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<p style="text-align: center;">APPROVED FOR PUBLIC RELEASE</p> <p><i>KMB 9/30/94</i></p>		
7. Abstract This report is the result of an investigation to determine the available data in literature and documents, concerning single-shell tank (SST) leaks on the Hanford Site, that imply that waste leaking from SSTs reached ground water. Report provides information on documents that contain data showing SST leaks and other incidents such as leaks from pipes, surface spills, and early discharges from SST to ground.		
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LETTER REPORT

**RESEARCH OF DOCUMENTS PERTAINING TO
WASTE MIGRATION FROM
LEAKING SINGLE-SHELL TANKS**

WORK ORDER ER5100

Prepared for

Westinghouse Hanford Company

September 1994

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Richland, Washington

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RESEARCH OF DOCUMENTS PERTAINING TO
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WORK ORDER ER5100

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LETTER REPORT

**RESEARCH OF DOCUMENTS PERTAINING TO
WASTE MIGRATION FROM
LEAKING SINGLE-SHELL TANKS**

INTRODUCTION

This report contains the results from an investigation of the literature concerning single-shell tank (SST) leaks on the Hanford Site. The purpose of the investigation is to determine if available data confirm or refute the assertion that leaked waste from the SSTs has reached ground water.

Within the 16 tank farms of the 200-East and 200-West Areas, 67 of the 149 SSTs have been identified as "assumed leakers" (ref 1). The current estimated volume of leaked waste ranges from approximately 2,271,000 to 4,013,000 L (600,000 to 1,060,000 gal). The minimum and maximum values were calculated from Table 1. (All tables are located in Appendix B.) The volume includes an estimate of leaked cooling water from some of the tanks in accordance with Washington Administrative Code (WAC) WAC 173-303-070, "Designation of Dangerous Waste" (see ref 1 in Appendix A).

Research began with the book On the Home Front. The book states "They then daily released millions of gallons of low-level radioactive wastes with added chemical constituents (mixed waste as now defined by the U.S. Environmental Protection Agency), through trenches and cribs, to the soil. By the late 1950s, underground tanks holding the most toxic, concentrated, and long-lived radionuclides at Hanford had begun to leak into the ground. Sometimes these releases have reached the water table." The last sentence is ambiguous because releases were not defined as applying to only intentional releases or both intentional releases and unintentional leaks from the SSTs.

This report does not include information about waste that was released intentionally to cribs and trenches without being processed through SSTs.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

There are 67 leaking single-shell tanks (SSTs) on the Hanford Site. Although the maximum volume of leaked waste is approximately 4,013,000 L (1,060,000 gal), it is not the only waste in the ground beneath the 200 Area. Before 1966, supernatant solution (i.e., liquid above solids in the tanks) was intentionally discharged from the cascading SSTs to the ground. Other leaks from piping and surface spills contributed to the waste in the ground. The maximum estimated volume of unintentionally leaked waste from the tanks is less than 1% of the intentionally released liquid waste (i.e., approximately 456,702,000 L [120,661,000 gal]) that was sent to the cribs and trenches from the SSTs. The volume does not include the liquid waste sent intentionally from other facilities directly to the cribs, trenches, and injection wells. The components and concentrations of the intentionally released waste were in compliance with applicable standards at the time of release.

It is unknown from the current data available if the contaminants in the ground water are from intentional discharges or if any percentage is from the leaking tanks. Studies of several leaking tanks concluded that the leaked waste did not appear to have reached the ground water. However, angled drilling beneath the tanks was recommended to confirm the depth of waste penetration.

APPROACH/EVALUATION

The research of documents for this report began with references cited in On the Home Front. A list of related documents was obtained from a computer database search at the Hanford Technical Library. The references found in the database also contained related document listings for research. Excerpts from many of the references used in this report are contained in Appendix A.

Two references were cited to support the statement in On the Home Front about releases reaching the water table. The first reference is the U.S. Energy Research and Development Administration (ERDA), Final Environmental Statement, "Waste Management Operations, Hanford Reservation" (ref 3). This document lists estimated volumes of intentionally disposed of waste as well as incidents of unplanned releases from 1946 to 1973. Most

of the unplanned liquid waste releases were from leaking pipes. Eighteen tanks were listed as leaking along with the methods that were used to stop or reduce the leaks and the dates the leaks were discovered. The list does not include the 50 additional tanks that were found leaking since the document was published in 1975.

The second reference is a report by General Electric that summarizes environmental contamination incidents from 1958 to 1964 (ref 4). The summary contains only one incident involving a release of liquid waste that reached the ground water. A leak in the cooling coil of the waste sampling tank (F-15) allowed approximately 10,000 curies of mixed fission products to escape to B Swamp (B Pond) and Gable Mountain Swamp. Some radioactive material reached the ground water. The bulk of the radioactive material that had not decayed by the time the report was written remained associated with the sediments at the bottom of the swamps. The report contains no details of leaking SST incidents.

The waste found in SSTs is in the ground water (ref 5). According to the data obtained from wells used to monitor the ground water, some chemicals and radionuclides found in the ground water exceed regulatory standards as shown on Table 2 (ref 6 and 7). However, past practice was to discharge wastes directly into the ground via pumping or overflow from the cascading tanks to the cribs and trenches. Cascading tanks are arranged in a series with liquid waste cascading between tanks after the solids settle from the solution. During 1946 to 1966, approximately 456,702,000 L (120,661,000 gal) of liquid wastes were discharged intentionally from the SSTs to the ground on the 200 Area plateau (ref 5). Most of the discharged waste came from the early recovery processes for plutonium conducted in the 221-B facility (B Plant) and the 221-T facility (T Plant), and uranium conducted in the 221-U facility (U Plant). From 1960 to 1966, laboratory wastes from the 300 Area and wastes from decontaminating equipment in the 200-West Area were sent to the SSTs before being discharged to the ground. Most of the sites of these trenches and cribs are adjacent to the tank farms (see Figures 1 and 2). Lists of wastes discharged to the trenches and cribs by volume, curies, and chemical composition are contained in ref 5.

Figure 1

200 WEST AREA

Figure 2

Some wastes overflowed into injection wells after passing through settling tanks (ref 8). Well 216-B-5 discharged directly into the aquifer. Approximately 30,560,000 L (8,074,000 gal) were discharged into the aquifer from 1945 to 1947. The waste contained 4,270 grams of plutonium, 75.6 curies of ^{90}Sr , 80.7 curies of ^{137}Cs , 163 curies of ^{106}Ru , and 3,800 curies of beta activity. Some of these discharge sites are upgradient from some of the tank farms.

Approximately 70 unplanned releases (not including leaking tanks) identified in the Waste Information Data System database are associated with the tank farms (ref 5). At least 378,000 L of liquid waste were released to the ground. Very little information is available about these releases (ref 9).

Table 1 contains the details on the 67 tanks that have been identified as "assumed leakers" (data from July 1993). Nineteen of the leaking tanks do not have individual volumes of leaked waste listed. The total volume of leaked waste for the 19 tanks was estimated as 568,000 L (150,000 gal) (ref 1). The estimated total of curies released from 66 tanks is 120,000 (ref 5).

The water table is approximately 65.5 m below the footings of the tanks in the farms of the 200-East Area (ref 10). In the 200-West Area, the water table is on average approximately 49 m below the tank footings. In the 200-West Area, the soils beneath the T Tank Farm enhance lateral migration. Liquid spreads faster horizontally than vertically (ref 11). Beneath the A Tank Farm in the 200-East Area, liquids were found to percolate downward with little horizontal spreading if the leak was slow and the liquid had low viscosity (ref 12).

Leak assessments have been conducted on Tanks 241-A-105, 241-SX-108, 241-SX-109, and 241-SX-115 (ref 12, 13, 14, 15, and 16). The authors reviewed records in detail to determine the amount of liquids that had leaked including estimating the amount of lost cooling water. These tanks all had laterals (i.e., horizontal pipes extending from caissons that are 3 m below the tank bottom) and dry wells for leak detection. A dry well is a borehole in the vadose zone (i.e., the unsaturated zone above the water table), located 1.8

to 3 m from tank perimeter, and used to run tools that measure physical properties, especially radiation levels. Laterals are located only in the A and SX Tank Farms. Tank 241-A-105 leaked between 38,000 and 1,049,000 L (10,000 and 227,000 gal) (ref 1). A leaking raw water line apparently contributed to further movement of contamination in the vadose zone (ref 12). The leak in Tank 241-SX-108 was believed to have self-healed for a few years before the tank was removed from service. Two dry wells between Tanks 241-SX-108 and 241-SX-109 appeared to be contaminated by the leak from Tank 241-SX-108 and, therefore, were not used to determine the extent of the leak from Tank 241-SX-109. The volume of leaked waste from Tank 241-SX-109 was estimated originally as 19,000 L (5,000 gal) or less because the detection system in the laterals was capable of detecting a leak of only 19,000 L or more and the detected radiation levels were low. The estimate was changed later (see Table 1). Tank 241-SX-115 leaked approximately 189,000 L (50,000 gal) from at least three locations. Part of the estimated volume of leaked liquid waste was not accounted for according to the data.

Tank 241-T-106 leaked approximately 435,000 L (115,000 gal) into coarse-grained sediments of the Hanford formation in 1973 which is the largest confirmed volume of waste listed as leaking from a single tank (ref 17). Leakage apparently began in April 1973 and was discovered in June 1973. The liquid waste that could be pumped was removed on June 10, 1973. The waste contained in the tank at the time of the leak was evaporator bottoms. In 1979, a report was published concluding that the liquid waste did not penetrate more than 33 m below grade (ref 11). Only two dry wells were in the vicinity of the tank when the leak occurred and neither was close enough to use for leak detection. Subsequently, dry wells were drilled to delineate the spread of contamination. The plume of contamination was contoured around the vertical dry wells. However, no laterals were drilled beneath this tank leaving an area with no data which might have changed the apparent distribution of the plume.

The migration of wastes through the soil beneath Tank 241-T-106 was analyzed using a three-dimensional, numerical modeling program, PORFLO-3, version 1.0 (ref 17 and 18). The migration of radionuclides ^{137}Cs and ^{106}Ru were modeled and compared to the gamma spectrometry data from the dry wells in 1973 and 1978. The model was calibrated to the field data from the plumes measured in the vadose zone in 1973. The model showed

the ^{106}Ru waste continuing to migrate, although it was not confirmed by the spectrometry data. The absence of data specific to the site was one possible reason for the discrepancy. The value used for the vertical saturated hydraulic conductivity was reduced which produced a plume similar to the one measured. The pattern of simulated distribution of ^{137}Cs for 1978 resembles the measured distribution for 1978. The ^{137}Cs remained bound to the soil in close proximity to the tank.

Another study of Tank 241-T-106 used PORFLO-3 and UNSAT-H to model infiltrating precipitation (ref 19). The coarse-grained sediments of the backfill used to bury the tanks allow precipitation to percolate through the soil instead of being retained for evaporation. An average of approximately 20% of the precipitation evaporated according to the simulation. Less than 1% of the moisture was retained in the backfill and the remaining water drained through the backfill. The tank farms are kept free of vegetation and there is no transpiration of water from the soil. Saturated conditions exist along the exterior walls of the tank because the tank deflects water from the roof to the sides. Precipitation can remobilize some of the contaminants in the soil beside and beneath the tanks.

UNCERTAINTIES AND RECOMMENDATIONS FOR FURTHER STUDY

Movement of liquid waste through the soils is dependent on the types of radionuclides involved; the pH of the solution; the chemical composition of the solution; the amount of precipitation contributing to recharge; the volume of liquid released; and the type, moisture content, and sorptive capacity of the soil. Even if the largest volume of leaked waste from a tank did not reach the ground water, it is not certain that a smaller volume under different circumstances would not percolate to the water table.

Only two tank farms had laterals installed beneath the tanks. Even with the data from the laterals, the spread of waste beneath some tanks was not resolved.

The worst case total volume of leaked waste from the tanks is less than 1% of the intentionally released waste sent to the cribs, trenches, and injection wells. The presence of the intentionally released waste in the ground water obscures any contributions that may have come from the leaking tanks. The data on contaminants from SSTs in the ground

water cannot be used to confirm or refute if the source of contamination is only from the intentional releases through the SSTs or from a combination of intentional releases and unintentional leaks.

The studies that used computer modeling programs appeared inconclusive. The modeling often showed more migration of the waste than what initially appeared in the dry well data. As a result, more recent data should be obtained. Some site-specific data such as the hydraulic conductivity of the soils beneath the leaking tank were cited as causing the computer model discrepancy.

REFERENCES

1. Report, "Tank Farm Surveillance and Waste Status Summary Report for July 1993," prepared by Westinghouse Hanford Company, Document No. WHC-EP-0182-64, November 1993.
2. Gerber, Michelle S., On the Home Front, University of Nebraska Press, 1992.
3. Final Environmental Statement, "Waste Management Operations, Hanford Reservation," prepared by U.S. Energy Research and Development Administration, Document No. ERDA-1538, December 1975.
4. Report, "Summary of Environmental Contamination Incidents at Hanford, 1958-1964," prepared by General Electric, Document No. HW-84619, April 1965.
5. Report, "Tank Wastes Discharged Directly to the Soil at the Hanford Site," prepared by Westinghouse Hanford Company, Document No. WHC-MR-0227, April 1991.
6. Report, "Westinghouse Hanford Company Operational Groundwater Status Report, 1990-1992," prepared by Westinghouse Hanford Company, Document No. WHC-EP-0595, March 1993.

7. Report, "Hydrogeologic Model for the 200-East Groundwater Aggregate Area," prepared by Westinghouse Hanford Company, Document No. WHC-SD-EN-TI-019, September 1992.
8. Final Environmental Impact Statement, "Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes," prepared by the U.S. Department of Energy, Document No. DOE/EIS-0113, December 1987.
9. Report, "Assessment of the Surveillance Program of the High-Level Waste Storage Tanks at Hanford," prepared by Hanford Engineering Development Laboratory, March 1980.
10. Supporting Document, "Ground Water Maps of the Hanford Site, June 1991," prepared by Westinghouse Hanford Company, Document No. WHC-EP-0394-3, December 1991.
11. Report, "High-Level Waste Leakage from the 241-T-106 Tank at Hanford," prepared by Rockwell Hanford Operations, Document No. RHO-ST-14, February 1979.
12. Report, "Tank 241-A-105 Leak Assessment," prepared by Westinghouse Hanford Company, Document No. WHC-MR-0264, June 1991.
13. Report, "Tank 241-SX-108 Leak Assessment," prepared by Westinghouse Hanford Company, Document No. WHC-MR-0300, May 1992.
14. Report, "Tank 241-SX-109 Leak Assessment," prepared by Westinghouse Hanford Company, Document No. WHC-MR-0301, August 1992.
15. Report, "Tank 241-SX-115 Leak Assessment," prepared by Westinghouse Hanford Company, Document No. WHC-MR-0302, November 1992.

16. Supporting Document, "Tank 241-SX-115 Supporting Documentation," prepared by Westinghouse Hanford Company, Document No. WHC-MR-0302, Supplement 1, October 1992.
17. Report, "Three-Dimensional Contaminant Plume Dynamics in the Vadose Zone: Simulation of the 241-T-106 Single-Shell Tank Leak at Hanford," prepared by Pacific Northwest Laboratory, Document No. PNL-7221, January 1990.
18. Report, "Three-Dimensional Plume Dynamics in the Vadose Zone: PORFLO-3 Modeling of a Defense Waste Leak at Hanford," prepared by Pacific Northwest Laboratory, Document No. PNL-SA-17402, April 1990.
19. Report, "Simulations of Infiltration of Meteoric Water and Contaminant Plume Movement in the Vadose Zone at Single-Shell Tank 241-T-106 at the Hanford Site," prepared by Westinghouse Hanford Company, Document No. WHC-EP-0332, November 1989.
20. Report, "Three-Dimensional Simulations of Contaminant Plumes in the Sands and Gravels Underlying the Hanford Site, Washington," prepared by Westinghouse Hanford Company, 1990.
21. Reports, "Chemical Processing Division Waste Status Summary," prepared by Atlantic Richfield Hanford Company, Document No. ARH-2794B, April 1, 1973 through July 31, 1973.
22. Unreleased Report, "Leak Testing of the 113-SX Tank," prepared by Westinghouse Hanford Company and Pacific Northwest Laboratory, Document No. HW-75714, 1962.
23. Supporting Document, "Data Compilation: Iodine-129 in Hanford Groundwater," prepared by Westinghouse Hanford Company, Document No. WHC-EP-0037, August 1987.

24. Report, "Distribution of Plutonium and Americium Beneath the 216-Z-1A Crib: A Status Report," prepared by Rockwell Hanford Operations, Document No. RHO-ST-17, February 1979.
25. Report, "Input and Decayed Values of Radioactive Liquid Wastes Discharged to the Ground in the 200 Areas through 1971," prepared by Atlantic Richfield Hanford Company, Document No. ARH-2761, 1973.
26. Supporting Document, "Waste Storage Tank Status and Leak Detection Criteria," prepared by Rockwell Hanford Operations, Document No. RHO-213-CD, December 1977 (with revisions through 1987).
27. Report, "216-S-1 and S-2 Mixed Fission Product Crib Characterization Study," prepared by Rockwell Hanford Operations, Document No. RHO-ST-39, March 1982.
28. Report, "200-West Ground Water Aggregate Area Management Study," prepared by U.S. Department of Energy, Richland Operations Office, Document No. DOE/RL-92-16, January 1993.
29. Report, "200-East Ground Water Aggregate Area Management Study," prepared by U.S. Department of Energy, Richland Operations Office, Document No. DOE/RL-92-19, 1992.

APPENDICES

- Appendix A. Reference Excerpts and Comments
Appendix B. Tables

APPENDIX A

Reference Excerpts and Comments

1. Hanlon, B.M., "Tank Farm Surveillance and Waste Status Summary Report for July 1993," WHC-EP-0182-64, November 1993.

Tank 241-SX-102 was reclassified from "assumed leaker" to "sound". Total number of tanks assumed leaking are 67.

Page I-4 (Appendix I): The WAC 173-303-070, as amended in 1990, required that any cooling water that was added and subsequently leaked must be classified as a waste. Thus, an estimate of the leaked cooling water was included in the total leak volume. The estimate was broad, however, because the actual amount that evaporated rather than leaked is unknown.

Page I-5 (Appendix I): Some leaks were suspected long before they were confirmed. Tank 241-U-104 was suspected of leaking in 1956, but "confirmed" in 1961. In 1984, the six designations for tanks were merged into the one category of "assumed leaker". "It is highly likely that there have been undetected leaks from single-shell tanks because of the nature of their design and instrumentation."

2. U.S. Energy Research and Development Administration (ERDA), "Final Environmental Statement, Waste Management Operations, Hanford Reservation," ERDA-1538, December 1975.

Page II.1-C-50: Figure showing radionuclide distribution beneath the 216-S-1 and S-2 cribs indicates ⁹⁰Sr at the water table.

3. Backman, G.E., "Summary of Environmental Contamination Incidents at Hanford, 1958-1964," General Electric, HW-84619, April 1965.

The leaks from diversion boxes were releases of steam and the concern was about airborne contamination.

4. Waite, J.L., "Tank Wastes Discharged Directly to the Soil at the Hanford Site," WHC-MR-0227, April 1991.

Page 2: One unplanned release (UN-200-E-86) in March 1971 resulted in the release of approximately 25,000 curies (at the time of discharge) of ¹³⁷Cs to the ground. This leak was from a transfer line between the Plutonium-Uranium Extraction Plant and the tank farm.

Page 10: "Almost 26 million liters (7 million gallons) of first-cycle waste and evaporator bottoms supernatant were discharged to the ground. This resulted in the largest discharge of radionuclides to the ground from the fuel reprocessing mission."

Page 13: ".. in 1956, it was found that cobalt-60 in the supernatant would go to the groundwater and exceed allowable AEC limits." This was learned at the BY cribs in 200-BP-1. The supernatant had to be sent to specific retention trenches.

Page 15: Ferrocyanide was added to the uranium recovery waste stream to precipitate ^{137}Cs , and this was in the waste released to the soil. "A cyanide plume above regulatory standards has moved several miles from the BY cribs."

5. Johnson, V.G., "Westinghouse Hanford Company Operational Groundwater Status Report, 1990-1992," WHC-EP-0595, March 1993.

This report contains numerous maps of contaminant distribution with an interpretation of each. Contaminant concentrations averaged since 1988 are listed by well.

Page iv: The status report on ground water uses data from nearly 300 ground water monitoring wells. Ground water samples are tested for 380 individual constituents. Only a small number of these constituents exceed ground water protection or national drinking water standards. "...the most significant contamination involves the widespread occurrence of carbon tetrachloride and related volatile organic compounds, resulting from past practice disposal of plutonium processing waste from Z Plant activities in the 200 West Area." The plume of contamination in the ground water covers an area of over 10 km^2 (4 mi^2) with concentrations over 10,000 times higher than the state ground water quality standard. "The unknown distribution of the residual inventory in the soil column and uncertainty about the depth distribution in the ground water beneath the major disposal sites are of particular concern."

Page v: "The challenge at ... active waste disposal and storage sites has been to demonstrate that continued discharge of low volumes of relatively uncontaminated wastewater until 1995 will not exacerbate existing subsurface contamination." Initial modeling of solute transport in "the soil column beneath the 216-U-17 Crib suggests wastewater will not infiltrate to ground water and that contaminants will be retained in the upper portion of the soil column."

Page vi: Tritium remains the most widespread contaminant in the ground water in the 200 East Area.

6. Trent, S.J., "Hydrogeologic Model for the 200 East Groundwater Aggregate Area," WHC-SD-EN-TI-019, September 1992.

This document contains descriptions and maps of the distribution and concentrations of the contaminants sampled in the ground water.

Page 4-5: ^{60}Co contamination is associated with the plume of cyanide in the ground water north of 200 East (around well 699-50-53A). Chemical complexation with ferrocyanide is a possible explanation for the ^{60}Co , which is generally immobile in the subsurface.

7. Final Environmental Impact Statement, DOE/EIS-0113, December 1987.

Page v.16 (Volume 3): ^{90}Sr and ^{137}Cs were both detected below the water table beneath the 216-S-1 and S-2 crib. One of the locations where ^{90}Sr was found is associated with the failure of the casing of a ground water monitoring well in 1955.

Page v.24 (Volume 3): Injection well, 216-B-5, was used from April 1945 to September 1947. More than 3.06×10^7 L of radioactive liquid was routed to this injection well via the 241-B-361 settling tank which removed the solids. This well discharged waste directly to the aquifer. The perforated casing extended up into the vadose zone and released waste above the water table.

Page v.28 (Volume 3): The radionuclides introduced directly into the aquifer did not migrate extensively.

8. Catlin, R.J., "Assessment of the Surveillance Program of the High-Level Waste Storage Tanks at Hanford," Rockwell Hanford Operations, March 1980.

Page 115: "Past unplanned releases to soil are not known; owing to the philosophy of using soil as a secondary containment, spills and other accidental releases within the tank farm boundaries were not recorded routinely until 1972."

10. Routson, R.C., W.H. Price, D.J. Brown, and K.R. Fecht, "High-Level Waste Leakage from the 241-T-106 Tank at Hanford," RHO-ST-14, February 1979.

"Unsaturated flow of waste liquids and sorption of radionuclides in the vadose zone sediments beneath the 241-T tank farm are partially controlled by the sedimentary structures present." Thin, nearly horizontal, discontinuous laminations and cross-stratified bedding dominate the Hanford formation under beneath this tank farm. "These sedimentary structures impede downward migration and enhance lateral spreading....under partially saturated conditions..."

Clastic dikes are a secondary sedimentary structure that can enhance the downward movement of liquid wastes. These structures have been observed during drilling operations in the 241-T tank farm.

11. "Tank 241-A-105 Leak Assessment," WHC-MR-0264, June 1991.

Page 6: The sediments beneath the tank are highly conductive according to the data from the drilling logs. A slow leak of liquid with low viscosity can percolate downward with little horizontal spreading. "A flow of this type, directly between the radiation laterals, would show only localized radiation: conceivably, it could be missed completely."

Page 34: "Although the amount of material leaking from Tank 105-A was probably relatively small, the depth of penetration into the soil under the tank cannot be determined from existing data." Core drilling at an angle beneath the tank was recommended by the authors to determine the magnitude of the remediation problem.

Page 54: On February 23, 1978, approximately 60,000 gal of uncontaminated water was released to the ground from the rupture of the M5a water line about 30 feet southeast of the 501 Building. This water moved along a pipe encasement and caused a cave-in between tanks A-102 and A-105. The wetting front advanced to at least 60 feet below the ground indicated by data from probes detecting gamma activity in the lateral leak detection pipes adjacent to tanks A-106 and A-103. Less than three months later, radiation increased in "lateral 14-05-03". This could have been caused by the leak from the ruptured raw water line or from tank A-105 leaking additional cooling water.

12. "Tank 241-SX-108 Leak Assessment," WHC-MR-0300, May 1992.

Page iii: Radiation detected in the laterals was the first indication of a possible leak in December of 1962. The radiation stopped increasing and the tank was kept in service. Increased radiation was again detected in the laterals and also in a dry well in August of 1964. The readings leveled off again in December of 1965. The tank had been isolated during this time and the leak was judged to be inactive in December of 1965. The volume of leaked waste was estimated as 2,400 gal based on soil samples and radiation intensities. The tank was declared to be leaking and removed from service in 1967 when activity began again in the laterals. The original estimate of leaked waste was made before the renewed increase in radiation, so the total volume leaked probably exceeds 2,400 gal. Drilling new wells and sampling more soil was recommended to obtain a more accurate estimate of the volume of leaked waste.

Page 4-11: Radiation levels in the laterals indicate a large increase from 1964 to 1971. Waste was apparently still leaking through the 1970s and was still moving through the soil during the 1980s. There was also evidence of a second leak location.

13. "Tank 241-SX-109 Leak Assessment," WHC-MR-0301, August 1992.

Page iv: It has been assumed that tank 241-SX-109 contained the same composition of waste as 241-SX-108 when leaking began because both received REDOX salt waste.

Page 9: Continuing increases in radioactivity were detected after the tank was interim stabilized. A tank is interim stabilized when it contains less than 189,000 L of drainable interstitial liquid and less than 18,900 L of supernatant liquid. The continued increases appeared to confirm both a new leak as well as movement of the previously leaked radionuclides.

14. "Tank 241-SX-115 Leak Assessment," WHC-MR-0302, November 1992.

Page 12: Raymond and Shdo (1966) could only account for 60% of the approximately 51,000 gal known to have leaked from Tank SX-115. It is possible that liquid leaking in zone 3 may have penetrated the sediments beneath Lateral 3. This is suggested by the relatively high radiation readings observed in Lateral 3 from 1969 to 1987. This is one possibility that could account for the missing 20,000 gal. Core drilling at an angle beneath the tank was recommended by the authors to confirm this possibility.

Page A-2: Seven dry wells and three laterals were installed to monitor Tank 241-SX-115 in 1962. The tank was suspected of leaking because of liquid level measurements in early 1965. Radiation readings from the laterals confirmed the leak. Estimates of the volume of leaked material ranged from approximately 45,000 gal to 51,000 gal.

Page A-4: The waste entered the soil from at least three separate locations according to the concentrations of contamination detected from the laterals.

15. "Tank 241-SX-115 Supporting Documentation," WHC-MR-0302 Supplement 1, October 1992.

Page 23-1: An occurrence report was written in June of 1975. Increased radiation was observed in Lateral 1 (S-21°-10'-W). The change was attributed to changing soil conditions. The soil was being dried by the heat of the tank. Since water is a shield to radioactivity, the loss of moisture would allow more radiation to reach the probe from radionuclides already present in the soil.

16. Smoot, J.L. and B. Sagar, "Three-Dimensional Contaminant Plume Dynamics in the Vadose Zone: Simulation of the 241-T-106 Single-Shell Tank Leak at Hanford," PNL-7221, January 1990.

The model shows continued movement of the simulated plume of ^{106}Ru after the leak in 1973, but the real plume appears to have stopped spreading according to the gamma spectrometry data from 1978. The simulation of the ^{137}Cs plume matched the spectrometry data. The author recommended obtaining more recent gamma spectrometry data.

17. Smoot, J.L. and B. Sagar, "Three-Dimensional Plume Dynamics in the Vadose Zone: PORFLO-3 Modelling of a Defense Waste Leak at Hanford," PNL-SA-17402, April 1990.

This is the same study described in ref 6 as presented at the first Annual International High-Level Radioactive Waste Management Conference.

18. Smoot, J.L., J.E. Szecsody, B. Sagar, G.W. Gee, and C.T. Kincaid, "Simulations of Infiltration of Meteoric Water and Contaminant Plume Movement in the Vadose Zone at Single-Shell Tank 241-T-106 at the Hanford Site," WHC-EP-0332, November 1989.

Page v: Coarse backfill kept free of vegetation allows infiltration of a significant portion of the annual precipitation.

Page 1: The simulation of infiltrating meteoric water through 2 meters of surface sediments above the buried tank were made using the one-dimensional computer code UNSAT-H, Version 2.0. The results were used as the surface boundary conditions to model the movement of the plume of contamination in three-dimensions. PORFLO-3, Version 1.0, was the code used for the three-dimensional simulation.

19. "200 West Groundwater Aggregate Area Management Study," DOE/RL-92-16, January 1993.

Page 2-19: For leaking tanks in the S and SX Tank Farms - "...the areal size of the tank leaks is not known. Therefore, the comparison between the vadose zone pore volume and the liquid discharged to evaluate the potential for migration to the uppermost aquifer cannot be performed for these unplanned releases."

Page 2-25: In describing leaks from single-shell tanks in the T, TX, and TY Tank Farms, this document states "Because the leaks are apparently from point sources rather than from some specified surface area, no evaluation was possible for the potential of the releases to contribute contaminants to the ground water."

Page 2T-2a: This table contains descriptions of the potential for migration of liquid discharges to the unconfined aquifer from single-shell tanks as well as from cribs, trenches, etc. Tank 241-T-105 is included on this list, but is not listed in the waste status summary reports or any other referenced documents.

APPENDIX B

Tables

Table 1 Leaking Single-Shell Tank Data

Table 2 Contaminants Exceeding Regulatory Standards

TABLE 1

LEAKING SINGLE-SHELL TANK DATA						
Tank	Waste Type	Total Volume Leaked ¹ (gal)	Watch List	Year Stabilized ²	Year Declared Leaking ³	Removed from Service ⁴
A-103	DSSF	5,500		1988	1987	1980
A-104	NCPLX	500 to 2,500		1978	1975	1975
A-105	NCPLX	10,000 to 277,000		1979	1963	1963
AX-102	CC	3,000		1988	1988	1980
AX-104	NCPLX			1981	1977	1978
B-101	NCPLX			1981	1974	1974
B-103	NCPLX		organic salts	1985	1978	1977
B-105	NCPLX			1984	1978	1972
B-107	NCPLX	8,000		1985	1980	1969
B-110	NCPLX	10,000		1984	1981	1971
B-111	NCPLX			1985	1978	1976
B-112	NCPLX	2,000		1985	1978	1977
B-201	NCPLX	1,200		1981	1980	1971
B-203	NCPLX	300		1984	1983	1977
B-204	NCPLX	400		1984	1984	1977
BX-101	NCPLX			1978	1972	1972
BX-102	NCPLX	70,000	ferrocyanide	1978	1971	1971
BX-108	NCPLX	2,500		1979	1974	1974
BX-110	NCPLX			1985	1976	1977
BX-111	NCPLX			N.A.	1984	1977
BY-103	NCPLX	<5,000	ferrocyanide	N.A.	1973	1973
BY-105	NCPLX		ferrocyanide	N.A.	1984	1974
BY-106	NCPLX		ferrocyanide	N.A.	1984	1977
BY-107	NCPLX	15,100	ferrocyanide	1979	1984	1974
BY-108	NCPLX	<5,000	ferrocyanide	1985	1972	1972

TABLE 1 (Continued)

LEAKING SINGLE-SHELL TANK DATA						
Tank	Waste Type	Total Volume Leaked ¹ (gal)	Watch List	Year Stabilized ²	Year Declared Leaking ³	Removed from Service ⁴
C-101	NCPLX	20,000		1983	1980	1970
C-110	DC	2,000		N.A.	1984	1976
C-111	NCPLX	5,500	ferrocyanide	1984	1968	1978
C-201	NCPLX	550		1982	1988	1977
C-202	EMPTY	450		1981	1988	1977
C-203	NCPLX	400		1982	1984	1977
C-204	NCPLX	350		1982	1988	1977
S-104	NCPLX	24,000		1984	1968	1968
SX-104	DSSF	6,000	hydrogen	N.A.	1988	1980
SX-107	NCPLX	<5,000		1979	1964	1964
SX-108	NCPLX	2,400 to 35,000		1979	1967 (1962)	1967
SX-109	NCPLX	<10,000	hydrogen - vents other tanks	1981	1965	1965
SX-110	NCPLX	5,500		1979	1976	1976
SX-111	NCPLX	500 to 2,000		1979	1974	1974
SX-112	NCPLX	30,000		1979	1969	1969
SX-113	NCPLX	15,000		1978	1962 (1958)	1958
SX-114	NCPLX			1979	1972	1972
SX-115	NCPLX	50,000 (sodium nitrate solution, 40 kCi)		1978	1965	1965
T-101	NCPLX	7,500		1993	1992	
T-103	NCPLX	<1,000		1983	1974	1974
T-106	NCPLX	115,000		1981	1973	1973
T-107	NCPLX		ferrocyanide	N.A.	1984	1976
T-108	NCPLX	<1,000		1978	1974	1974
T-109	NCPLX	<1,000		1984	1974	1974
T-111	NCPLX	<1,000		N.A.	1974	1974

TABLE 1 (Continued)

LEAKING SINGLE-SHELL TANK DATA						
Tank	Waste Type	Total Volume Leaked ¹ (gal)	Watch List	Year Stabilized ²	Year Declared Leaking ³	Removed from Service ⁴
TX-105	NCPLX		organic salts	1983	1977	1977
TX-107	NCPLX	2,500		1979	1984	1977
TX-110	NCPLX			1983	1977	1977
TX-113	NCPLX			1983	1974	1971
TX-114	NCPLX			1983	1974	1971
TX-115	NCPLX			1983	1977	1977
TX-116	NCPLX			1983	1977	1969
TX-117	NCPLX			1983	1977	1969
TY-101	NCPLX	<1,000	ferrocyanide	1983	1973	1973
TY-103	NCPLX	3,000	ferrocyanide	1983	1973	1973
TY-104	NCPLX	1,400	ferrocyanide	1983	1981	1974
TY-105	NCPLX	35,000		1983	1960	1980
TY-106	NCPLX	20,000		1978	1959	1959
U-101	NCPLX	30,000		1979	1959	1960
U-104	NCPLX	55,000		1978	1961 (1956)	1951
U-110	NCPLX	5,000 to 8,100		1984	1975	1975
U-112	NCPLX	8,500		1978	1980	1970
<p>CC - concentrated complexant - concentrated product from the evaporation of dilute complexed waste</p> <p>DC - dilute complexed waste - characterized by a high content of organic carbon including organic complexants: ethylenediaminetetra-acetic acid (EDTA), hydroxyethyl-ethylenediaminetri-acetic acid (HEDTA), citric acid, and iminodiacetate (IDA)</p> <p>DSSF - double-shell slurry feed - waste concentrated just before reaching the sodium aluminate saturation boundary in the evaporator without exceeding receiver tank composition limits.</p> <p>N.A. - not applicable (not yet interim stabilized)</p> <p>NCPLX - noncomplexed waste - general waste term applied to all Hanford site liquors not identified as complexed.</p> <p>NOTES:</p> <p>(1) The total volumes leaked do not include (except for some tanks) (1) cooling or raw water leaks, (2) infiltrating precipitation, (3) leaks within the tank farm from sources other than the tanks (pipelines, joints for overflow and fill lines, etc.), and (4) leaks from diversion boxes, catch tanks, encasements, etc.</p> <p>(2) This is the year when the tank underwent interim stabilization.</p> <p>(3) This is the year the tank was determined to have begun leaking if different from year declared leaking.</p> <p>(4) This is the last year a tank was capable of receiving waste. The date of the last waste received may have been earlier.</p>						

TABLE 2

CONTAMINANTS EXCEEDING REGULATORY STANDARDS (after ref 6 and 7)		
Constituent	Standard Exceeded	Limit
Arsenic	WAC 173-200	0.05 ppb
Chromium	WAC 173-200, DWS	50 ppb
Fluoride	WAC 173-200, DWS	4,000 ppb
Iron	WAC 173-200, DWS	300 ppb
Manganese	WAC 173-200, DWS	50 ppb
Carbon Tetrachloride	WAC 173-200, DWS	0.3 ppb
Chloroform	WAC 173-200, DWS	7 ppb
Trichloroethylene	WAC 173-200, DWS	*3 ppb
Hydrazine	WAC 173-200	*0.03 ppb
Styrene	DWS	5 ppb
Cyanide	DWS (proposed)	200 ppb
Nitrate	WAC 173-200, DWS	45 ppb
Sulfate	WAC 173-200, DWS	250 ppb
Bis(2-ethylhexyl)phthalate	WAC 173-200	*6 ppb
Coliform	DWS	1 ppb
Alpha	WAC 173-200, DWS	15 pCi/L
Beta	WAC 173-200, DWS	50 pCi/L
Cesium-137	DWS, 1/25 DCG	120 pCi/L
Cobalt-60	DWS, 1/25 DCG	100 pCi/L
Iodine-129	DWS, 1/25 DCG	1 pCi/L
Plutonium-239/240	DWS, 1/25 DCG	1 pCi/L
Radium	WAC 173-200, DWS	3 pCi/L
Strontium-90	WAC 173-200, DWS, 1/25 DCG	8 pCi/L
Technetium-99	DWS, 1/25 DCG	900 pCi/L
Tritium	WAC 173-200, DWS, 1/25 DCG	20,000 pCi/L
Uranium	DWS	40 pCi/L
<p>* The detection limit for this constituent is higher than the most stringent regulatory limit.</p> <p>WAC 173-200 Washington Administrative Code - Model Toxics Control Act</p> <p>DWS Drinking water standard (maximum contaminant level) - taken from 40 CFR 141 and 143 (primary and secondary drinking water regulations)</p> <p>DCG Derived concentration guide - WHC-CM-7-5, "Environmental Compliance"</p>		