks would occur and that both single- and double-shell tanks would maintain their structural integrity for the next 100 years.

- A DOE 2006 performance assessment of the single-shell tanks estimated the potential health and environmental effects that may remain after the single-shell tanks are emptied under DOE's current strategy.[34] This study assumed that 99 percent of the waste would be removed from the tanks and treated and that the tanks themselves would be left in the ground after retrieval. The study concluded that after 99 percent of the waste had been retrieved from the tanks and the tanks were filled with grout, the groundwater beneath the tanks would never exceed drinking water standards, even 4,000 to 6,000 years from now. The study did not assess the short-term risks to Hanford Site workers, the public, or the environment, but it did evaluate long-term risks as far as 10,000 years into the future. In addition, like the 1996 environmental impact statement, this study did not attempt to analyze the tanks' condition or long-term viability.

- DOE is preparing an environmental impact statement evaluating a number of potential strategies for permanently closing the tanks after the waste has been retrieved. According to DOE, this study will include an analysis of (1) the costs and risks posed by waste left in tanks under a number of different closure configurations; (2) the contamination associated with other waste sites at Hanford; and (3) risks under various treatment, disposal, and closure scenarios to workers, the public, and the

[33]Department of Energy, *Tank Waste Remediation System, Hanford Site, Richland, Washington: Final Environmental Impact Statement*, DOE/EIS-0189 (Washington, D.C., August 1996). DOE's present cleanup approach at Hanford is based on the preferred alternative identified in this study.

[34]Department of Energy, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*, DOE/ORP-2005-01, rev. 0 (Richland, Washington, April 2006).

environment.[35] According to DOE officials, this study is not intended to assess the tanks' present condition or their ability to continue safely storing waste until retrieval. Although we have discussed the progress of this study with DOE officials, drafts of the study were not available at the time of our review. We could not therefore determine whether or to what extent this new study will detail the "risk-based" approach that we believe is needed for making key decisions about waste retrieval and final closure of the tanks. Both EPA and Ecology officials stated that this study will contribute to the risk information available on tank wastes but will not represent a comprehensive study of those risks. They acknowledged that even after this study is completed, more data will likely be needed to make long-term decisions about the risks of using the tanks over an extended period. Meanwhile, DOE is proceeding under its current tank management strategy and renegotiating new milestones with its regulators, even though the department does not expect to issue the final environmental impact statement before late 2009, with a decision about tank closure to follow later.

DOE Has Not Demonstrated That Its Tank Management Strategy Is Appropriate in Light of Rising Costs

According to DOE and its tank farm contractor's own estimates, the cost of retrieving Hanford's tank waste and maintaining and closing the tanks is escalating. DOE estimated in 2003 that waste retrieval and closure costs from fiscal year 2007 onward—in addition to the $236 million already spent to empty the first seven tanks—would be $4.3 billion. By 2006, this estimate had grown to $7.6 billion.[36] As DOE empties tanks, it has found that its estimates for retrieving the waste have significantly understated actual costs. For example, in 2003, DOE estimated that retrieving waste from all the single-shell tanks would cost approximately $1.1 billion, or an average of about $7.6 million per tank. The actual costs of removing waste from the first seven tanks have totaled about $236 million, or about

[35]In addition to a "no action" alternative, this environmental impact statement is evaluating the risks, costs, and benefits of three tank waste retrieval alternatives that involve removing 90 percent, 99 percent, or 99.9 percent of the waste from a tank.

[36]These estimates are understated. DOE was unable to provide information on the administrative and other support costs associated with DOE's management of the tanks. The 2003 estimate includes retrieval costs through tank closure in 2032. The 2006 estimate, which incorporates schedule delays, includes retrieval costs through tank closure in 2042.

$34 million per tank.[37] Because four of the emptied tanks were Hanford's smallest tanks, actual costs for the more-numerous larger tanks could be much higher. Moreover, as DOE continues to extend its time frames for tank waste retrieval, the time and costs for monitoring and maintaining the tanks also continue to expand.

DOE and its contractor have also found that the costs of retrieving the last portion of waste from a tank can be costly. Yet in the absence of specific risk analyses, the accompanying reduction in risk, if any, is unclear. Specifically, DOE estimates that the cost of retrieving the final 15 percent of waste can equal or exceed the cost of removing the initial 85 percent (the cost per gallon can be as much as three times higher); in contrast, DOE has little information about any concomitant risk reduction. Our review did find one case where DOE and its tank farm contractor weighed the relative risks, benefits, and costs of retrieving the last portion of waste from a tank. After retrieving all but just over 1 percent (or about 400 cubic feet) of the waste in tank C-106, DOE analyzed the costs and risks associated with retrieving the rest of the waste. This analysis concluded that the risk to workers from removing the waste, combined with the associated high cost, outweighed a relatively minimal reduction in risk to the public and future users of the site.[38] The analysis determined that the cost of removing each additional cubic foot, or about 8 gallons, of waste ranged from $35,000 to $84,000—in other words, from 7 to 16 times the average cost per cubic foot to retrieve the first nearly 99 percent of the waste.

Until DOE completes an analysis of risks to human health and the environment due to the waste in the tanks throughout the retrieval and closure process, DOE cannot demonstrate the risk reductions that will be achieved by its increasingly costly tank management strategy. Without

[37]Retrieval costs per tank for each of the seven tanks retrieved to date have varied significantly, ranging from $143 million for a larger tank to less than $10 million per tank for four of the smallest tanks. Although DOE believes that future tank waste retrieval costs will decrease as lessons learned from current tank retrievals are applied, no clear evidence confirms this belief. In fact, DOE's recent experience retrieving tank S-102, which resulted in a spill of radioactive waste and 1-year halt in all tank retrieval activities, show that costs remain uncertain.

[38]The results of this analysis are consistent with a 2006 National Research Council report, which stated that the risk of leaving an incrementally larger amount of waste in a tank may be less than the risk of existing contamination in the soil around the tanks. National Research Council, *Tank Waste Retrieval, Processing, and On-Site Disposal at Three Department of Energy Sites* (Washington, D.C, National Academies Press, 2006).

quantifying these risks and comparing the data to the costs associated with various tank management approaches, DOE cannot be sure that it has developed a strategy that appropriately addresses the risks posed by the tank waste to workers, who are most vulnerable to direct exposure during retrieval operations; the public, who live near the site or will use the site in future years; and the environment. Hanford's manager of the Office of River Protection told us that having this kind of risk information would be valuable in negotiating tank closure guidelines and standards with federal and state environmental agencies and in controlling costs. To date, however, such information has not been available.

Conclusions

DOE has spent billions of dollars over the last 2 decades managing Hanford's underground tanks and the radioactive and hazardous wastes they contain; nevertheless, progress in emptying the tanks has been limited. In addition, many critical uncertainties—such as whether the tanks can safely be used until all have been emptied and closed—remain. In the absence of comprehensive information, DOE is relying on several key assumptions to carry out its tank management strategy, some of which seem overly optimistic in light of DOE's past experiences. We recognize that, with technical complexities, intensifying fiscal pressures, and multiple stakeholders with competing visions of success, DOE faces unique challenges in carrying out its responsibility to protect people and the environment during its tank remediation efforts. Nevertheless, we believe that fulfilling this responsibility requires a strategy grounded in fundamental information about the tanks and the risks they pose as they are emptied and closed. DOE's knowledge about tank integrity, tank viability over time, and tank risk is still incomplete. Consequently, DOE cannot appropriately weigh the relative risks of its strategy to workers, the public, and the environment against the climbing costs or weigh the risks and costs of its present strategy against other possible options for managing the tanks and their waste. Moreover, in the absence of this needed information, DOE may continue to face difficulties in developing achievable and reliable remediation milestones.

Recommendations for Executive Action

To ensure that DOE has the fundamental information needed to make appropriate and cost-effective decisions about how to manage Hanford's tank waste, we recommend that the Secretary of Energy take the following three actions:

- Give priority to carrying out the department's assessment, in early planning stages as of 2008, of the structural integrity of Hanford's single-shell tanks—an effort we fully support—and ensure that this assessment includes examining the following key attributes: corrosion of the tanks' inner steel shells; the condition of concrete domes and outer shells, especially where waste has leaked; the integrity of long-obscured parts of the tanks for tanks that have been emptied; and the long-term viability of the tanks in light of their increasing age and DOE's extended schedule for waste retrieval, waste treatment, and tank closure.

- On a routine basis—such as every 3 to 5 years—specifically quantify the risks posed by the tank waste to workers, the public, and the environment and the risks posed by DOE's tank management strategy in light of the tanks' questionable viability.
- Work with Ecology and EPA to (1) reassess its tank management strategy, incorporating quantified risk information, and (2) develop and agree to realistic schedule and cost milestones.

Agency Comments and Our Evaluation

We provided a draft of this report to the Secretary of Energy for review and comment. In a written response, DOE's Principal Deputy Assistant Secretary for Environmental Management, acting for the Assistant Secretary for Environmental Management, stated the department does not agree that it lacks the necessary information to make informed decisions regarding tank integrity, waste retrieval, and treatment but views the report's recommendations as consistent with the department's present and planned activities in tank integrity, risk management, and regulatory negotiations. DOE also provided technical comments, which we incorporated throughout the report as appropriate. DOE's comments are reproduced in appendix IV.

Regarding our report's conclusions, DOE stated its belief that it has adequate knowledge to make decisions about tank waste storage, retrieval, and treatment, although it acknowledged that as the mission progresses, additional tank integrity monitoring, waste characterization, and development of retrieval technology will be required. In its response, DOE cited work by the Defense Nuclear Facilities Safety Board and the National Academy of Sciences as support that it has adequate knowledge of the tanks and their contents.

DOE stated that, working with its regulators and the Safety Board, it had conducted extensive characterization of tank contents, resolved safety issues, and implemented the Safety Board's recommendation. This 1993 recommendation focused on the safety of selected Hanford tanks, specifically those containing potentially flammable and explosive chemicals. The Safety Board did not address the continued use, condition, or viability of Hanford's waste tanks during a treatment schedule that may be extended by decades. DOE also stated that in a 2006 report, the National Academy of Sciences concluded that the department's knowledge of tank waste characteristics was adequate for waste retrieval activities. The National Academy of Sciences, however, made this statement within the context of "waste processing and the design of processing facilities." Its report acknowledged that the tanks still needed to be "sampled for specific data needs," which at Hanford are driven by waste compatibility, chemistry control to mitigate corrosion, and other factors. Similar to the Safety Board's recommendation, this report did not address the extent to which single-shell waste tanks—about half of which are confirmed or presumed to have leaked—will remain viable under the lengthening cleanup time frames.

Our report recognizes that DOE has made some progress in gaining data about the condition of the tanks, in particular the double-shell tanks, and general tank contents. Despite its monitoring efforts, however, the department still has limited information about the actual condition of the single-shell tanks. For example, DOE has performed limited examinations of the condition of the tanks' inner steel shells beneath the waste and the buried concrete exteriors and foundations—information that is critical for assessing the long-term viability of these tanks. Moreover, DOE is in early planning stages of a multiyear study to assess single-shell tank integrity, which represents the department's own acknowledgment of the need for more information. At this early stage, it is unclear if or when this study will provide DOE with more comprehensive information. Without timely execution of this study, neither DOE nor its regulators can benefit from the information the study would provide as they negotiate a new schedule for retrieving the tank waste and closing the tanks. Thus, in our view, DOE's current knowledge is not adequate, for the single-shell tanks in particular, to assess the appropriateness of the department's tank management strategy—which involves continuing to store waste in aging tanks until they can be emptied and closed—especially in light of lengthening cleanup time frames.

Regarding our report's recommendations, DOE stated that it views them as consistent with its present and planned activities; nevertheless, we are not convinced. We continue to believe that the department must give priority to its assessment of single-shell tank integrity, quantify the risks posed by the tank waste and the tank management strategy, and work with Ecology and EPA to reassess its strategy and develop realistic milestones.

Without these specific steps, DOE can not ensure that its tank management strategy is appropriate in light of escalating costs.

We are sending copies of this report to other interested congressional committees and to the Secretary of Energy. We will also make copies available to others upon request. 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 regarding 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. Key contributors are listed in appendix V.

Gene Aloise
Director, Natural Resources
and Environment

Appendix I: Scope and Methodology

To determine the current condition, contents, and long-term viability of Hanford's underground tanks, we gathered and reviewed numerous reports and studies addressing the tanks' physical status, expected design life, age, and integrity. To understand the tanks' physical condition, we reviewed historical as well as current documents that describe the condition of the tanks' carbon-steel shells, concrete domes and exteriors, and ancillary piping and equipment. We reviewed studies, including tank waste sampling and analysis data, to document the major radioactive constituents, chemically hazardous materials, and other miscellaneous material found in the tanks. To address the tanks' long-term viability, we reviewed historical documents, studies by independent experts, and Department of Energy (DOE) reviews to determine the tanks' actual age and estimated life span and their predicted leak and corrosion rates over time. We interviewed DOE and contractor officials, Washington State Department of Ecology (Ecology), and Environmental Protection Agency (EPA) officials to obtain their views on these topics and to obtain additional information. To assist in evaluating the technical aspects of the tanks, their contents, and viability, we obtained assistance from a technical consultant, Dr. George W. Hinman, Professor Emeritus of Applied Energy Studies at Washington State University, who has extensive nuclear energy experience in industry, government, and academia.

To determine DOE's strategy for managing the tanks and the waste they contain, we reviewed DOE's most recent tank waste retrieval documents, detailing how the department plans to manage the tanks and their contents. We reviewed regulatory requirements and milestones governing the tank waste cleanup. To document DOE's approach for removing waste and closing the tanks, we reviewed DOE's approved project baseline schedule and cost for the department's tank management strategy and discussed this schedule and other schedule proposals with DOE officials at Hanford. We also reviewed DOE and its tank farm contractor's reports assessing management risks associated with tank farm activities to identify potential problems facing Hanford's aging tanks and the possible effects of these problems on DOE's strategy for dealing with the tank waste. To understand these problems and to obtain information on the tank waste cleanup milestones that were in negotiation as of May 2008, we interviewed representatives from Ecology and EPA. To understand the complexity of removing waste from the tanks, we visited several tank farms on the Hanford Site and observed workers removing waste from a tank. We also gathered and reviewed documents describing the status of various waste retrieval technologies that DOE has used and plans to use and discussed these technologies with DOE and contractor officials.

To determine the extent to which DOE has assessed whether the reduction in risk that may result from its current tank management strategy warrants the growing costs of that strategy, we examined budget and financial documents, environmental impact studies, and assessments of risks. We reviewed financial documents to obtain the most current information on the estimated life-cycle cost of retrieving wastes and closing the tanks. We reviewed environmental studies and risk assessments to determine the extent to which cleanup costs and risks to workers, public health, and the environment associated with the tank waste have been quantified. As we reviewed these documents, we frequently interviewed key DOE and contractor officials to discuss, clarify, and confirm our interpretation of the information.

We relied on dollar figures and tank strategy assumptions provided by DOE and its contractors but took various steps—such as reviewing cost estimating documents and strategy assumptions, reviewing budget documents, and obtaining clarifications from the officials who prepared them—to ensure that the data were sufficiently reliable for purposes of this report. We discussed our findings with, and obtained the views of, DOE and contractor officials responsible for the tank farms and with representatives of Ecology and EPA agencies, as well as with outside experts.

We conducted this performance audit from July 2007 through June 2008 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.

Appendix II: Capacity, Age, and Retrieval Schedule for Hanford's Single-Shell Tanks as of February 2008

Tank	Tank capacity (gallons)	Total waste (gallons)	Drainable liquid (gallons)[a]	Year placed in service[b]	Age in 2008 (years)	Year scheduled for emptying[c]	Anticipated age when emptied of waste (years)	Year waste leaked	Waste leaked (gallons)[d]
A-101	1,000,000	320,000	37,000	1954	54	2020	66		
A-102	1,000,000	40,000	9,000	1954	54	2032	78		
A-103	1,000,000	378,000	86,000	1954	54	2025	71	1987	5,500
A-104	1,000,000	28,000	0	1954	54	2028	74	1975	2,500
A-105	1,000,000	37,000	0	1954	54	2030	76	1963	270,000
A-106	1,000,000	79,000	9,000	1954	54	2030	76		
AX-101	1,000,000	358,000	44,000	1965	43	2020	55		
AX-102	1,000,000	30,000	0	1965	43	2031	66	1988	3,000
AX-103	1,000,000	107,000	22,000	1965	43	2032	67		
AX-104	1,000,000	7,000	0	1965	43	2031	66	1977	Unknown
B-101	530,000	109,000	20,000	1945	63	2029	84	1974	Unknown
B-102	530,000	32,000	7,000	1945	63	2030	85		
B-103	530,000	56,000	10,000	1945	63	2028	83	1978	Unknown
B-104	530,000	374,000	45,000	1945	63	2016	71		
B-105	530,000	290,000	20,000	1945	63	2017	72	1978	Unknown
B-106	530,000	123,000	8,000	1945	63	2029	84		
B-107	530,000	161,000	23,000	1945	63	2019	74	1980	8,000
B-108	530,000	92,000	19,000	1945	63	2021	76		
B-109	530,000	126,000	23,000	1945	63	2021	76		
B-110	530,000	245,000	27,000	1945	63	2020	75	1981	10,000
B-111	530,000	242,000	23,000	1945	63	2022	77	1978	Unknown
B-112	530,000	35,000	2,000	1945	63	2032	87	1978	2,000
B-201	55,000	29,000	5,000	1945	63	2014	69	1980	1,200
B-202	55,000	28,000	4,000	1945	63	2014	69		
B-203	55,000	50,000	5,000	1945	63	2013	68	1983	300
B-204	55,000	50,000	5,000	1945	63	2013	68	1984	400
BX-101	530,000	48,000	4,000	1948	60	2031	83	1972	Unknown
BX-102	530,000	79,000	0	1948	60	2031	83	1971	70,000
BX-103	530,000	75,000	4,000	1948	60	2032	84		
BX-104	530,000	100,000	4,000	1948	60	2022	74		
BX-105	530,000	72,000	4,000	1948	60	2030	82		
BX-106	530,000	38,000	4,000	1948	60	2033	85		
BX-107	530,000	347,000	37,000	1948	60	2018	70		
BX-108	530,000	31,000	4,000	1948	60	2031	83	1974	2,500

Tank	Tank capacity (gallons)	Total waste (gallons)	Drainable liquid (gallons)[a]	Year placed in service[b]	Age in 2008 (years)	Year scheduled for emptying[c]	Anticipated age when emptied of waste (years)	Year waste leaked	Waste leaked (gallons)[d]
BX-109	530,000	193,000	25,000	1948	60	2029	81		
BX-110	530,000	214,000	35,000	1948	60	2021	73	1976	Unknown
BX-111	530,000	188,000	6,000	1948	60	2028	80	1984	Unknown
BX-112	530,000	164,000	9,000	1948	60	2018	70		
BY-101	758,000	370,000	24,000	1950	58	2016	66		
BY-102	758,000	278,000	40,000	1950	58	2028	78		
BY-103	758,000	414,000	55,000	1950	58	2027	77	1973	5,000
BY-104	758,000	405,000	44,000	1950	58	2024	74		
BY-105	758,000	481,000	47,000	1950	58	2024	74	1984	Unknown
BY-106	758,000	430,000	37,000	1950	58	2024	74	1984	Unknown
BY-107	758,000	271,000	42,000	1950	58	2025	75	1984	15,100
BY-108	758,000	222,000	33,000	1950	58	2029	79	1972	5,000
BY-109	758,000	287,000	37,000	1950	58	2022	72		
BY-110	758,000	366,000	20,000	1950	58	2024	74		
BY-111	758,000	402,000	14,000	1950	58	2023	73		
BY-112	758,000	286,000	24,000	1950	58	2021	71		
C-101	530,000	88,000	4,000	1946	62	2012	66	1980	20,000
C-102	530,000	316,000	62,000	1946	62	2012	66		
C-103	530,000	3,000	N/A	1946	62	2006	60		
C-104	530,000	259,000	29,000	1946	62	2013	67		
C-105	530,000	132,000	10,000	1946	62	2014	68		
C-106	530,000	3,000	N/A	1946	62	2003	57		
C-107	530,000	247,000	30,000	1946	62	2015	69		
C-108	530,000	8,000	N/A	1946	62	2007	61		
C-109	530,000	10,000	N/A	1946	62	2008	62		
C-110	530,000	178,000	37,000	1946	62	2014	68	1984	2,000
C-111	530,000	57,000	4,000	1946	62	2016	70	1968	5,500
C-112	530,000	104,000	6,000	1946	62	2015	69		
C-201	55,000	0	N/A	1946	62	2006	60	1988	550
C-202	55,000	0	N/A	1946	62	2005	59	1988	450
C-203	55,000	0	N/A	1946	62	2005	59	1984	400
C-204	55,000	0	N/A	1946	62	2006	60	1988	350
S-101	758,000	352,000	45,000	1950	58	2030	80		
S-102	758,000	34,000	N/A	1950	58	2010	60		
S-103	758,000	237,000	45,000	1950	58	2017	67		

Tank	Tank capacity (gallons)	Total waste (gallons)	Drainable liquid (gallons)[a]	Year placed in service[b]	Age in 2008 (years)	Year scheduled for emptying[c]	Anticipated age when emptied of waste (years)	Year waste leaked	Waste leaked (gallons)[d]
S-104	758,000	288,000	49,000	1950	58	2021	71	1968	24,000
S-105	758,000	406,000	42,000	1950	58	2016	66		
S-106	758,000	455,000	26,000	1950	58	2017	67		
S-107	758,000	358,000	42,000	1950	58	2019	69		
S-108	758,000	550,000	4,000	1950	58	2019	69		
S-109	758,000	533,000	16,000	1950	58	2018	68		
S-110	758,000	389,000	30,000	1950	58	2026	76		
S-111	758,000	401,000	42,000	1950	58	2026	76		
S-112	758,000	3,000	N/A	1950	58	2007	57		
SX-101	1,000,000	420,000	44,000	1953	55	2025	72		
SX-102	1,000,000	342,000	37,000	1953	55	2034	81		
SX-103	1,000,000	509,000	40,000	1953	55	2019	66		
SX-104	1,000,000	446,000	48,000	1953	55	2020	67	1988	6,000
SX-105	1,000,000	375,000	39,000	1953	55	2031	78		
SX-106	1,000,000	396,000	37,000	1953	55	2016	63		
SX-107	1,000,000	94,000	7,000	1953	55	2022	69	1964	5,000
SX-108	1,000,000	74,000	0	1953	55	2033	80	1962	35,000
SX-109	1,000,000	241,000	0	1953	55	2029	76	1965	10,000
SX-110	1,000,000	56,000	0	1953	55	2026	73	1976	5,500
SX-111	1,000,000	115,000	11,000	1953	55	2022	69	1974	2,000
SX-112	1,000,000	75,000	6,000	1953	55	2033	80	1969	30,000
SX-113	1,000,000	19,000	0	1953	55	2035	82	1962	15,000
SX-114	1,000,000	155,000	30,000	1953	55	2028	75	1972	Unknown
SX-115	1,000,000	4,000	0	1953	55	2018	65	1965	50,000
T-101	530,000	99,000	16,000	1943	65	2031	88	1992	7,500
T-102	530,000	32,000	3,000	1943	65	2032	89		
T-103	530,000	27,000	3,000	1943	65	2032	89	1974	1,000
T-104	530,000	317,000	31,000	1943	65	2016	73		
T-105	530,000	98,000	5,000	1943	65	2031	88		
T-106	530,000	22,000	0	1943	65	2032	89	1973	115,000
T-107	530,000	173,000	34,000	1943	65	2034	91	1984	Unknown
T-108	530,000	16,000	4,000	1943	65	2031	88	1974	1,000
T-109	530,000	62,000	11,000	1943	65	2032	89	1974	1,000
T-110	530,000	370,000	48,000	1943	65	2016	73		
T-111	530,000	447,000	38,000	1943	65	2015	72	1979	1,000

Tank	Tank capacity (gallons)	Total waste (gallons)	Drainable liquid (gallons)[a]	Year placed in service[b]	Age in 2008 (years)	Year scheduled for emptying[c]	Anticipated age when emptied of waste (years)	Year waste leaked	Waste leaked (gallons)[d]
T-112	530,000	67,000	4,000	1943	65	2034	91		
T-201	55,000	30,000	4,000	1943	65	2014	71		
T-202	55,000	20,000	3,000	1943	65	2014	71		
T-203	55,000	36,000	5,000	1943	65	2014	71		
T-204	55,000	36,000	5,000	1943	65	2014	71		
TX-101	758,000	91,000	7,000	1947	61	2029	82		
TX-102	758,000	217,000	27,000	1947	61	2026	79		
TX-103	758,000	145,000	18,000	1947	61	2030	83		
TX-104	758,000	69,000	9,000	1947	61	2031	84		
TX-105	758,000	576,000	25,000	1947	61	2026	79	1977	Unknown
TX-106	758,000	348,000	37,000	1947	61	2024	77		
TX-107	758,000	30,000	7,000	1947	61	2033	86	1984	2,500
TX-108	758,000	127,000	8,000	1947	61	2030	83		
TX-109	758,000	363,000	6,000	1947	61	2026	79		
TX-110	758,000	467,000	14,000	1947	61	2028	81	1977	Unknown
TX-111	758,000	364,000	10,000	1947	61	2028	81		
TX-112	758,000	634,000	26,000	1947	61	2026	79		
TX-113	758,000	638,000	18,000	1947	61	2022	75	1974	Unknown
TX-114	758,000	532,000	17,000	1947	61	2027	80	1974	Unknown
TX-115	758,000	553,000	25,000	1947	61	2026	79	1977	Unknown
TX-116	758,000	599,000	21,000	1947	61	2022	75	1977	Unknown
TX-117	758,000	480,000	10,000	1947	61	2027	80	1977	Unknown
TX-118	758,000	247,000	31,000	1947	61	2022	75		
TY-101	758,000	118,000	2,000	1951	57	2025	74	1973	1,000
TY-102	758,000	69,000	13,000	1951	57	2031	80		
TY-103	758,000	154,000	23,000	1951	57	2027	76	1973	3,000
TY-104	758,000	44,000	4,000	1951	57	2029	78	1981	1,400
TY-105	758,000	231,000	12,000	1951	57	2028	77	1960	35,000
TY-106	758,000	16,000	1,000	1951	57	2032	81	1959	20,000
U-101	530,000	23,000	4,000	1946	62	2036	90	1959	30,000
U-102	530,000	327,000	37,000	1946	62	2033	87		
U-103	530,000	417,000	33,000	1946	62	2018	72		
U-104	530,000	54,000	0	1946	62	2034	88	1961	55,000
U-105	530,000	353,000	44,000	1946	62	2032	86		
U-106	530,000	170,000	36,000	1946	62	2016	70		

Tank	Tank capacity (gallons)	Total waste (gallons)	Drainable liquid (gallons)[a]	Year placed in service[b]	Age in 2008 (years)	Year scheduled for emptying[c]	Anticipated age when emptied of waste (years)	Year waste leaked	Waste leaked (gallons)[d]
U-107	530,000	294,000	32,000	1946	62	2035	89		
U-108	530,000	434,000	46,000	1946	62	2025	79		
U-109	530,000	401,000	47,000	1946	62	2031	85		
U-110	530,000	176,000	16,000	1946	62	2028	82	1975	8,100
U-111	530,000	222,000	31,000	1946	62	2034	88		
U-112	530,000	45,000	4,000	1946	62	2035	89	1980	8,500
U-201	55,000	4,000	1,000	1946	62	2015	69		
U-202	55,000	4,000	0	1946	62	2015	69		
U-203	55,000	3,000	0	1946	62	2015	69		
U-204	55,000	3,000	0	1946	62	2016	70		
Total		**29,813,000**	**2,744,000**						**903,250**

Source: DOE.

[a]Drainable liquids refers to waste in the tanks that is in liquid form but remains trapped within more solid waste forms; N/A refers to tanks from which waste has been or is being retrieved.

[b]In cases where available data indicate a range of dates, this date represents the earliest date.

[c]This date reflects DOE's 2007 approved project baseline. These dates were under renegotiation with Ecology and EPA as of May 2008.

[d]When DOE's data indicated a range of amounts, we list the larger amount. "Unknown" indicates that although the precise volume of waste leaked from the tank is unknown, it is likely to be less than 2,000 gallons per tank.

Appendix III: Capacity, Age, and Retrieval Schedule for Hanford's Double-Shell Tanks as of February 2008

Tank	Tank capacity (gallons)	Total waste (gallons)	Year placed in service[a]	Age in 2008 (years)	Year scheduled for emptying[b]	Anticipated age when emptied of waste (years)
AN-101	1,160,000	1,141,000	1981	27	2042	61
AN-102	1,160,000	1,057,000	1981	27	2042	61
AN-103	1,160,000	958,000	1981	27	2042	61
AN-104	1,160,000	1,051,000	1981	27	2042	61
AN-105	1,160,000	1,125,000	1981	27	2042	61
AN-106	1,160,000	756,000	1981	27	2042	61
AN-107	1,160,000	1,092,000	1981	27	2042	61
AP-101	1,160,000	693,000	1986	22	2042	56
AP-102	1,160,000	1,087,000	1986	22	2042	56
AP-103	1,160,000	1,136,000	1986	22	2042	56
AP-104	1,160,000	491,000	1986	22	2042	56
AP-105	1,160,000	1,137,000	1986	22	2042	56
AP-106	1,160,000	1,131,000	1986	22	2042	56
AP-107	1,160,000	1,122,000	1986	22	2042	56
AP-108	1,160,000	1,246,000	1986	22	2042	56
AW-101	1,160,000	1,131,000	1980	28	2042	62
AW-102	1,160,000	572,000	1980	28	2042	62
AW-103	1,160,000	1,093,000	1980	28	2042	62
AW-104	1,160,000	1,064,000	1980	28	2042	62
AW-105	1,160,000	415,000	1980	28	2042	62
AW-106	1,160,000	1,125,000	1980	28	2042	62
AY-101	1,000,000	898,000	1971	37	2042	71
AY-102	1,000,000	976,000	1971	37	2042	71
AZ-101	1,000,000	836,000	1975	33	2042	67
AZ-102	1,000,000	937,000	1975	33	2042	67
SY-101	1,160,000	1,106,000	1977	31	2042	65
SY-102	1,160,000	565,000	1977	31	2042	65
SY-103	1,160,000	740,000	1977	31	2042	65
Total		**26,681,000**				

Source: DOE.

[a]In cases where available data indicate a range of dates, this date represents the earliest date.

[b]This date reflects DOE's 2007 approved project baseline. These dates were under negotiation with Ecology and EPA as of May 2008.

Appendix IV: Comments from the Department of Energy

Department of Energy
Washington, DC 20585

JUN 1 8 2008

Gene Aloise, Director
Natural Resources and Environment
U.S. Government Accountability Office
Washington, DC 20548

Dear Mr. Aloise:

Thank you for the opportunity to review the draft report: NUCLEAR WASTE, DOE Lacks Critical Information Needed to Assess Its Tank Management Strategy at Hanford (GAO 08-793). The Department of Energy appreciates the opportunity to provide feedback on the assertions, conclusions, and recommendations in the report.

The report accurately states that the tank waste retrieval and treatment, and tank closure mission is complex and technically challenging. However, the Department of Energy does not agree with the report's conclusions that the Department lacks the necessary information to make informed decisions regarding tank integrity, waste retrieval, and treatment. The Department, working with its regulators and the Defense Nuclear Facility Safety Board (DNFSB), has conducted extensive characterization of tank contents, has resolved safety issues and closed applicable DNFSB recommendations (Recommendation 93-5), and has developed several technologies to perform tank waste retrievals from the single shell tanks. In its 2006 report, the National Academy of Sciences concluded that the Department's current knowledge of tank waste characteristics is adequate for waste retrieval, and recommended further characterization efforts after waste is retrieved from the single shell tanks and blended in the double shell tanks to facilitate waste treatment. Clearly, the Department will continue to improve present technologies and develop additional tools to improve retrieval efficiency while maintaining our commitment to safety. The Department will continue to assess tank integrity and will negotiate cleanup milestones with its regulators using tank risk information and sound estimates from the independently validated performance baseline.

The Department acknowledges that as the retrieval, treatment, and closure mission progresses, additional tank integrity monitoring, tank waste characterization, and retrieval technology development will be required. This is consistent with sound project management principles, where longer term conceptual planning gives way to cost-effective detailed work planning for nearer term activities.

The Department is committed to managing the tanks and the waste they contain in a manner that is protective of human health and the environment. The Department has balanced the safe storage of waste with the recognition that waste treatment is required to most safety disposition the waste. We view the report's recommendations as consistent with the Department's ongoing and planned activities in tank integrity, risk management, and regulatory negotiations, and therefore as confirming that we are pursuing the appropriate course of action.

If you have any further questions, please call Frank Marcinowski, Deputy Assistant Secretary for Regulatory Compliance, at 202-586-8022.

Sincerely,

Inés R. Triay (Acting for)
Assistant Secretary
for Environmental Management

Enclosure

Appendix V: GAO Contact and Staff Acknowledgments

GAO Contact

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

Staff Acknowledgments

In addition to the individual named above, Janet E. Frisch, Assistant Director; Robert Alarapon; Ellen W. Chu; Doreen Eng; George W. Hinman; Richard Johnson; Karen Keegan; Nancy Kintner-Meyer; Jeff Larson; Mehrzad Nadji; Omari Norman; Thomas Perry; and John Smale made key contributions to this report.

Related GAO Products

Hanford Waste Treatment Plant: Department of Energy Needs to Strengthen Controls over Contractor Payments and Project Assets. GAO-07-888. Washington, D.C.: July 20, 2007.

Nuclear Waste: DOE Should Reassess Whether the Bulk Vitrification Demonstration Project at Its Hanford Site Is Still Needed to Treat Radioactive Waste. GAO-07-762. Washington, D.C.: June 12, 2007.

Hanford Waste Treatment Plant: Contractor and DOE Management Problems Have Led to Higher Costs, Construction Delays, and Safety Concerns. GAO-06-602T. Washington, D.C.: April 6, 2006.

Nuclear Waste: Absence of Key Management Reforms on Hanford's Cleanup Project Adds to Challenges of Achieving Cost and Schedule Goals. GAO-04-611. Washington, D.C.: June 9, 2004.

Nuclear Waste: Challenges to Achieving Potential Savings in DOE's High-Level Waste Cleanup Program. GAO-03-593. Washington, D.C.: June 17, 2003.

Nuclear Waste: Department of Energy's Hanford Tank Waste Project—Schedule, Cost, and Management Issues. GAO/RCED-99-13. Washington, D.C.: October 8, 1998.

Nuclear Waste: Management and Technical Problems Continue to Delay Characterizing Hanford's Tank Waste. GAO/RCED-96-56. Washington, D.C.: January 26, 1996.

Nuclear Waste: Further Improvement Needed in the Hanford Tank Farm Maintenance Program. GAO/RCED-95-29. Washington, D.C.: November 8, 1994.

Nuclear Waste: Hanford Tank Waste Program Needs Cost, Schedule, and Management Changes. GAO/RCED-93-99. Washington, D.C.: March 8, 1993.

Nuclear Waste: Hanford Single-Shell Tank Leaks Greater Than Estimated. GAO/RCED-91-177. Washington, D.C.: August 5, 1991.

Nuclear Waste: Problems and Delays with Characterizing Hanford's Single-Shell Tank Waste. GAO/RCED-91-118. Washington, D.C.: April 23, 1991.

Nuclear Energy: Consequences of Explosion of Hanford's Single-Shell Tanks Are Understated. GAO/RCED-91-34. Washington, D.C.: October 10, 1990.

Nuclear Waste: DOE's Program to Prepare High-Level Radioactive Waste for Final Disposal. GAO/RCED-90-46FS. Washington, D.C.: November 9, 1989.

Nuclear Waste: DOE's Management of Single-Shell Tanks at Hanford, Washington. GAO/RCED-89-157. Washington, D.C.: July 18, 1989.

Progress and Problems in Programs for Managing High-Level Radioactive Wastes, Atomic Energy Commission. Washington, D.C.: January 29, 1971.

Observations Concerning the Management of High-Level Radioactive Waste Material. Washington, D.C.: May 29, 1968.

GAO's Mission

The Government Accountability Office, the audit, evaluation, and investigative arm of Congress, exists to support Congress in meeting its constitutional responsibilities and to help improve the performance and accountability of the federal government for the American people. GAO examines the use of public funds; evaluates federal programs and policies; and provides analyses, recommendations, and other assistance to help Congress make informed oversight, policy, and funding decisions. GAO's commitment to good government is reflected in its core values of accountability, integrity, and reliability.

Obtaining Copies of GAO Reports and Testimony

The fastest and easiest way to obtain copies of GAO documents at no cost is through GAO's Web site (www.gao.gov). Each weekday, GAO posts newly released reports, testimony, and correspondence on its Web site. To have GAO e-mail you a list of newly posted products every afternoon, go to www.gao.gov and select "E-mail Updates."

Order by Mail or Phone

The first copy of each printed report is free. Additional copies are $2 each. A check or money order should be made out to the Superintendent of Documents. GAO also accepts VISA and Mastercard. Orders for 100 or more copies mailed to a single address are discounted 25 percent. Orders should be sent to:

U.S. Government Accountability Office
441 G Street NW, Room LM
Washington, DC 20548

To order by Phone:	Voice:	(202) 512-6000
	TDD:	(202) 512-2537
	Fax:	(202) 512-6061

To Report Fraud, Waste, and Abuse in Federal Programs

Contact:

Web site: www.gao.gov/fraudnet/fraudnet.htm
E-mail: fraudnet@gao.gov
Automated answering system: (800) 424-5454 or (202) 512-7470

Congressional Relations

Ralph Dawn, Managing Director, dawnr@gao.gov, (202) 512-4400
U.S. Government Accountability Office, 441 G Street NW, Room 7125
Washington, DC 20548

Public Affairs

Chuck Young, Managing Director, youngc1@gao.gov, (202) 512-4800
U.S. Government Accountability Office, 441 G Street NW, Room 7149
Washington, DC 20548

PRINTED ON RECYCLED PAPER