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Report to the Chairman, Environment, Energy, and Natural Resources Subcommittee, Committee on Government Operations, House of Representatives

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NUCLEAR WASTE

Problems and Delays With Characterizing Hanford's Single-Shell Tank Waste

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Resources, Community, and
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The Honorable Mike Synar
Chairman, Environment, Energy,
and Natural Resources Subcommittee
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

You expressed concern that the Department of Energy (DOE) does not know enough about the high-level radioactive wastes stored in 149 underground single-shell tanks at DOE's Hanford Site near Richland, Washington, to determine appropriate disposal options or to develop technologies for retrieving the wastes from the tanks and treating them. Therefore, you asked us to review the current status of DOE's efforts to characterize the single-shell tank wastes, including any impediments, such as technological limitations and safety considerations.[1] Characterization is the first major step in disposing of the single-shell tank wastes; it involves determining through sampling and analysis the physical, chemical, and radiological constituents of the wastes in each tank.

Results in Brief

Although the Hanford Federal Facility Agreement and Consent Order—an agreement between DOE, the Environmental Protection Agency (EPA), and the state of Washington to bring Hanford into compliance with applicable environmental laws—stipulates that waste characterization must be completed by September 1998, DOE is unlikely to meet this milestone. The initial sampling efforts to characterize the single-shell tank wastes have not progressed as rapidly as anticipated, and DOE must still resolve safety problems associated with retrieving samples from tanks containing potentially explosive wastes.

More importantly, meeting the 1998 milestone was predicated on limiting sampling to two samples per tank; however, the agreement left open whether two samples per tank would provide enough information for decision-making. Both our evaluation of the variance in samples analyzed to date and the statements of DOE and Westinghouse officials suggest that two samples are not likely to provide a sufficient basis for making informed decisions. To resolve this issue, DOE is conducting

[1]Previously, as part of this effort, we reported on one major safety issue—the potential consequences of a chemical explosion in some of the tanks—Nuclear Energy: Consequences of Explosion of Hanford's Single-Shell Tanks Are Understated (GAO/RCED-91-34, Oct. 10, 1990).

studies that take into account the risks to workers and the public of disposing of the single-shell tank wastes. These studies should lead to agreement on the amount of sampling and analysis needed to reach defensible decisions and on the eventual schedule for characterization.

It is critical to obtain data that will be useful and adequate, even if the 1998 milestone is missed, because the ultimate decision on single-shell tank waste disposal has significant cost implications. In 1988, DOE estimated that disposal of Hanford's single-shell tank waste could range from $1 billion to $11 billion, depending on the amount of waste that must be removed from the tanks and treated for off-site disposal.

Background

The Hanford Site, located on the Columbia River in southeastern Washington State, is operated by the Westinghouse Hanford Company for DOE. Established in 1943, this major DOE facility, among other activities, has reprocessed spent reactor fuel to recover plutonium for the national defense program. This process produced a large volume of highly radioactive, heat-producing liquid and chemically toxic liquid wastes.

Underground storage tanks were built to temporarily store these wastes until a more permanent disposal solution could be found. The first underground storage tanks consisted of a single carbon-steel liner surrounded by reinforced concrete. Over the years, 149 single-shell storage tanks were constructed; these now contain about 37 million gallons of liquid and solid wastes. Later, 28 double-shell tanks—that is, a carbon-steel tank within a carbon-steel liner surrounded by reinforced concrete—were built.

According to DOE, the available historic records of single-shell tank wastes are not adequate for determining accurately the concentrations of the waste constituents or for developing waste retrieval and treatment technologies. Activities occurring during storage—including the cascading of waste (that is, its flowing by gravity) from one tank to another, the addititon of nonradioactive chemicals to settle out specific radionuclides in order to permit removal of the remaining liquid, and naturally occurring chemical and radiation-induced processes within the tanks—further complicate understanding the specific waste constituents in any given tank. As a result, the single-shell tanks and many of the double-shell tanks contain a complex intermingling of unknown waste constituents.

In 1987, DOE issued an environmental impact statement (EIS) covering Hanford's defense wastes.[2] The EIS presented alternatives for the final disposal of the single-shell tanks' structures and wastes. As the result of agency and public comments on the EIS, DOE concluded in April 1988 that until the characteristics of the single-shell tank wastes were fully understood, it could not determine final disposal options.

In May 1989, DOE, EPA, and the Washington State Department of Ecology (Ecology) signed the Hanford Federal Facility Agreement and Consent Order, commonly referred to as the Tri-Party Agreement. This agreement represents a comprehensive effort to bring the Hanford Site into compliance with the Resource Conservation and Recovery Act of 1976 (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).[3] According to DOE, EPA and Ecology required a maximum 30-year cleanup schedule unless DOE could demonstrate that for technical reasons the schedule was not achievable. Although earlier DOE planning documents had called for a later target date (2030), DOE committed itself to the 30-year schedule with the understanding that mid-course corrections might be needed as new information was developed.

The Tri-Party Agreement contains numerous interim milestones to ensure DOE's continued progress toward meeting the 30-year cleanup milestone. With respect to characterizing the single-shell tank wastes, the agreement established a series of interim sampling milestones, beginning with taking a minimum of 15 core samples from two tanks by December 1989, and continuing with retrieving and analyzing at least two core samples from each of the remaining single-shell storage tanks by September 1998.[4] (App. I lists the Tri-Party Agreement sampling milestones.) The agreement stated that two samples per tank may be adequate to support a decision to remove the tank wastes for treatment and ultimate disposal. However, according to the agreement, additional sampling will be required beyond September 1998 to support any decision to leave tank wastes in place. The information obtained from sampling the tank wastes will be used to prepare a supplemental EIS for the

[2]Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Department of Energy, DOE/EIS-0113 (Hanford Site, Richland, Washington: Dec. 1987).

[3]The agreement incorporated by reference CERCLA's Superfund Amendments and Reauthorization Act of 1986 and RCRA's Hazardous and Solid Waste Amendments of 1984.

[4]A core sample is the entire sample of waste taken from the top to the bottom of the tank. It is obtained by taking successive multiple core "segment samples" using a hollow core drill bit 19 inches long and approximately 1 inch in diameter.

disposal of the Hanford single-shell tank wastes. DOE is committed to issuing a draft supplemental EIS by June 2002.

The ultimate decision as to how the single-shell tank wastes will be disposed of has significant cost implications. In 1988, DOE estimated that in-place disposal of all wastes would cost $1 billion, compared with $11 billion if the wastes must be removed from all of the tanks and treated for off-site disposal. According to that 1988 estimate, if one-half of the tanks were dealt with by in-place disposal, the total disposal cost would be about $7 billion.

Efforts to Develop a Waste Characterization Plan

Concurrent with DOE's negotiating the Tri-Party Agreement with Ecology and EPA, Westinghouse developed a draft waste characterization plan to guide its sampling effort. In February 1989, Westinghouse outlined a two-phase sampling program to obtain information for decisions on disposal alternatives. The information obtained under Phase I of the program was intended to provide sufficient tank waste information to (1) reach a preliminary decision on whether the wastes can be left in place or must be retrieved for treatment and off-site disposal and (2) obtain information required for developing technologies to retrieve and treat waste. In Phase II, beginning after September 1998, additional characterization would be performed for "leave" candidate tanks (that is, tanks in which the wastes would be left) to verify the acceptability of an in-place disposal method and to satisfy any remaining regulatory or permitting requirements.

To begin the Phase I effort, Westinghouse was to obtain and analyze a minimum of 15 core samples from two tanks assumed to contain a soft "peanut butter-like" waste. The analytical results from these cores would then be incorporated into Westinghouse's ongoing studies, which use a systems analysis approach,[5] to better define the Phase I sampling program. The initial sampling effort was also expected to provide information concerning the accuracy of sampling techniques, the capability of the analytical laboratory procedures to deal with the mixed wastes, and the types and quantities of wastes in the tanks.

Westinghouse initially estimated that the cost to analyze each core sample was about $200,000. Subsequent changes to the draft waste

[5]A systems approach is a structured process for solving a problem by defining the goals and requirements for solving the problem, identifying and evaluating alternative solutions, and documenting why the preferred alternative was chosen.

characterization plan, in response to comments made by a panel of experts from the National Academy of Sciences and officials from Ecology, raised the estimated cost to approximately $430,000 per core sample. The principal change involved analyzing each 19-inch core sample segment, in addition to analyzing a composite sample as originally planned.[6]

Problems Delayed Completion of the Initial Characterization Phase

Because of several unanticipated events, Westinghouse was not able to evaluate the data obtained from the initial samples in time to develop a revised waste characterization plan for the remaining 147 single-shell tanks by November 1990 as scheduled. Although 16 core samples were retrieved by April 1990, only eight data packages[7] had been reviewed and approved by Westinghouse's Office of Sample Management in time to support revising the waste characterization plan. According to DOE Richland and Westinghouse officials, the initial delays occurred for the following principal reasons:

- One of the first two tanks unexpectedly contained dense saltcake material that clogged the sampler equipment.[8] Therefore, 23 of the 32 core segments that Westinghouse retrieved from this tank contained less waste than needed for the analytical procedures. Westinghouse efforts to develop a sampler that can penetrate hard waste and retain the dense material continue, but because of funding cuts, this sampler may not be available in fiscal year 1992 as planned.
- Westinghouse was unable to perform some analytical procedures because of unanticipated procedural problems. For example, the measurement of the amount of nickel in the waste was inaccurate because the container that held the waste sample while it was being prepared for analysis was manufactured of a material that included nickel. Nickel from this container leached into the waste sample, making it impossible to determine how much nickel had originally been in the waste. Westinghouse estimated that about $1 million would be needed in fiscal year 1991 for developing several new analytical procedures. Westinghouse

[6]A composite sample is prepared by mixing together a sample from each core segment.

[7]A data package consists of the raw and processed data from the analytical procedures performed to characterize the wastes in each core sample. The voluminous data package—about 2,000 pages—is intended to provide sufficient documentation to adequately support any disposal decisions that will be presented in the supplemental EIS.

[8]Saltcake is the damp, crystallized solid material left after water has drained or evaporated from the waste solutions.

officials said in February 1991 that none of the development efforts for analytical procedures were funded.

- Materials used in obtaining the samples from the tanks contaminated the waste in the samples. As a result, EPA-prescribed screening procedures for measuring the quantities of volatile and semivolatile organics in the wastes did not work. Westinghouse officials told us that efforts to resolve this sampling problem were not funded in fiscal year 1991.
- Westinghouse significantly underestimated both the amount of documentation needed and the time required to prepare data packages to adequately support decisions on disposing of single-shell tank wastes. According to Westinghouse officials, preparing future data packages should take less time because both the package format and content have now been established.

As a result of these problems, Westinghouse did not have enough information in November 1990 to develop a revised waste characterization plan for the balance of the single-shell tanks as planned. Therefore, in order to continue progress toward meeting the Tri-Party Agreement sampling schedule, DOE obtained Ecology and EPA concurrence to develop an interim waste characterization plan to cover only those tanks to be sampled during 1991.

The 1991 sampling schedule, however, may also be in jeopardy. According to the Westinghouse Project Manager for Waste Management Technologies, single-shell tank resources, including personnel and the only tank sampling truck, were diverted in February 1991 to address higher priority double-shell tank safety issues. He said this diversion will delay the scheduled May 1991 sampling of two single-shell tanks until September 1991 and could affect other sampling milestones as well. The Project Manager said that a Waste Tank Core Sampling Committee has been established to evaluate all of the Hanford sampling programs, as well as the need for additional equipment and laboratory capacity. The committee plans to develop an integrated sampling plan and schedule for all Hanford sampling programs by the end of March 1991. This action, according to the Project Manager, will ensure that when a Tri-Party Agreement milestone is established, it will be compatible not only with the single-shell tank characterization effort but also with all other Hanford sampling activities.

DOE and State Must Still Agree on a Sampling Plan

In agreeing to the September 1998 Tri-Party Agreement milestone, DOE assumed that only two core samples per tank would be taken. However, according to Westinghouse officials, the number of cores as well as the number of analyses required to adequately characterize the wastes in the tanks will not be known until the analytical results of the first 15 samples are evaluated. At that time, the analytical results will be incorporated into ongoing systems analysis studies, which will then provide the technical basis for agreeing on a revised waste characterization plan. If the revised plan increases the sampling required, both the 1998 Tri-Party Agreement milestone date and the estimated cost to complete the sampling program could be affected.

In a written response to our questions on the current assessment of key characterization planning assumptions, Westinghouse officials said:

> Although ongoing evaluations are not yet complete, it is currently believed that characterization programs based on one or two cores per tank will not likely improve the current SST [single-shell tank] waste inventory data base such that tank-by-tank remediation decisions can be made with adequate CONFIDENCE.

Further, with respect to the types of analyses to be performed—core segment versus core composite—Westinghouse officials said:

> The current technical judgment is that the most cost-effective way to reduce uncertainties associated with inventory estimates (and therefore to reduce the potential for remediation decision errors) is to perform analyses on composites of cores rather than on individual core segments.

Our evaluation of the analytical results from three core samples taken from one of the first two tanks shows that tank waste concentrations vary significantly not only between different cores (horizontal variation) but also between different segments of the same core (vertical variation). For example, we found large vertical variations in concentrations for several constituents. Further, although horizontal variations in concentrations were relatively small for many constituents, for other constituents, the variations were very large. The large vertical and horizontal variations in concentrations of important constituents, at least in this one tank, emphasize the difficulty in characterizing the wastes by analyzing a small number of core samples.

The ongoing systems analysis studies will provide the information needed to better define and establish milestones for the single-shell tank waste characterization program. These studies take into account (1)

public and worker risk, (2) the uncertainty in tank waste characterization methods and how that uncertainty translates into potential errors in making remediation decisions, and (3) regulatory requirements for designing and operating the remedial system and for characterizing the wastes. The results of these studies, which incorporate the analytical results of the initial core samples, will provide the technical basis for reaching agreement with Ecology on the types of analyses to be performed, the data to be obtained, and the likely number of samples to be retrieved in the waste characterization program. The waste characterization plan will then be revised to incorporate agreements reached. Because of the many unknowns involved, Ecology and EPA officials believe that it may take 2 or 3 years to develop a revised waste characterization plan for sampling the balance of the single-shell tanks.

Although the systems analysis studies are not yet complete, several sampling scenarios being evaluated would increase the number of samples to be taken and the number of analyses to be performed. Therefore, adopting any one of these scenarios could affect both the 1998 Tri-Party Agreement milestone date and the estimated cost to complete the first phase of the sampling program. For example, Westinghouse's preliminary assessments indicate that the 1998 milestone date would not change (1) if core composite analyses were performed on three cores per tank or (2) if core segment analyses were performed on two cores as currently planned. However, if each segment of the three cores had to be analyzed, completing the initial characterization phase would require an additional 4 years. Segment analyses of four core samples, on the other hand, would add 6 years to the characterization schedule. Although no cost figures for the various sampling scenarios have been developed to date, any additional analyses will likely result in higher costs.

Safety Concerns Must Still Be Resolved

In October 1990, DOE stopped sampling all Hanford underground storage tanks until it could demonstrate that the sampling procedures would not cause an unsafe condition. The major concern was that the sampling equipment could cause a spark or increase the temperature in those tanks containing potentially explosive hydrogen gas or ferrocyanide materials. DOE officials believe that 47 of the 149 single-shell tanks contain either hydrogen gas or ferrocyanide materials.

As mentioned previously, a hard crust (saltcake) in one of the first two tanks that were sampled clogged the core sampler's hollow drill bit during retrieval operations. Subsequent testing of the drill bit on simulated waste indicated that this hard crust caused the drill bit to spin in

place, rather than move down through the waste, resulting in temperatures in the immediate area of the drill bit as high as 475° Centigrade (887° Fahrenheit). This temperature is considerably above the lowest temperature (446° F) observed for a ferrocyanide reaction in preliminary testing.

Westinghouse initiated several studies to resolve problems encountered in retrieving samples in hard waste. The results of these studies, which are being performed by Battelle Pacific Northwest Laboratories at Richland and by the Los Alamos National Laboratory, are expected to be issued by March 1991. At that time, Westinghouse will conduct a readiness review of the revised sampling procedures to insure that those tanks containing hard waste can be sampled safely.

Completing the waste characterization will depend on resolving safety problems associated with potentially explosive wastes. In addition, a key assumption of the various scenarios being evaluated in the systems analysis studies is that equipment, facilities, and personnel will be available when needed to support the characterization process. However, competing demands for scarce resources, caused by safety concerns, have already delayed some interim milestones. Specifically, DOE recently diverted both equipment and personnel from the single-shell tank characterization effort to address safety problems in the double-shell tanks.

Conclusions

Because of the many issues that must be resolved, DOE is unlikely to complete the Phase I characterization of the single-shell tank wastes by 1998. Principal among these issues are the number of samples that must be taken and the kind of analysis to which these samples must be subjected to produce sufficient data to decide whether the waste must be retrieved or left in place. Meeting the 1998 milestone was predicated on limiting sampling to two samples per tank; however, the Tri-Party Agreement left open the issue of whether two samples per tank would provide enough information, even for decisions to retrieve wastes. Both our analysis of the variance in samples analyzed to date and the statements of DOE and Westinghouse officials support the view that two samples are not likely to provide an adequate basis for making informed decisions.

Given these uncertainties, we believe that DOE is correct in pursuing its systems analysis approach. This approach, which takes into account the risks to workers and the public of disposing of the single-shell tank

wastes, should lead to a balanced decision on how to proceed with sampling: It should lead to agreement on the amount of sampling and analysis needed to reach defensible decisions and the eventual schedule for characterization. It is critical to obtain a clear understanding of whether the data collected will be useful and adequate, even if currently scheduled milestones are missed.

Completing the waste characterization will depend on resolving safety problems associated with potentially explosive wastes. DOE must also solve other problems, such as allocating scarce sampling equipment, that might arise as additional work is performed. In an undertaking this complex, it is not unreasonable to expect more delays. However, a steady flow of resources to this effort is needed so that essential studies can be undertaken in a timely manner and facilities and equipment be made available when needed.

As you requested, we did not obtain official DOE comments on this report. However, we discussed the facts presented in the report with DOE officials. DOE generally concurred with the facts.

We performed our review between August and December 1990 in accordance with generally accepted government auditing standards. Technical assistance in performing this review was provided by Dr. George W. Hinman, D.Sc. Dr. Hinman, currently Director of the Office of Applied Energy Studies at Washington State University, has worked for 40 years in the nuclear energy field in industry, government, and academia.

To assess DOE's efforts to characterize the wastes stored in the underground single-shell tanks at Hanford, we interviewed cognizant officials at DOE, Westinghouse Hanford Company, Washington State Department of Ecology, and EPA. We also discussed with them any impediments to completing the characterization effort as planned, such as the explosive potential posed by some of the tanks. We reviewed DOE contractor procedures for determining the characteristics of the material stored in the single-shell tanks. We also reviewed the Tri-Party Agreement and several of the systems engineering/analysis studies, such as the Single-Shell Tank Systems Technical Support Program Plan, that have been prepared to date.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from

the date of this letter. At that time, we will provide copies to DOE and other interested parties upon request.

Please call me at (202) 275-1441 if you have any questions. Major contributors to this report are listed in appendix II.

Sincerely yours,

Victor S. Rezendes
Director, Energy Issues

Current Single-Shell Tank Sampling Milestones

The Tri-Party Agreement sampling milestones agreed to with the Washington Department of Ecology (Ecology) and the Environmental Protection Agency (EPA) are as follows.

Milestone	Date	Activity
M-10-01	March 1989	Submit draft waste characterization plan to National Academy of Sciences, Ecology, and EPA
M-10-02	May 1989	Submit waste characterization plan to Ecology for approval
M-10-03	December 1989	Obtain 15 cores from 2 tanks
M-10-04	December 1990	Obtain 4 cores from 2 tanks
M-10-05	September 1991	Obtain 16 cores from 8 tanks
M-10-06	September 1992	Obtain 24 cores from 12 tanks
M-10-07	September 1993	Obtain 24 cores from 12 tanks
M-10-08	September 1994	Obtain 44 cores from 22 tanks
M-10-09	September 1995	Obtain 48 cores from 24 tanks
M-10-10	September 1996	Obtain 48 cores from 24 tanks
M-10-11	September 1997	Obtain 48 cores from 24 tanks
M-10-12	September 1998	Obtain 38 cores from 19 tanks
Total		**Obtain 309 cores from 149 tanks**

On February 11, 1991, the Manager, Waste Management Technologies, Westinghouse Hanford Company, told us that the December 1990 scheduled samples were not obtained. He also said that a revised sampling schedule would not be determined until the end of March 1991. At that time the Westinghouse Committee on Waste Tank Core Sampling will provide its recommended integrated sampling schedule for the Hanford Site.

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