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Report to Congressional Requesters

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NUCLEAR WASTE

DOE's Management of Single-Shell Tanks at Hanford, Washington

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Resources, Community, and
Economic Development Division

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July 18, 1989

The Honorable Brock Adams
United States Senate

The Honorable Jolene Unsoeld
House of Representatives

As requested, we reviewed the Department of Energy's (DOE) management of underground single-shell waste storage tanks at its Hanford, Washington, site. (Single-shell tanks are constructed with one steel wall and encased in concrete.) The tanks, first used at Hanford in 1944, contain highly radioactive and nonradioactive hazardous liquid and solid wastes from nuclear materials production. Hundreds of thousands of gallons of these wastes have leaked, contaminating the soil. A small amount of leaked waste has reached the groundwater. It is expected that more of the waste will reach the groundwater and the Columbia River. Specifically, we (1) reviewed DOE's efforts to monitor the movement of leaked waste from the single-shell tanks and assess the environmental effects of leaks and (2) examined some methods DOE could use to reduce the environmental impact of past leaks and the risk of future leaks.

Results in Brief

DOE does not collect sufficient data to adequately trace the migration of the leaks through the soil, and studies predicting the eventual environmental impact of tank leaks do not provide convincing support for DOE's conclusion that the impact will be low or nonexistent.

DOE can do more to minimize the environmental risks associated with leaks. To reduce the environmental impact of past leaks, DOE may be able to install better ground covering over the tanks to reduce the volume of precipitation that drains through the soil and carries contaminants toward groundwater. The environmental risk of future leaks could be reduced by accelerating the program to pump liquid from the single-shell tanks.

For more than 15 years, DOE's stated strategy for limiting the dangers associated with leaks from single-shell tanks has been to remove the liquid waste as soon as practicable. However, schedules to pump the liquid from the tanks have been repeatedly delayed. In May 1989, DOE signed a tri-party agreement with the Environmental Protection Agency (EPA) and Washington State that establishes a schedule to remove all feasibly pumpable liquid waste from single-shell tanks by September 1996.[1] The establishment, within a formal agreement, of a definitive date to complete the tank-pumping program may help ensure successful program completion. However, we believe that the agreement's 1996 date should not be used as a rationale to delay removal of liquid that could be pumped before 1996.

Background

Hanford's 149 single-shell tanks have capacities that range from about 55,000 to about 1 million gallons. They are covered with about 6 to 9 feet of soil topped with gravel and are clustered in 12 groups called tank farms. (See fig. I.1.) From 1959 through 1988, DOE officials identified definite or possible leaks in 66 of Hanford's 149 single-shell tanks—5 of the 66 tanks were identified in 1988. DOE contractor staff currently estimate that about 750,000 gallons have leaked. Recent estimates had ranged from 670,000 to 900,000 gallons. (See table I.1.)

DOE estimates that the single-shell tanks contained about 77 million gallons of liquid and solid waste in 1966, but this volume was reduced by October 1988 to about 37 million gallons, including about 8 million gallons of liquid. (See fig. II.1.) All tanks built at Hanford since 1968 have been double-shell tanks (concrete-encased tanks that have two steel shells), and DOE estimates that most of the liquid waste in single-shell tanks was reduced by pumping it into double-shell tanks or by evaporating the liquid and leaving the solid residue in the single-shell tanks.[2] Recent production activity at Hanford has resulted in about 8 million to 12 million gallons of waste being added to double-shell tanks annually. Evaporation processes reduce this amount to about 2 million to 4 million gallons.

Some radioactive and nonradioactive contaminants that leak from the tanks tend not to migrate through the soil very much because they attach to soil particles and essentially remain in place. However, other contaminants are more mobile and migrate more quickly because they do not adhere to soil particles. One DOE contractor study estimated the time required for contaminants to reach the groundwater ranges from several decades to several thousand years, depending on such things as

[1]In a draft of this report sent to several agencies for comment, we reported the date identified in the tri-party agreement to remove all feasibly pumpable liquid from the single-shell tanks was October 1995. However, two tanks are not scheduled to be pumped until 1996. This change has been incorporated here and on pages 3, 6, 7, 10, and 27.

[2]For the remainder of this report, the word "tank" and the term "single-shell tank" will be used interchangeably.

the volume of the leak, the extent to which the soil retards movement of the contaminants, the distance from the tank to the groundwater, and the amount of water draining through the soil where leaks have occurred.[3] (See table I.2.)

DOE completed an environmental impact statement in 1987 for disposal of most defense wastes at Hanford, but it deferred decisions on disposal of the remaining single-shell tank waste until the issuance of a supplemental environmental statement for this waste in about the year 2000. A May 1989 tri-party agreement—signed by DOE, EPA, and Washington State—calls for removal of feasibly pumpable liquid waste from single-shell tanks by 1996 and final disposal or removal of the remaining single-shell tank waste by 2018. Appendix III contains a chronology of major events in the tanks' history.

Better Data Needed to Assess Effects of Single-Shell Tank Leaks

As discussed below, there are serious limitations in DOE's efforts to assess the leaked wastes' movement through the soil and the environmental impact of past leaks. First, DOE has not collected adequate data upon which informed management decisions can be based or program priorities established concerning single-shell tank hazards or remedial actions required. And second, although DOE has maintained that the environmental impact of leaks will be extremely low or nonexistent, the studies we reviewed do not provide convincing evidence that this is the case.

Current Data-Gathering Techniques Inadequate

DOE has gathered extensive data about tank leaks, but its current monitoring efforts do not provide sufficient data to adequately trace the migration of the leaks or to fully assess their effects. DOE contractor scientists say that better waste migration data can be obtained through expanded use of current monitoring methods and through adoption of new methods.

According to DOE contractors, DOE traces the migration of tank leaks through the soil by monitoring the movement of ruthenium-106. However, DOE contractor scientists say that ruthenium-106 is not an adequate tracer, in part because it has a relatively short half-life (approximately 1 year) and is no longer measurable in many locations.[4]

[3]Precipitation at Hanford averages a little more than 6 inches a year.

[4]A half-life is the time required for a substance's radioactivity to decrease to half of its earlier level through radioactive decay.

They also say DOE could use additional methods to trace the movement of leaked long-lived mobile contaminants—radioactive contaminants such as technetium-99 (half-life about 230,000 years) and iodine-129 (half-life about 16 million years), and nonradioactive contaminants such as nitrates, chromium, and mercury. These contaminants should be monitored since they are more likely to reach groundwater in measurable concentrations than is ruthenium-106. DOE officials said that it is much more expensive to trace some of these contaminants than it is to trace ruthenium-106.

DOE could collect more complete data and better trace the mobile contaminants, according to contractor scientists, by (1) analyzing soil samples from beneath the tank farms for mobile contaminants that have not been monitored directly, (2) deepening dry wells in the tank farm areas that have had contamination at or near the bottom to determine how much farther contaminants may have penetrated toward the groundwater, and (3) increasing the number of groundwater monitoring wells to detect contamination from tank leaks.[5] DOE officials agree that more could be done, and it is developing a plan to study soil samples beneath the tank farms. However, there is no consensus on the merits of increased dry well or groundwater monitoring.

DOE contractor scientists have also noted that DOE needs to better determine the characteristics of the waste stored in and leaked from the tanks if it is to assess fully the impact of the tank leaks. For example, some waste products may accelerate contaminant migration through the soil, but DOE does not know to what extent these products are still present in the tanks. Some of these products may have been destroyed by radiation or heat, according to scientists. DOE currently plans to complete an initial determination of waste characteristics by September 1998 by collecting and analyzing 2 core samples from each of the 149 tanks.

DOE also needs more information about the soil between the tanks and the groundwater. One sediment layer below some tank farms, for example, could—depending on the type of waste—accelerate the migration of some contaminants and leave them relatively undiluted or could slow and disperse contaminants. However, the sediment layer's location has

[5] DOE contractor studies report that a small amount of leaked tank waste reached groundwater because of the drilling of a groundwater monitoring well in 1970. More recently, however, contractor scientists told us that there are insufficient data to confirm how the waste reached groundwater, and that there is some chance that the waste reached the water by normal migration through the soil.

not been adequately mapped, and its effects on waste migration have not been fully assessed.

Studies Are Inconclusive About Environmental Impact

DOE officials have stated that the environmental impact of the single-shell tank leaks will be low or nonexistent and have cited several studies as a basis for their assessment. However, we believe the studies do not provide conclusive evidence about the degree of environmental impact attributable to tank leaks. Some studies indicated there would be limited environmental impact, but they did not analyze the impact of several mobile contaminants on Hanford's groundwater. One study predicted groundwater contamination would exceed safe drinking water standards but did not project the impact on the Columbia River. Four of the studies we reviewed are discussed below.[6]

Three studies focused on the impact of radioactive substances leaking from the tanks. Two of these considered only substances that move so slowly through the soil that virtually all of them decay before they can reach groundwater. The third study addressed the potential radiological effects of leaks on the Columbia River and on surrounding populations but not on groundwater near the tanks. Only the third study included any discussion of the impact of nonradioactive substances.[7]

A fourth study reviewed 20 radioactive and nonradioactive contaminants that leak from the tanks and predicted that many substances will reach Hanford's groundwater and that several will be in concentrations greatly above the safe drinking water standards established by EPA and Washington State. However, this study did not project the impact on the Columbia River. On the basis of varying assumptions, this study concluded that peak concentrations of one radioactive contaminant (iodine-129) could reach groundwater as soon as 170 years or as late as 5,500 years, and at levels exceeding the safe drinking water standard by 4,800 and 31 times, respectively. According to the study, contaminant concentration levels and migration speeds are highly dependent on the volume

[6] R.C. Routson, et al., Rockwell Hanford Operations, "High-Level Waste Leakage From the 241-T-106 Tank at Hanford," Feb. 1979 (RHO-ST-14); DOE, Environment, Safety, and Health, Office of Environmental Audit, "Environmental Survey: Preliminary Summary Report of the Defense Production Facilities," Sept. 1988 (DOE/EH-0072); K.S. Murthy, et al., Pacific Northwest Laboratory, "Assessment of Single-Shell Tank Residual Liquid Issues at Hanford Site, Washington," June 1983 (PNL-4688); A.E. Reisenauer, Pacific Northwest Laboratory, "A Letter Report for Hanford Operations: Estimated Impacts of Extending the Salt Well Pumping Program," July 22, 1986.

[7] The third study indicated that in a worst-case scenario the concentration of leaked nitrates in the groundwater directly below a tank farm could be as high as about 67 times the drinking water standard.

of water that drains through the soil. (See table I.2.) This study's conclusions sharply contrast with some DOE statements that the impact will be extremely low or nonexistent. However, the study does not provide conclusive answers about the environmental effects of tank leaks because its conclusions are based, as are the other studies, on unproven assumptions about such things as the characteristics of the waste in the tanks and of the soil beneath them.

DOE Can Do More to Minimize Risks Associated With Tank Leaks

DOE has reduced the volume of liquid waste in the single-shell tanks by solidifying a large volume of the liquid, primarily through evaporation, and by pumping liquid from the tanks. However, DOE can help to reduce the risk of future single-shell tank leaks by accelerating its program to pump liquid from the tanks and may help to minimize the risks associated with past leaks by providing better ground covering in the tank farm areas to minimize the volume of precipitation that drains through the soil and carries the contaminants toward the groundwater.

As early as 1973, DOE's stated strategy for limiting the danger from tank leaks was to remove the highly radioactive liquid waste as soon as technically and economically feasible and seal the tanks to prevent liquid, such as rainwater, from washing through them. According to DOE documents on waste volume projections (Sept. 1986-88), about 2 million gallons of single-shell tank waste could be pumped annually. In the May 1989 tri-party agreement, DOE agreed that all feasibly pumpable liquid waste (about 5.3 million gallons) would be removed from the single-shell tanks by 1996. We believe that the risk of environmental damage from future leaks makes it imperative that DOE follow its stated strategy to remove the liquid as soon as it is practicable. Although the agreement gives DOE until 1996 to complete the pumping program, the establishment of this target date should not be used to delay removal of any liquid that could be pumped before then.

The Tank-Pumping Program Has Been Repeatedly Delayed

To reduce the liquid in the single-shell tanks, DOE has sought to solidify the waste through evaporation and to pump liquid waste into double-shell tanks. By 1981 DOE had removed nearly all of the liquid that rested above the solid waste in the bottom of the tanks. DOE had planned to remove all liquid that could feasibly be pumped by September 1985—about 8.5 million gallons that was mostly interspersed within the solid waste. DOE did not meet this deadline and repeatedly extended the completion date for the program. From September 1985 through October

1988, DOE, with one exception,[5] limited the pumping program to tanks suspected of leaking. As of October 1988, about 5.3 million gallons of pumpable liquid remained in the tanks. (See fig. II.3.)

DOE delayed its pumping program in part because it allocated most of its available double-shell tank space through fiscal year 1993 for waste from ongoing production of nuclear materials. Additionally, some waste previously discharged to the soil is now stored in double-shell tanks, and space previously allocated for single-shell tank waste was reallocated to receive other wastes. However, in September 1988, a DOE contractor task force identified several options that, collectively, could make available an additional 7 million gallons of double-shell tank space. These options include further concentration of some double-shell tank waste, accelerating low-level waste disposal, and using alternative storage methods for some wastes. DOE officials said these options would require vigorous evaluation and they are being studied. DOE officials at Hanford said pumping-program delays also occurred because some scientists had concluded that the effects of tank leaks would be insignificant, and because DOE placed greater priority on funding other programs.

By 1987 DOE had established a revised schedule to complete the pumping program by September 1996, but, according to program officials, funding has not been adequate to meet this schedule. During the last 5 years, as shown in table II.1, funding allocations for programs to pump and seal the tanks have been, on average, about 5 percent of the amount requested by DOE officials at Hanford. In the May 1989 tri-party agreement, DOE agreed to seek the money necessary to pump the remaining 5.3 million gallons by September 1996. According to DOE officials, completion of pumping on this schedule is contingent on timely funding of about $56.3 million through fiscal year 1996.

New Ground Surface Material Could Slow Movement of Leaks

The movement of leaked waste toward the groundwater is determined to a great extent by how much water drains through the soil. A 1987 DOE contractor study noted that more water drained through the soil at a Hanford site where coarse material covered the ground surface than at those locations covered by vegetation or finely textured soil. Since coarse material (gravel) covers the ground surface at the tank farms, experiments are currently being conducted to determine if the same results occur in the tank farm areas.

[5]In 1986 DOE pumped 16,000 gallons from one tank that was not assumed to have leaked.

If DOE's final disposal plan involves leaving any waste at the tank farms, regulations established to implement the Resource Conservation and Recovery Act (42 U.S.C. 6901-6991) require that a permanent barrier (ground surface material) must be placed over the tank farms to minimize the amount of surface water that could drain through the soil. Because DOE does not plan to complete final disposal until at least 2018, some scientists have suggested the gravel over the tank farms be replaced with an interim surface material—such as finely textured soil planted with grass—in the intervening period to reduce water draining through the soil.

DOE and its contractor officials gave two reasons for not placing a new ground surface material over the tank farms. First, they said that monitoring data have not indicated a problem with accelerated movement of wastes. As discussed above, however, we believe DOE's current data cannot adequately demonstrate that no problem exists. Second, they said that data are needed on the volume of water that moves through the soil at gravel-covered and unvegetated sites near the tanks. In this regard, they told us that results from ongoing experiments should provide such data beginning about November 1989. They expect these experiments, like the 1987 study, will show that gravel surfaces in the tank farm areas allow greater volumes of water to drain through the soil than would surfaces covered by vegetation or finely textured soil.

Insufficient DOE Emphasis on Environmental Concerns

Since 1981 GAO has reported or testified many times on the environmental, safety, and health aspects of DOE's nuclear weapons complex. (See p. 33 for a partial listing of related GAO products.) We have presented information that demonstrates, and DOE's studies concur, that DOE has emphasized the production of nuclear material to the detriment of environmental concerns. We did not evaluate DOE's production and environmental priorities for this report. However, some problems associated with the management of Hanford's single-shell tanks that we examined during this review are indicative of DOE's insufficient emphasis on environmental concerns:

- Scientists suggested as early as 1980 that DOE test soil samples from beneath the tank farms to improve its monitoring of certain mobile contaminants that have leaked from the tanks. However, as we discussed, DOE has not used readily available techniques to accomplish this.
- Single-shell tank leaks were first suspected in 1956 and confirmed in 1959, but wastes continued to be added to the tanks as late as November 1980. (See app. III.) According to DOE, waste was also added to some

tanks that were suspected of having leaked. DOE officials said that operational limits were placed on the amount of liquid placed in the tanks to keep the liquid below the point of the suspected tank breach.

- DOE's stated strategy for limiting the danger of future tank leaks is to pump the liquid into double-shell tanks whenever practicable. However, as we discussed, the pumping program has been repeatedly delayed, at least in part, because most of the available double-shell tank space is allocated through fiscal year 1993 to ongoing production programs.

Conclusions

DOE has not taken advantage of available techniques to track leaked contaminants or to predict their movement. Until DOE obtains better data, information about the impact of the tank leaks will continue to be inconclusive. DOE needs to, for example, trace the movement of the contaminants—such as technetium-99, iodine-129, nitrates, chromium, and mercury—that are more likely to reach groundwater in measurable concentrations than ruthenium-106.

We believe that available studies do not provide convincing support for DOE assertions that the environmental effects of tank leaks will be extremely low or nonexistent. To resolve uncertainty about the effects, DOE needs to obtain better data from the tank farms to support future study assumptions and validate study results.

The program to pump liquid from the single-shell tanks has often been delayed because insufficient space has been reserved in double-shell tanks for this purpose. Insufficient space allocation in the double-shell tanks has been the result, at least in part, of higher priorities being assigned to waste from ongoing production activities.

In view of the potential for long-term environmental damage from tank leaks, DOE needs to immediately develop specific plans to place an interim ground surface material over the tank farms. If the current experiments indicate that the gravel surfaces at the tank farms significantly affect water drainage through the soil, DOE would then be able to expeditiously replace the gravel surfaces in the tank farm areas.

Recommendations

To minimize the environmental effects of tank leaks on the surrounding soil and, eventually, on the groundwater, we recommend that the Secretary of Energy take the following actions:

- Conduct a data-gathering program sufficient to assess the risks and extent of groundwater contamination from tank leaks of mobile, nonradioactive contaminants and mobile, long-lived radioactive substances.
- Assign appropriate resources and priority to the single-shell tank pumping program to ensure that (1) at a minimum, all feasibly pumpable liquid is removed from the tanks by 1996 and (2) the 1996 goal is not used to delay removal of liquid that could be pumped before 1996.
- Develop specific plans to replace the gravel surfaces at the tank farms with a less permeable material and promptly replace the gravel surfaces if ongoing studies indicate that these surfaces could promote the movement of waste toward the groundwater.

Agency Comment and Our Response

EPA officials said the text on EPA was accurate and had no further comment. Washington State officials generally agreed with the report but disagreed with one conclusion. They said that it was too early to make decisions on a new interim ground covering in the tank farm area. A revision was made to the last conclusion to preclude any appearance of a prejudgment on the results of ongoing studies. However, since similar studies indicate that surfaces such as those in the tank farm areas may increase the movement of leaked waste toward groundwater, the thrust of the conclusion was not changed. Comments on the draft report from EPA and the Washington State Department of Ecology are reproduced in appendixes V and VI.

To obtain our information, we interviewed engineers, managers, and scientists at DOE headquarters, the DOE Hanford field office, Pacific Northwest Laboratory, Westinghouse Hanford Company, EPA, and the Washington State Department of Ecology. We also reviewed official files and published and unpublished reports. (See app. IV.)

Our review was conducted between August 1988 and March 1989, in accordance with generally accepted government auditing standards. We requested written comments from DOE, EPA, and Washington State's Department of Ecology. DOE did not provide written comments. However, we did obtain DOE's views on a statement of facts that pertained to information presented in this report and during a conference at the end of our review. These views have been incorporated where appropriate.

As arranged with your offices, unless you publicly announce its contents earlier, we plan no further distribution until 10 days from the date of this letter. At that time, we will provide copies to DOE and other interested parties upon request.

This report was prepared under the direction of Keith O. Fultz, Director of Energy Issues, who may be reached on (202) 275-1441, if you or your staff have any questions. Other contributors to this report are listed in appendix VII.

J. Dexter Peach
Assistant Comptroller General

Contents

Abbreviations

DOE	Department of Energy
EPA	Environmental Protection Agency
GAO	General Accounting Office

Background

This appendix provides background information on some of the features of a typical Hanford single-shell tank, the extent of leaks from the tanks, and one study's conclusions about the impact of these leaks on Hanford's groundwater. The Department of Energy (DOE)[1] assumes that 66 of the 149 single-shell tanks at Hanford have leaked, but data concerning the amount leaked from many tanks are inconclusive. According to the study, the time required for peak concentrations of leaked contaminants to reach groundwater, and the levels of those concentrations, are highly dependent upon the amount of water that drains through the soil each year (recharge rate).

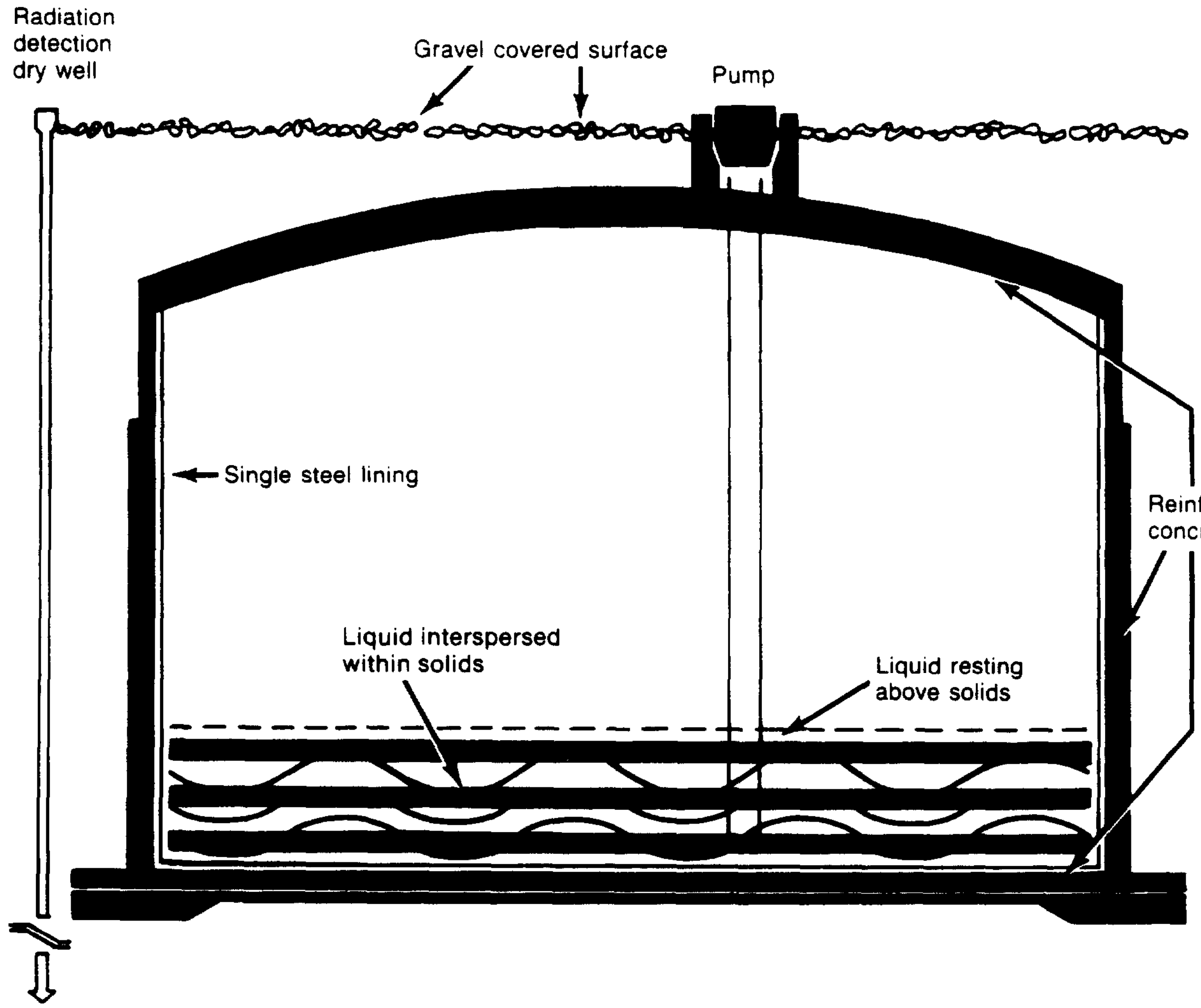
A Typical Single-Shell Tank

Figure I.1 shows some of the features of a typical Hanford single-shell tank that can hold 1 million gallons. Special pump equipment extends into wells created in the mostly solid waste. To detect leaks, DOE monitors the liquid levels in the tanks and measures levels of radiation in the dry wells near the tanks.

There are 25 single-shell underground waste storage tanks at Hanford with 1-million-gallon capacities. As of October 31, 1988, each of these tanks contained, on average, 280,000 gallons of waste—about 7,000 gallons of liquids resting above the solids (such as sludge and crystalline salt deposits) and about 87,000 gallons of drainable liquids interspersed in the solids.

[1] For convenience, we identify DOE throughout this discussion as the federal agency responsible for operations at Hanford. DOE was preceded in this responsibility by the Army Corps of Engineers (1943-46), the Atomic Energy Commission (1946-75), and the Energy Resources and Development Agency (1975-77).

Figure I.1: Cross-Section of a Typical Single-Shell Tank (Capacity of 1 Million Gallons)



Single-Shell Tanks That DOE Assumes Have Leaked

DOE cannot measure the liquid level in many tanks and depends on dry well monitoring to detect tank leaks and estimate the amount of leakage. According to DOE officials, the designation "assumed leaker" does not indicate the tank is currently leaking, but rather that DOE assumes the tank has leaked at some time. DOE's list of assumed leakers includes tanks in each of Hanford's 12 single-shell tank farms. Additionally, two of the four most recently constructed single-shell tanks are also on the assumed-leaker list. DOE estimates that the 149 single-shell tanks contain about 6.9 million gallons of drainable waste and, as shown in table I.1, about 1.2 million gallons of this waste remain in the 66 tanks that DOE has identified as assumed leakers. The volumes for tank leaks shown in table I.1 are based on estimates by DOE contractor staff. The other information in the table is based on DOE records.

Table I.1: Single-Shell Tanks at Hanford That DOE Assumes Have Leaked

		Thousands of gallons	
When identified as an assumed leaker	**Number of tanks**	**Estimated leakage**	**Drainable liquid[a] remaining in tanks assumed to have leaked**
1959-63	7	162	16
1964-68	5	90	44
1969-73	13	284	101
1974-78	30	180	831
1979-83	3	10	14
1984-88	8	17	188
Total	**66**	**743[b]**	**1,194[c]**

[a]Drainable liquid includes all liquid waste (as of October 1988) that could drain from the tanks because of gravity if the tanks ruptured. It does not include a portion of liquid waste that would adhere to the solid waste within the tanks.

[b]DOE contractor staff have rounded this figure to the nearest 50,000 gallons (750,000). The staff have no precise estimate of the amount of leakage from many individual tanks and, until recently, had estimated the total leakage could range from about 670,000 gallons to 900,000 gallons. The staff expressed relative confidence that 900,000 gallons was the uppermost figure but were less confident that 670,000 gallons was the lowermost figure.

[c]DOE estimates that about 600,000 gallons of this drainable waste could be pumped from six tanks. (See fig. II.4.)

Recharge Rate Can Significantly Affect Environmental Impact of Leaked Waste

The length of time required for peak concentrations of leaked tank contaminants to reach the groundwater and the level of the peak concentrations vary greatly depending on the annual recharge rate. Higher recharge rates reduce the time required for contaminants to reach groundwater. In the study upon which table I.2 is based, the highest annual recharge rate examined was 5 centimeters. (Average annual recharge rate at one Hanford site has since been estimated at about 10 centimeters.) The study assumed that a ground covering installed over the tank farms would reduce the annual recharge rate to 0.1 centimeter.

The study results presented in table I.2 were based on the impact of assumed leaks of 530,000 gallons from 27 tanks in 2 of Hanford's single-shell tank farms. The table is based on a study by a DOE contractor. The recharge rate of .1 centimeter for an installed ground covering is an assumed figure, and the actual figure could differ; but the study is valuable because it demonstrates that relatively minor differences in the recharge rate can greatly affect the environmental impact of tank leaks.

Table I.2: The Effect of the Annual Recharge Rate on Peak Levels of Contaminants in the Hanford Groundwater—Time of Arrival and Concentration

	Number of years after leak before peak concentration reaches groundwater[a] at an annual recharge rate of:			Peak concentration compared with drinking water standards (Predicted level of contamination is this many times the standard)[b] at an annual recharge rate of:		
Contaminant	**0.1 cm**	**0.5 cm**	**5.0 cm**	**0.1 cm**	**0.5 cm**	**5.0 cm**
Iodine-129	5,500	1,300	170	31	640	4 800
Technetium-99	5,500	1 300	160	22	478	4 111
Plutonium-239	20,000	5,000	700	1 3	41	429
Carbon-14	5,500	1,500	180	65	20	120
Uranium-238	5,500	1,700	180	11	1 3	6
Chromium	4,900	1,230	155	74	15	136
Nitrates	4,900	1 230	155	.06	1 3	12
Mercury	4,900	1 230	155	33	7	60

[a]This is the elapsed time between the occurrence of the tank leak and the arrival of peak concentrations in the groundwater 300 meters from the tank farms

[b]This is the predicted peak concentration of contaminants in the groundwater 300 meters from the tank farms as a multiple of drinking water standards set by the Environmental Protection Agency (EPA) and Washington State. Concentrations directly below the tank farms could be higher

DOE's Storage and Management of Hanford Single-Shell Tank Waste

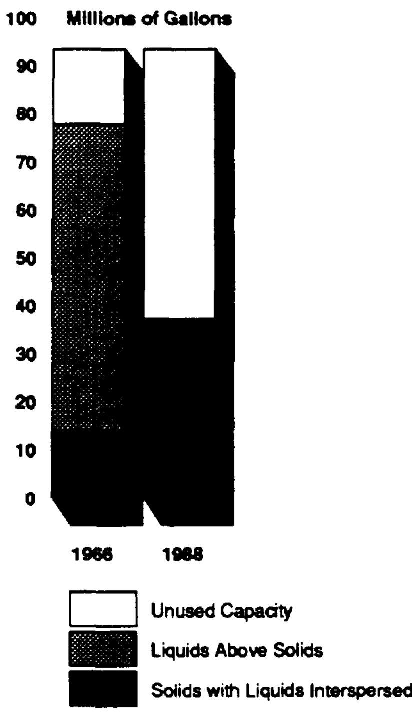
This appendix describes past DOE management of the single-shell tank liquid waste and the current status of that waste including the following:

- decrease in tank waste from 1966 to 1988,
- annual data on amounts pumped and amounts remaining in the tanks that could be pumped (1981-88),
- disposition of liquid waste in and around the tanks,
- amount of liquid that could be pumped from each of 43 tanks, and
- amount of money spent to pump and seal the tanks (1984-88).

Changes in Single-Shell Tank Waste Categories, 1966-88

Figure II.1 shows the decline in peak levels of both total waste and liquid waste stored in the tanks over the past 2 decades—from about 77 million gallons of mostly liquid waste to about 37 million gallons of mostly solid waste. The volume of solids increased (from 13.7 million gallons to about 36.2 million gallons) primarily because residue, such as salt deposits, left in the tanks from evaporation of liquid wastes has solidified. DOE continued to put waste into the tanks until 1980. Also, DOE placed solids into some tanks to help absorb the liquids. The amount of liquid resting above the solids declined from about 64 million gallons in 1966 to about 0.7 million gallons in 1988.

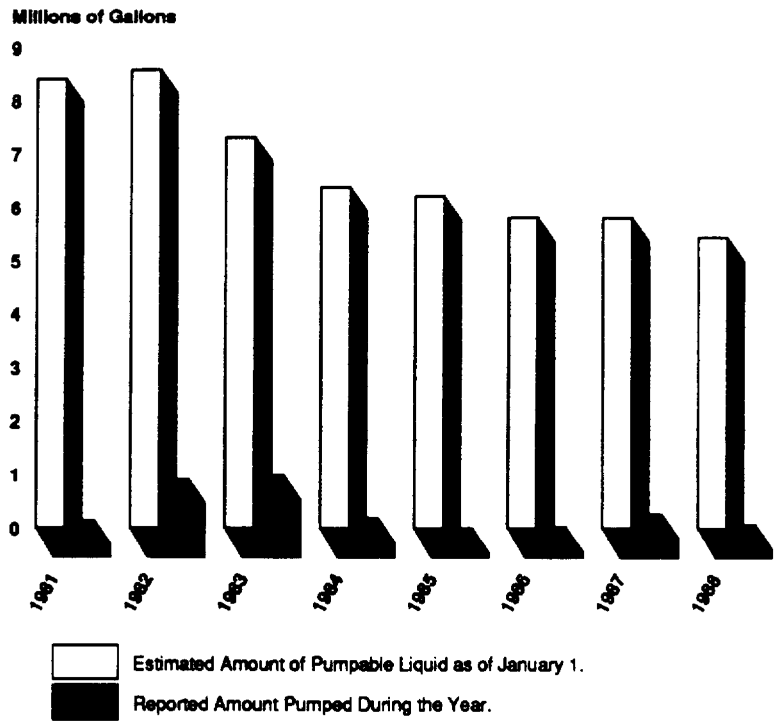
Figure II.1: Waste Stored in Hanford's Single-Shell Tanks, 1966-88



Tank-Pumping Progress Since 1981

As shown in figure II.2, the estimated amount of liquid in the tanks that could be feasibly pumped has declined since 1981, but the rate of decrease has been lower since 1985. Scheduled pumping ended in August 1985, and, with one exception, DOE has pumped liquids since August 1985 only from tanks with suspected leaks. (DOE pumped about 16,000 gallons from one tank in 1986 that was not suspected of leaking.)

Figure II.2: Estimated Amount of Pumpable Liquid in Single-Shell Tanks and Reported Amount Pumped Each Year, 1981-88



Notes:
Most but not all of the decline in the estimated amount of pumpable liquid from 1981 through 1988 resulted from DOE's pumping. The reported amount pumped during this period was about 2.5 million gallons (about 80 percent of the decline).

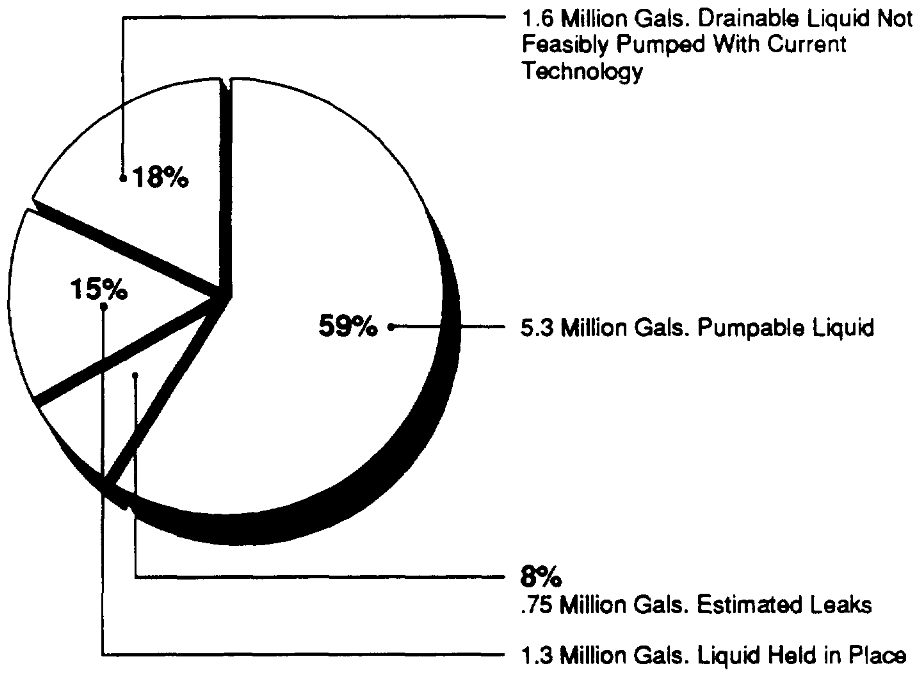
Although DOE pumped liquid from five single-shell tanks in 1985, the amounts were not reported

Most of the change in the volume of pumpable liquid volume is attributable to DOE's pumping program (about 2.5 million gallons pumped since 1981). According to a DOE contractor, most of the other changes are due to changes in methods to estimate and report the amount of pumpable liquid in the tanks. According to this contractor, evaporation of the waste, leaks of liquid out of the tanks, and leaks of water (such as rainwater) into the tanks, have had a minimal effect.

Liquid Waste Stored in and Leaked From Single-Shell Tanks

As of October 1988, the tanks contained about 8.2 million gallons of liquid waste. About 6.9 million gallons of that waste could drain into the soil through tank ruptures. However, as shown in figure II.3, DOE estimates that only 5.3 million gallons of this waste could be feasibly pumped because some of the liquid drains too slowly through the solid waste. The remaining 1.3 million gallons of liquid waste will not drain (as a result of gravitational forces) because it adheres to the solids.

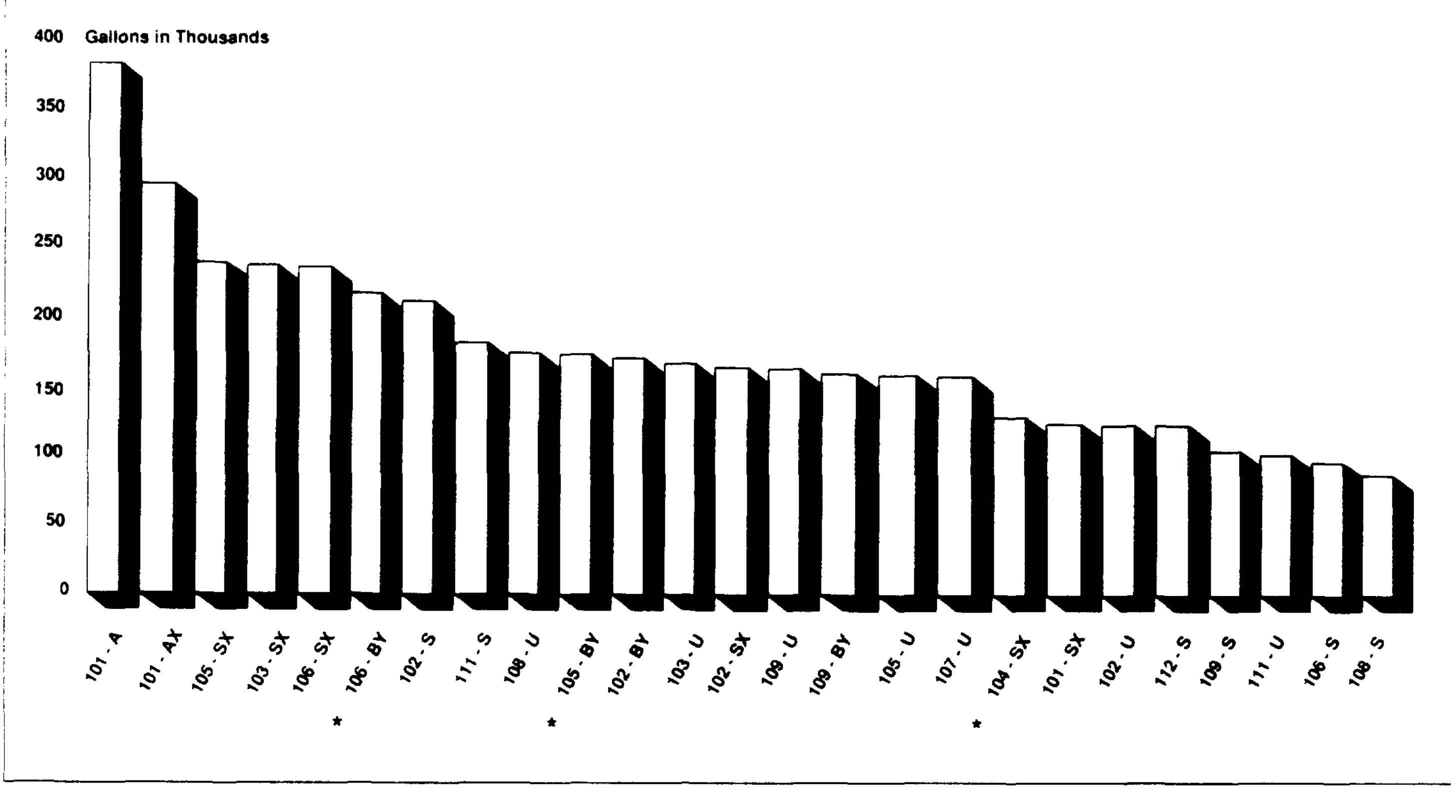
Figure II.3: Disposition of Liquid in and Around Single-Shell Tanks at Hanford, as of October 1988

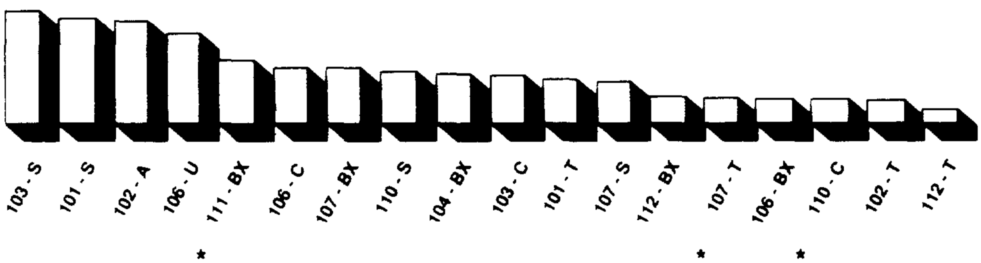


Single-Shell Tanks With Liquid That Could Be Pumped

DOE has two basic criteria to identify tanks that contain drainable liquid that could be feasibly pumped: (1) those that have 50,000 gallons or more of drainable liquid interspersed in solid waste and (2) those that have 5,000 gallons or more of liquid above solid waste. By applying these criteria, GAO found that 43 of Hanford's 149 single-shell tanks contain liquid that could be feasibly pumped. (See fig. II.4.) According to a DOE official, DOE may identify additional tanks with feasibly pumpable liquid when it performs engineering analyses and reviews its current pumping criteria.

Figure II.4: Amount of Pumpable Liquid in Each of 43 Single-Shell Tanks, as of October 31, 1988





* Tanks that DOE assumes have leaked.

Note:
Engineering analyses and a review of DOE's current pumping criteria may indicate that liquid can be feasibly pumped from additional tanks.

Amounts Spent to Pump and Seal Single-Shell Tanks

As shown in table II.1, DOE expended about $1.8 million during the 5-year period 1984-88 (fiscal years) to pump liquid from the tanks and seal them to prevent unwanted intrusions of liquid such as rainwater into the tanks. This amount is about 5 percent of the money requested by Hanford officials for those years and about 3 percent of the total $56.3 million officials now estimate (as of April 1989) it will cost to complete the pumping and sealing programs. For 1989, Hanford officials requested about $5.6 million to pump and seal the single-shell tanks.

Table II.1: Hanford Budget Requests and Expenditures to Pump and Seal Single-Shell Tanks

(Dollars in thousands)

Fiscal year	Hanford budget request	DOE expenditures	Expenditure as a percent of request
1984	$11,120	$101	1
1985	10,180	454	4
1986	3,710	219	6
1987	8,680	592	7
1988	1,271	394	31
Total	**$34,961**	**$1,759**	**5**

During this same time period, as shown in table II.2, other expenditures for the single-shell tank program exceeded the initial Hanford budget requests in 3 years—1984, 1985, and 1988. The low percentage of expenditures during these years for pumping and sealing the single-shell tanks, therefore, reflects a major shift in DOE's program priorities, after the budget request was initially submitted by Hanford officials, in favor of activities other than pumping and sealing the tanks. In 1984, for example, expenditures for pumping and sealing activities were only 1 percent of the funds originally requested, while expenditures for other single-shell tank activities were nearly double the funds originally requested.

Table II.2: Hanford Budget Requests and Expenditures for Single-Shell Tank Management, Excluding Pumping and Sealing

(Dollars in thousands)

Fiscal year	Hanford budget request	DOE expenditures	Expenditure as a percent of request
1984	$5,665	$9,672	171
1985	5,820	7,410	127
1986	7,320	5,472	75
1987	8,410	4,666	55
1988	5,962	7,142	120
Total	$33,177	$34,362	104

For the remaining 2 years during this period (1986-87), total expenditures for the single-shell tank program were less than the initial Hanford budget requests. However, as shown in tables II.1 and II.2, funds to pump and seal the tanks during those 2 years were reduced significantly more than funds for other single-shell tank activities. Expenditures to pump and seal the tanks were 6 percent and 7 percent, respectively, of the funds requested, while expenditures for other activities were 75 percent and 55 percent, respectively, of the funds requested.

Chronology of Major Events in the History of Single-Shell Tanks at Hanford, Washington

1944	First single-shell tanks went into service
1956	First indication of a potential leak.
1959	First leak confirmed.
1964	Construction completed on the last group of single-shell tanks.
1966	The last of the 149 single-shell tanks went into service.
1966	The total volume of waste in the single-shell tanks reached about 77 million gallons.
1968	Construction of the first double-shell tanks began.
1970	Groundwater monitoring well was drilled. Highly radioactive contaminants leaked from single-shell tank later detected in groundwater. According to DOE, migration to the groundwater most likely occurred due to the drilling of the well but the migration may have been a natural progression through the soil.
1971	Double-shell tanks became operational.
1972	Pumping program begun to transfer liquid from single- to double-shell tanks.
1973	The largest single-shell tank leak occurred—an estimated 115,000 gallons.
1980	DOE stopped placing any waste into the single-shell tanks. Liquid waste levels in single-shell tanks reduced to no more than 1 foot above the solid waste. Plans adopted to transfer the remaining 8.5 million gallons of single-shell tank waste that could be feasibly pumped into the double-shell tanks by 1985.
1985	Planned pumping schedule not followed, and scheduled pumping of the single-shell tanks ended. Since August 1985, DOE has pumped liquids only from tanks it assumed had leaked, with the exception of about 16,000 gallons pumped from one tank in 1986.
1988	Five tanks were added to the list of assumed leakers.
1989	DOE, EPA, and Washington State signed an agreement in which DOE agreed to pump most of the remaining 5.3 million gallons of feasibly pumpable liquid waste from the single-shell tanks by the end of fiscal year 1995. However, in accordance with the agreement, two tanks that may be susceptible to excessive heating and will require supplemental cooling are scheduled to be pumped by the end of fiscal year 1996.

Objectives, Scope, and Methodology

As a result of discussions with the offices of Senator Adams and Representative Unsoeld's predecessor, Representative Bonker, in August and November 1988, we reviewed DOE's management of underground single-shell waste storage tanks at its Hanford, Washington site. Specifically, we

- reviewed DOE's efforts to monitor the movement of leaked single-shell tank waste and assess the effects of leaks on groundwater, and
- examined some methods DOE could use to reduce the environmental impact of past leaks and the risk of future leaks.

To meet these objectives, we interviewed scientists, engineers, and managers working for DOE's operations office at Richland, Washington, and at the DOE headquarters Office of Environmental Audit, the Westinghouse Hanford Company, the Battelle Memorial Institute at the Pacific Northwest Laboratory, EPA's Region 10 office, and the Washington State Department of Ecology. We also reviewed official records of tank farm surveillance data, monthly waste inventory reports for both single- and double-shell tanks, reports on single-shell tank pumping, annual and quarterly projections of single- and double-shell tank space utilization, and published and unpublished studies and reports concerning such subjects as single-shell tank-pumping plans, safety of single-shell tank operations, and the mobility of various contaminants in Hanford soils.

We provided a statement of facts concerning our audit findings to DOE officials in the Office of Defense Programs and the Office of Environment, Safety, and Health during the course of our review and conducted an interview at the review's conclusion. We also obtained written comments on a draft of this report from EPA and the State of Washington's Department of Ecology and, where appropriate, modified the report accordingly. DOE did not provide written comments on a draft of this report. We conducted our review in accordance with generally accepted government auditing standards. Our audit work was conducted between August 1988 and March 1989.

Comments From the Environmental Protection Agency

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUN 29 1989

OFFICE OF
POLICY, PLANNING AND EVALUATION

Mr. Keith O. Fultz
Director
Energy Issues
Resources, Community, and Economic Development Division
General Accounting Office
Washington, D.C. 20548

Dear Mr. Fultz:

In your June 12 letter to the Administrator, you requested that the Environmental Protection Agency review and comment on a draft GAO report. The report is entitled "Nuclear Waste: DOE's Management of Single-Shell Tanks at Hanford, Washington" (GAO/RCED-89-157).

Appropriate staff at Headquarters and in our Region X (Seattle) office reviewed the report, with particular attention to references concerning the Agency. The Agency found the text on EPA to be accurate and has no further comments.

Thank you for the opportunity to review the draft report and I look forward to receiving copies to the final report.

Sincerely,

Linda J. Fisher
Assistant Administrator

Comments From the Washington State Department of Ecology

CHRISTINE O. GREGOIRE
Director

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DEPARTMENT OF ECOLOGY
Mail Stop PV-11 • Olympia, Washington 98504-8711 • (206) 459-6000

June 29, 1989

Mr. Keith O. Fultz
Director, Energy Issues
U.S. General Accounting Office
Washington D.C. 20584

Dear Mr. Fultz:

Thank you for the opportunity to comment on the draft report entitled Nuclear Waste: DOE's Management of Single-Shell Tanks at Hanford Washington (GAO/RCED-89-157). The subject of this report is of enormous interest to the state of Washington and we appreciate the efforts of you and your staff. We agree with the major conclusions of this report, and offer the following in clarification of some of the points raised.

We agree that (to date) USDOE has not collected sufficient data to adequately characterize or trace contaminant migration through the soil. The Hanford Federal Facility Agreement and Consent Order ("Tri-Party Agreement") lays the ground work for the collection of this data, including a schedule for installing twenty-three initial groundwater monitoring wells around the single-shell tanks by the end of 1990. Installation activities will need to incorporate practices which ensure that boreholes do not themselves become a pathway to groundwater. Adequate monitoring, characterization of the nature and extent of contaminated soils, contaminant mobility, and adequate characterization of tank contents are each needed to adequately assess migration, and determine the degree of environmental impact.

We agree that removal of feasibly pumpable liquid wastes from Hanford's tanks should proceed as soon as possible, and should, if possible, be completed in advance of the 1995 Tri-Party Agreement date.

We feel that it may be too early to make decisions regarding the placement of new surface material (cover) over the tank farms. Activities associated with waste retrieval and sample collection at the single-shell tanks would likely damage any newly emplaced surface material. In the intervening years prior to final closure, USDOE should continue to emphasize the management of run-off and the prevention of ponding in the tank farm areas.

Mr. Keith O. Fultz
June 29, 1989
Page 2

We believe the Tri-Party Agreement has established a management system to address most of the issues raised within GAO's report. Assignment by USDOE of appropriate resources and priority will expedite efforts to minimize the effects of single-shell tank leaks.

Sincerely,

Terry Husseman

Terry Husseman
Assistant Director
Waste Management

cc: Christine O. Gregoire
Carl Bannerman

Major Contributors to This Report

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Debra J. Evick, Evaluator

Related GAO Products

Modernization and Cleanup Problems Are Enormous in the Nuclear Weapons Complex (GAO/T-RCED-89-17, Mar. 15, 1989).

Environmental Problems at the Department of Energy's Nuclear Weapons Complex (GAO/T-RCED-89-12, Feb. 24, 1989).

Nuclear Health and Safety: Summary of Major Problems at DOE's Rocky Flats Plant (GAO/RCED-89-53BR, Oct. 27, 1988).

Ineffective Management and Oversight of DOE's P-Reactor at Savannah River, South Carolina, Raises Safety Concern (GAO/T-RCED-88-68, Sept. 30, 1988).

Nuclear Health and Safety: DOE Needs to Take Further Actions to Ensure Safe Transportation of Radioactive Materials (GAO/RCED-88-195, Sept. 27, 1988).

Nuclear Science: Issues Associated With Completing WNP-1 as a Defense Materials Production Reactor (GAO/RCED-88-222, Sept. 21, 1988).

Status of the Department of Energy's Waste Isolation Pilot Plant (GAO/T-RCED-88-63, Sept. 13, 1988).

Nuclear Waste: Problems Associated With DOE's Inactive Waste Sites (GAO/RCED-88-169, Aug. 3, 1988).

Nuclear Health and Safety: Stronger Oversight of Asbestos Control Needed at Hanford Tank Farms (GAO/RCED-88-150, July 29, 1988).

Nuclear Health and Safety: Oversight at DOE's Nuclear Facilities Can Be Strengthened (GAO/RCED-88-137, July 8, 1988).

Nuclear Waste: DOE's Handling of Hanford Reservation Iodine Information (GAO/RCED-88-158, May 25, 1988).

Nuclear Health and Safety: Summary of Problem Areas Within the DOE Nuclear Complex (GAO/RCED-88-130, Mar. 28, 1988).

Nuclear Waste: Unresolved Issues Concerning Hanford's Waste Management Practices (GAO/RCED-87-30, Nov. 4, 1986).

Nuclear Energy: Comparison of DOE's Hanford N-Reactor With the Chernobyl Reactor (GAO/RCED-86-213BR, Aug. 5, 1986).

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