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3		~~Design Authority~~ N.A. Homan H6-25	3		J. C. Sonnichsen H6-26
		Design Agent	3		HTI Files (2) H6-08
2	1	Cog.Eng. D. L. Becker [signature] H6-12	3		A. F. Choho H6-35
2	1	Cog. Mgr. E. A. Fredenburg [signature] H6-12	3		C. Henderson B5-36
		QA N/A	2	1	R. W. Root [signature] 12/19 H6-12
		Safety N/A	3		C. D. West S7-53
3		W. A. Skelly H5-61	3		T. L. Stewart K9-69

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AX Tank Farm Waste Inventory Study for The Hanford Tanks Initiative Project

D. L. Becker, (SESC - D. W. Hendrick~~er~~son, T. W. Staehr, S. L. Lambert, D. C. Ramsower)
Numatec Hanford Corporation, Richland, WA 99352
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Abstract: In May of 1996, the U. S. Department of Energy implemented a four-year demonstration project identified as the Hanford Tanks Initiative (HTI). The HTI mission is to minimize technical uncertainties and programmatic risks by conducting demonstrations to characterize and remove tank waste using technologies and methods that will be needed in the future to carry out tank waste remediation and tank farm closure at the Hanford Site. Included in the HTI scope is the development of retrieval performance evaluation criteria supporting readiness to close single-shell tanks in the future. A path forward that includes evaluation of closure basis alternatives has been outlined to support the development of retrieval performance evaluation criteria for the AX Farm, and eventual preparation of the SEIS for AX Farm closure. This report documents the results of the Task 4, Waste Inventory, study performed to establish the best-basis inventory of waste contaminants for the AX Farm, provides a means of estimating future soil inventories, and provides data for estimating the nature and extent of contamination (radionuclide and chemical) resulting from residual tank waste subsequent to retrieval. Included in the report are a best-basis estimate of the existing radionuclide and chemical inventory in the AX Farm Tanks, an estimate of the nature and extent of existing radiological and chemical contamination from past leaks, a best-basis estimate of the radionuclide and chemical inventory in the AX Farm Tanks after retrieval of 90 percent, 99 percent, and 99.9 percent of the waste, and an estimate of the nature and extent of radionuclide and chemical contamination resulting from retrieval of waste for an assumed 30.2m3 (8 kgal) and 151.m3 (40 kgal) leakage from the tanks during retrieval.

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The current AX Tank waste volume inventory estimates reported in this document were used as input for developing the Hanford best-basis tank inventory estimates reported in Kupfer et al. 1997, Hendrickson and Herting 1997, Hendrickson and Lambert 1997a, Hendrickson and Lambert 1997b, and Hendrickson et al. 1997. Estimates of AX Tank waste inventories reported in this document may differ in some cases from the Hanford best-basis tank inventory estimates given in the referenced documents (Kupfer et al. 1997, Hendrickson and Herting 1997, Hendrickson and Lambert 1997a, Hendrickson and Lambert 1997b, and Hendrickson et al. 1997) due to refinements in the latter during preparation and finalization. The reader is advised to refer to the referenced documents (Kupfer et al. 1997, Hendrickson and Herting 1997, Hendrickson and Lambert 1997a, Hendrickson and Lambert 1997b, and Hendrickson et al. 1997), and subsequent revisions thereof, for best-basis estimates of current waste inventories in AX Farm Tanks. Results in this report are intended only for the purpose of evaluating retrieval and closure alternatives for the AX Farm.

In preparation of this document consideration was given to: (1) eliminating the water source term correction from the supernate mixing model for determining the salt cake in tank 241-A-102, which was then used as a reference basis for determining the salt cake in Tanks 241-AX-101, -102, and -103, (2) eliminating analytical adjustments for Fe, Ni, CO_3 and Si in the 241-AX-102 data, (3) correcting the best-basis OH estimate so that this estimate is consistent with the expanded list of analytes used in the HTI study (including Ag, As, B, Ba, Cd, Cu, Mg, Se, Zn, EDTA, NH_4, Cr^{+6}, CN and H_2O), (4) accounting for the appropriate decay date (12/31/99) for all radionuclides, (5) basing the uranium inventory on the activities of its isotopes when referred to the Hanford Defined Waste model inventory, and (6) assessing the affect of the revised K inventory on the previous leakage estimates for Tank 241-AX-104. This list of considerations has been submitted for incorporation into the Hanford best-basis inventories for AX Tanks. Accordingly, this document also includes additional data on the expanded list of analytes of importance to the HTI evaluations.

Attachments to letter SESC-97-646 have been incorporated into this document.

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CONTENTS

1.0 INTRODUCTION

This study establishes the best-basis waste contaminates inventory for the 241-AX Tank Farm. The purpose is to provide a means of estimating future soil inventories, and the nature and extent of contamination (radioactive and chemical) resulting from residual waste once the waste has been removed (retrieved) from the tanks. The data provided will be used to develop the retrieval performance evaluation criteria for the Hanford Tanks Initiative.

The data presented will provide the following information:

- A best-basis estimate of the existing radionuclide and chemical inventory in the 241-AX Tank Farms.
- An estimate of the nature and extent of existing radiological and chemical contamination from past leaks.
- A best-basis estimate of the radionuclide and chemical inventory in the 241-AX Tank Farms after retrieval of 90 percent of the waste, retrieval of 99 percent of the waste, and retrieval of 99.9 percent of the waste.
- An estimate of the nature and extent of radionuclide and chemical contamination resulting from retrieval of waste for an assumed 30.2m^3 (8 kgal) and 151.4 m^3 (40 kgal) leakage from the tanks.

2.0 241-AX TANK FARM DESCRIPTION AND HISTORY

The 241-AX Tank Farm, the fifth and final generation of single-shell tanks (SST) built at Hanford, is located in the East Tank Farm area north of the A Tank Farm, east of Buffalo Avenue and west of Canton Avenue. They were placed in service in 1966. The farm consists of four 100 series, 3.785 X 10^3 m^3 (1,000,000 gal), 22.8 m (75 ft) diameter SST with no cascade overflow lines between the tanks. The tanks were designed for PUREX and B Plant aging waste, which is boiling or self-concentrating with a minimum fluid temperature of 121.1°C (250° F) and a boiling period of five to ten years. The AX tanks were sluiced in the early 1970s to reduce the amount of heat generating strontium and cesium. Tanks AX-10, 102, and 103 were sluiced to a small heel and released to a saltcake waste receiver. In 1977, Tank AX-104 was found to be leaking and was removed from service. Tank AX-102 was deactivated in 1980 and declared an assumed leaker in 1988. The two remaining tanks were also removed from service in 1980 but are categorized as sound.

3.0 SUMMARY

The results of this study are presented in six stand alone appendices. Appendix A, A Summary of Leaks and Spills Contributing to 241-AX Tank Farm Vadose Zone Contamination, provides information relative to Item 2 above. Appendices B through E, Best-Basis Inventory, Retrieval Inventory and Leakage Inventory Estimates of Waste from Single-Shell Tanks 241-AX-101 through 241-AX-104 provide the information described in Items 1, 3, and 4 above. Appendix F, Report of Best-Estimate Past Release Vadose Zone Contamination of the 241-AX Tank Farm provides additional data for information relating to Item 2. This report supplements and complements the vadose zone characterization information provided by U.S. Department of Energy - Richland Operations Office (DOE-RL) (1997).

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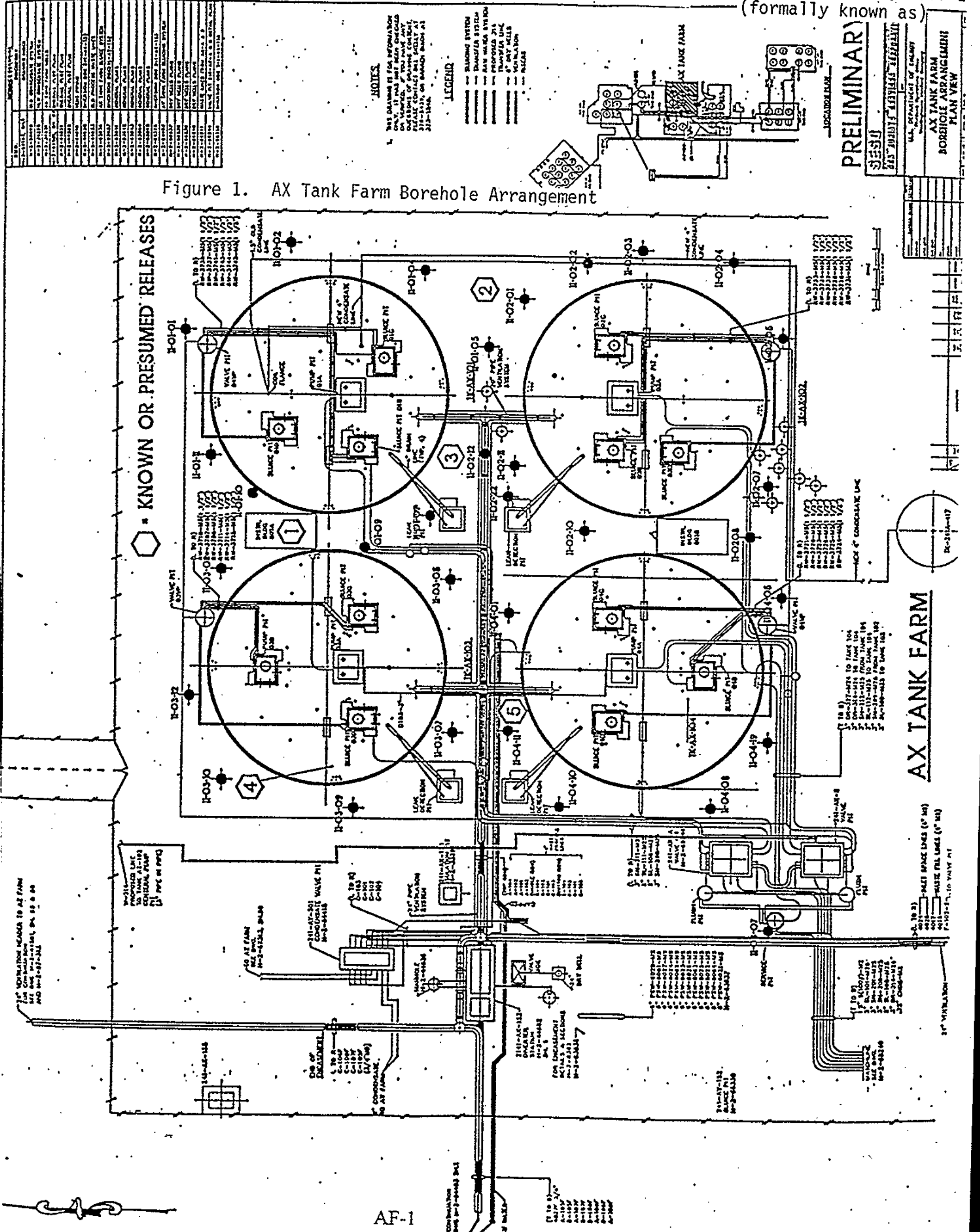

Figure 1. AX Tank Farm Borehole Arrangement

APPENDIX A

A SUMMARY OF LEAKS AND SPILLS CONTRIBUTING TO AX TANK FARM VADOSE ZONE CONTAMINATION

T. W. Staehr
SGN Eurisys Services Corporation
Richland, Washington

CONTENTS

The purpose of this study is to provide historical data to support estimates for the nature and extent of vadose zone contamination resulting from past-practice leaks and leaks during waste retrieval operations, in tanks AX-101, 102, 103, and 104. The data provided in this report are a combination of research of both published and unpublished reports, occurrence reports, letters, memos, and personnel interviews (Baumhardt 1989, Becker 1997, Deford and Carpenter 1995, Hamilton 1997, Hanlon 1995, and RHO 1979).

In general, the AX tanks were in service for approximately 17 years, from 1963 to 1980. Tanks AX-101 and AX-103 have been categorized as non-leakers and tanks AX-102 and AX-104 are categorized as assumed leakers. The basis for categorizing the AX-102 and AX-104 tanks as assumed leakers was either through the detection of radiation in surrounding leak detection wells, or through excessive decreases in liquid level, beyond those attributed to evaporation. No evidence was found that indicates that there were any leaks due to a definite breach of any of the four AX tanks.

Monitoring boreholes were drilled around all four of the tanks between 1974 and 1978. Historical gross-gamma plots indicate that near-surface contamination was present in all tanks before the boreholes were drilled, thus the majority of the leaks/spills are assumed to have occurred while the tanks were in service prior to 1980. Subsurface contamination may also be the result of surface contamination being carried down during the drilling operations. Unfortunately, documentation of these incidents is difficult to find and often does not provide a detailed account of the volume and source of the leak or spill.

The most extensive source of information on vadose contamination sources is contained in recently published reports from the U.S. Department of Energy (DOE), Grand Junction Office (JCO), (DOE-JCO 1997a, 1997b, 1997c, 1997d). The JCO has recently completed a Spectral Gamma Logging (SGL) study of the boreholes surrounding each of the AX farm tanks, to characterize and establish a baseline of man-made radionuclide concentrations in the vadose zone. The reports provide comprehensive studies of the SGL performed on individual boreholes for each tank, as well as a summary and explanation of possible sources of contamination.

This report summarizes the results and conclusions drawn from the JCO reports concerning 241-AX Tank Farm contamination, and other sources. A summary of the known or presumed releases are contained in Section 5.0 of this Appendix.

1.0 PAST PRACTICE LEAKS AND SPILLS IN THE 241-AX TANK FARM

1.1 TANK AX-101

Tank 101-AX has no history of tank leakage and is currently considered a sound tank. However, near-surface contamination has been identified around the tank base on the SGL and historical gross-gamma surveys. The near-surface contamination consists mainly of ^{137}Cs, and is generally confined to the upper 3.1 m (10 ft). Historical gross-gamma plots for the majority of the boreholes surrounding the tank show that the near-surface contamination was present before the boreholes were drilled and that the contamination has not migrated more than 1.5 m (5 ft) in the past 10 to 20 years.

A contributing cause of the surface contamination was a spill in the AX-801-A instrument building, located between the AX-101 and AX-102 tanks, that occurred in 1966 (Lacey 1994). The spill occurred when highly radioactive waste liquid pressurized a 103-AX tank recirculator line and flowed onto the floor of the instrument building. Dose rates from the spill were greater than 5 R/hr at a distance of 3.1 m (10 ft) from the spill. It was estimated that approximately 20 L (5.3 gal) of waste, containing 50 Ci Beta, and 25 Ci ^{137}Cs, were spilled. The waste was washed from the instrument building, using a firehose, into a 0.9 m (3 ft) deep trench extending northward for approximately 15.2 m to 24.4 m (50 ft to 80 ft) and then eastward for approximately 27.4 m (90 ft). (See note on Drawing H-2-44675). A second trench that paralleled the first trench (See drawing H-2-33295) was dug to receive a second washing. The trenches were later covered with soil. The shallow zone of highly concentrated ^{137}Cs contamination detected by the SGL in borehole 11-01-10 may be associated with this incident.

Another occurrence of ground contamination was reported in October 1975 (Lacey 1994) in an approximate 3.1 m by 3.7 m (10 ft by 12 ft) area between the AX-101 and AX-102 tanks and around monitoring borehole 11-02-01. An attempt was made to remove the contamination from around the casing. The soil along the casing was contaminated to 90 mrad/hr at a depth of 22.9 cm (9 in.). The source and concentration of contaminants is unknown.

Two occurrence reports were issued in 1977 and another in 1980 for liquid level decreases exceeding the action criteria. However, there is no evidence indicating that these decreases were due to tank leaks.

Operating Limit Deviation Report No. 80-7 was issued in February 1980 for a liquid level decrease immediately after receiving a transfer from the 417 condensate receiver tank. The decrease was attributed to the mixing of dissimilar materials.

1.2 TANK AX-102

Tank AX-102 was designated as an assumed leaker in 1988 based on excessive liquid level decreases that could not be attributed to evaporation. Two occurrence reports were written in April 1975, detailing increased radiation readings in monitoring well 11-02-11 at a depth of 16.8 m (55 ft). Many investigations, including the drilling of borehole 11-02-12, were performed between 1975 and 1988 to determine the source of the contamination (WHC 1988 and WHC 1989). However, no evidence was found indicating a tank breach. The most probable source of contamination was attributed to leakage from the tank's 50.8 cm (20 in.) direct buried vapor line at the point of juncture with the 61.0 cm (24 in.) vessel vent system header. The leak is presumed to have occurred at a Dresser coupling joining the 50.8 cm (20 in.) header from Tank AX-102 to a main 24-inch vapor header. In late 1975, an asphalt sealant was injected into the soil to contain the activity and seal the Dresser coupling leak. Activity at the 17.1 m (56 ft) level continued to increase until March 1976 and has since slowly diminished. Activity at the 3.7 m (12 ft) level in borehole 11-02-12 has remained stable, with activity below this point slowly receding.

1.3 TANK AX-103

There have been no reportable occurrences of exceeding the liquid level decrease criteria or any contamination increases that would designate Tank AX-103 as an assumed leaker. SGL has indicated (DOE-JCO 1994c) that there is surface contamination in the upper sections of all seven monitoring boreholes surrounding the tank.

The SGL also indicates subsurface contamination at the 10.1 m to 11.3 m (33 ft to 37 ft) level of the northwest side of the tank at monitoring boreholes 11-03-02 and 11-03-12. However, there is no evidence of a source for the contamination. Historical gross-gamma logs indicate that the contamination was present at the time the monitoring boreholes were drilled. Subsequent logs indicate that the gamma-ray activity has not migrated measurably downward into the vadose zone over time.

A possible source of this near-surface contamination was a transfer line leak, reported in 1968, that occurred while trying to unplug a transfer line from the AX-102 tank. Radiation levels on the ground at the leak were 400 mrad/hr and greater than 5 R/hr on the line. Some contaminated soil was removed for burial.

1.4 TANK AX-104

Tank AX-104 was designated as an assumed leaker in 1977 based on increasing radiation detected in monitoring boreholes. Increasing radiation at the 12.2 m (40 ft) depth of borehole 11-04-11, located northwest of the AX-104 tank, was observed in early 1975 (ARCHO 1975). However, neither tank liquid level, leak detection pit liquid level, or radiation monitoring gave any indication of tank leakage. Through subsequent investigation, the source of the contamination was presumed to be from leaks at Dresser coupling joints on the tanks 50.8 cm (20 in.) vapor line at points where the line ties into the tank and where the line ties into the 61.0 cm (24in.) vessel vent header.

Increasing radiation was also detected in boreholes 11-04-01 and 11-04-11 in February 1976. The gamma profiles supported the assumption that leaks were from Dresser coupling connections at the AX-104 tanks and at the 61.0 cm (24 in.) vapor header. Historical gross-gamma profiles for Tank AX-104 identified contamination at borehole 11-04-11 at far lower depths than similar Dresser coupling leaks for Tank AX-102. A possible explanation is that there was a tank breach, or that the leak at the juncture of the 50.8 cm (20 in.) vapor header and the AX-104 tank migrated down the outside of the tank.

2.0 PAST PRACTICE LEAKS AND SPILLS OUTSIDE THE 241-AX TANK FARM

2.1 216-A-40 TRENCH

The 216-A-40 trench is reported to have received 9.5×10^5 L (2.5×10^5 gal) of diverted cooling water and steam condensate from the 244AR vault, (WHC 1990). The open trench is 121.9 m (400 ft) long by 6.1 m (20 ft) wide, and is located approximately 152.4 m (500 ft) west of the 241-241-AX Tank Farm. The trench has been described as "a rubber bag type diverter trench for the recovery of radioactive cooling water that might become contaminated from equipment failure."

2.2 216-A-41 CRIB

The 216-A-41 crib was in service from 1968 to 1974 and received drainage from the 244AR vault canyon and cell exhauster stack (296-A-13) (WHC 1990) . The gravel-filled crib has a 3.1 m by 3.1 m (10 ft by 10 ft) bottom surface and is located approximately 152.4 m (500 ft) west and 61 m (200 ft) south of the 241-AX Tank Farms.

2.3 RAW WATER LINE

On February 3, 1993, raw water was valved in to the 241-AX Tank Farm to support a flushing operation of the 241 AX-B valve pit, (WHC 1993). The flushing operation was completed at approximately 1200 hours and all but one valve was returned to the original configuration. At approximately 2200 hours, the Computer Automated Surveillance system (CASS) operator informed the operations shift supervisor that a raw water meter was measuring water usage in 241-AX, AY, or AZ farms. The leak was determined to be located to the south of the AX-B Valve Pit, southwest of the 241-AX Tank Farms. Approximately 13,250 L (3,500 gal) of raw water was estimated to have been discharged to the soil.

3.0 POTENTIAL FUTURE LEAKS DURING RETRIEVAL OPERATIONS

3.1 EXISTING TRANSFER LINES

There are currently two existing transfers lines in the vicinity of the 241-AX Tank Farm that are a source for potential leaks. These lines have been in service for more than 20 years and will be used to provide waste feed from the AZ and AN tank farms to the privatized vitrification facilities. The lines are both 5.1 cm (2 in.) diameter schedule 80 pipe that are encapsulated (pipe-in-pipe) with 10.2 cm (4 in.) schedule 40 pipe. The lines run in a north-south direction between the AX-A valve pit to the 241-AZ Tank Farm, (drawings H-2-70763, and H-2-70765). The closest point that the lines gets to the 241-AX Tank Farm is at a 8.5 m (28 ft) long expansion loop run located due west of Tank AX-104 and approximately 33.5 m (110 ft) from the tank centerline. The lines make a right angle to the west for 2.1 m (7 ft) before turning north again for approximately 22.6 m (74 ft). From this point, the lines again make a right angle to the west for 3.4 m (11.25) ft before turning north for 25.3 m (83 ft).

3.2 W-314 TRANSFER LINES

The W-314 Project is planning to install a 7.6 cm (3 in.) transfer line with a 15.2 cm (6 in.) secondary containment that would be located east of and running parallel to the existing transfer lines. The proposed line would tie into the west side of the 241-AX-B pit and run north to the 241-AZ-A pump pit located on the AZ-102 tank. The line would also be used to provide waste feed to the vitrification facilities.

3.3 AX-A AND AX-B VALVE PITS

The AX-A and AX-B valve pits are located just southwest of the 241-AX Tank Farm. The valve pits serve as a junction for transfer lines through the use of piping jumpers connected to the bridge transfer line. The replacement of piping jumpers has been a source of surface contamination in the past. Transfers from the AN, AZ, and AY farms to the vitrification facilities will be routed through the AX-A and AX-B valve pits.

4.0 SUMMARY OF KNOWN OR PRESUMED RELEASES

TANK AX-101

1. DATE:	June 1966
VOLUME:	20 L (5.3 gal) of tank waste diluted with several hundred gallons (estimated) of wash water.
AREA:	Surface spill from the north end of the 801-A instrument building into two parallel 0.9 m (3 ft) deep trenches running north 15.2 m to 24.4 m (50 ft to 80 ft) and then east for approximately 27.4 m (90 ft).
CONCENTRATION:	50 Ci Beta, 25 Ci ^{137}Cs
REFERENCE:	See 241-AX Tank Farm Figure 1, 241-AX Tank Farm Borehole Arrangement Plan View

2. DATE:	October 1975
VOLUME:	Unknown
AREA:	Surface spill in an area approximately 3.1 m by 3.7 m (10 ft by 12 ft) between AX-101 and AX-102 and around monitoring well 11-02-01.
CONCENTRATION:	90mrad/hr at 22.9 cm (9 in.) deep
REFERENCE:	See 241-AX Tank Farm Figure 1, 241-AX Tank Farm Borehole Arrangement Plan View

TANK AX-102

3.	DATE:	May 1975
	VOLUME:	11,356 L (3,000 gal)
	AREA:	Presumed to originate from 50.8 cm (20 in.) vapor header at juncture with 61.0 cm (24in.) header
	CONCENTRATION:	Auger soil sample read 3 Rad at contact
	REFERENCE:	See 241-AX Tank Farm Figure 1, 241-AX Tank Farm Borehole Arrangement Plan View

TANK AX-103

4.	DATE:	January 1968
	VOLUME:	Unknown, soil removed for disposal
	AREA:	Transfer line at tank AX-103
	CONCENTRATION:	400 mrad/hr at the surface; 5R/hr at the pipe surface
	REFERENCE:	See 241-AX Tank Farm Figure 1, 241-AX Tank Farm Borehole Arrangement Plan View

TANK AX-104

5.	DATE:	April 1975
	VOLUME:	30,283 L (8,000 gal)
	AREA:	Borehole 11-04-11 at 12.2 m (40 ft) depth
	CONCENTRATION:	Auger soil sample read 3 Rad at contact
	REFERENCE:	See 241-AX Tank Farm Figure 1, 241-AX Tank Farm Borehole Arrangement Plan View

AX FARM VICINITY

6.	DATE:	1968 - 1975
	VOLUME:	9.5 x 10^5 L (2.5 x 10^5 gal)
	AREA:	216-A-40 Trench - 121.9 m (400 ft) long by 6.1 m (20 ft) wide, located approximately 152.4 m (500 ft) west of the 241-AX Tank Farm
	CONCENTRATION:	Radionuclide content unknown
	REFERENCE:	See 241-AX Tank Farm Figure 1, 241-AX Tank Farm Borehole Arrangement Plan View
7.	DATE:	1968 - 1974
	VOLUME:	Unknown
	AREA:	216-A-41 Crib - 3.1-m (10-ft) by 3.1-m (10-ft) bottom surface, located approximately 152.4 m (500 ft) west and 61 m (200 ft) south of the 241-AX Tank Farm
	CONCENTRATION:	Small amounts of Beta, potentially slightly acidic
	REFERENCE:	See 241-AX Tank Farm Figure 1, 241-AX Tank Farm Borehole Arrangement Plan View

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Barnes, Dave	Environmental Engineering Support	
	373-3667	2750E/C100
Bowers, Dave	East Tank Farms Engineering	
	373-1841	MO405/1212
Bragg, Dave	SST East tank Farm Cog Eng	
	372-2899	272AW/B104
Culmer, Jack	Environmental Integration	
	373-4942	2440STVCN/2616
Farrell, Kelsey	East Tank Farms Occurrence Reporting	
	373/9181	272AW/B111
Lacey, Wendy	Environmental Health and Safety	
	373-2973	MO281/A109/200W
Miller, Phil	Environmental Cleanup and Compliance	
	373-6389	2750E/A109
Reberger, Dan	East Tank Farms Transfer Cog. Eng.	
	373-3926	MO268/1
Scott-Proctor, Nancy	East Tank Farms Operations Support	
	373-1945	272AW/B106

APPENDIX B

BEST-BASIS INVENTORY, RETRIEVAL INVENTORY, AND LEAKAGE INVENTORY ESTIMATES FOR RETRIEVAL OF WASTE FROM SINGLE-SHELL TANK 241-AX-101

D. W. Hendrickson, P.E.
S. L. Lambert, Ph.D.
SGN Eurisys Services Corporation
Richland, Washington

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CONTENTS (cont'd)

TABLES (cont'd):

The purpose of this study is to provide the best-basis estimate of the chemical and radiological waste inventory after retrieval of waste from the AX farm. As part of this effort, an evaluation of available information for Tank 241-AX-101 was performed and a best-basis inventory was established for three different retrieval scenarios. The first scenario is based on retrieving at least 90 percent of the waste to a residual volume of 101.94 m^3 (3,600 ft^3) of waste, or the current volume if this volume is less than 101.94 m^3 (3,600 ft^3) The second scenario assumes 99 percent retrieval of waste from the tank to meet the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990) milestone of 10.2 m^3 (360 ft^3) of residual waste, while the third scenario assumes 99.9 percent retrieval to a residual volume of 1.02 m^3 (36 ft^3) of waste. This study, detailed in the following sections, is based on the methodology that was established by the standard inventory task.

1.0 CHEMICAL INFORMATION SOURCES

Chemical and radionuclide inventory estimates are generally derived from one of three sources of information: (1) sample analysis and sample derived inventory estimates, (2) component inventories predicted by the Hanford Defined Waste (HDW) model based on process knowledge and historical tank transfer information, or (3) a tank-specific process estimate based on process flowsheets, reactor fuel data, essential materials records, or comparable sludge layers and sample information from other tanks.

Tank 241-AX-101 was placed into service in 1965. Initial tank receipts included Plutonium-Uranium Extraction (PUREX) process high-level waste (HLW), organic wash waste and B Plant fission product waste. Typically, these wastes were received from other tanks rather than directly from the plants. Steam coils were added to the tank in 1966 and the tank was used to concentrate the PUREX HLW, organic wash waste, and B Plant fission product additions. During 1968 and 1969, the tank was used to accumulate Sr and Cs recovery waste for staging to Tank 241-A-102. The tank received little transfer activity until the end of 1973 when most of the supernatant was removed. PUREX HLW supernatant was sent to the tank in 1973 and 1974. Pumping and sluicing of the tank contents for Sr and Cs recovery in 1975 and 1976 reduced the tank solids inventory to 11.35 kL of strontium recovery (SRR) sludge (Rodenhizer 1987).

After sluicing, Tank 241-AX-101 was used to receive product slurry from the 242-A Evaporator (1976-1980). Several evaporator products were added to Tank 241-AX-101, including Evaporator Bottoms, Hanford Defense Residual Liquid, and Double-Shell Slurry Feed. The tank also received complex waste.

2.0 CHEMICAL/RADIONUCLIDE INVENTORY ESTIMATES BEFORE RETRIEVAL

No current analyses of SRR are available; however, application of the HDW SRR sludge compositions to the small SRR volume ratioed to the volume of sludge deposited in Tank

241-AX-101 may provide a reasonable assessment of the sludge compositions. The summary of nonradioactive and radioactive constituents of this sludge analysis are contained in Tables 1 and 2, respectively. The chemical species are reported without charge designation per the best-basis inventory convention.

SMMA1 saltcake analyses have been conducted upon samples withdrawn from both Tanks 241-A-102 and 241-A-103. As was represented in the standard inventory assessment for Tank 241-AX-103 (Lambert and Hendrickson 1997), these saltcakes, with adjustment for iron, silica, and nickel, are expected to yield a reasonable estimate of the composition and inventory of Supernatant Mixing Model 242-S Evaporator saltcake generated from 1973 until 1976 (SMMA1) saltcake within Tank 241-AX-101. The summary of nonradioactive and radioactive constituents for this saltcake analysis are contained in Tables 3 and 4, respectively.

2.1 COMPONENT INVENTORY EVALUATION

The following evaluation of tank contents is performed to identify potential errors and/or missing information that would influence the sampling-based and HDW model component inventories.

The HDW model is based primarily on process production waste compositions, waste transaction records for each tank, and assumed solubilities for key components. The sample and process based estimate is based upon HDW-based SRR sludge compositions and SMMA1 saltcake samples from Tanks 241-A-102 and 241-A-103. The sample and process based estimate does not encompass PUREX neutralized high-level (P2) waste of which 38 kL (10 kgal) is described as being present by the Waste Status and Transaction Record Summary (WSTRS) model (Agnew et al. 1997b). Because that model describes its placement into the tank, following sluicing in 1975 to 1976 as P2 waste was produced from 1963 to 1967, it is not credible that direct placement of this waste type occurred in this tank. The volume ascribed to P2 waste is assumed to be SMMA1 saltcake from the subsequent operations yielding approximately 99.6 percent saltcake by volume in the tank.

Table 5 tabulates a comparison between the HDW model compositions for nonradioactive components with that estimated from sample data and limited (SRR sludge) HDW model input.

2.2 CONTRIBUTING WASTE TYPES

The current waste volumes for Tank 241-AX-101 are shown in Table 7 (Hanlon 1996).

Table 8 summarizes the documented quantities of waste discharged to Tank 241-AX-101 from the HDW model waste transaction database (Agnew et al. 1997b). Table entries with negative values are for transfers out of the tank. Quantities removed by self-concentration have not been included. These records indicate that the solids in this tank should be mostly salts from concentration of dilute wastes.

The types of solids that have accumulated in Tank 241-AX-101 are compiled in Tables 9 and 10. Waste types in brackets are expected to have been removed when the tank was sluiced in 1976.

2.3 EVALUATION OF SAMPLE AND PROCESS FLOWSHEET INFORMATION

Waste samples from Tank 241-AX-101 are limited to sludge samples collected before the tank was sluiced in 1976 and a supernatant sample collected in 1980. These samples are of limited value in establishing the current inventory in this tank.

Review of Anderson (1990) and Agnew et al. (1997a) indicates that the following events have probably occurred:

- Between startup in 1965 and sluicing in 1976, Tank 241-AX-101 was used to store various wastes generated by PUREX and Waste Fractionization.
- In 1976, Tank 241-AX-101 was sluiced to a 11.35 kL heel. This met the sludge heel requirement for tanks scheduled to be used for saltcake storage of a 2.5-cm to 5-cm (1-in. to 2-in.) sludge heel. The requirement was based on radiolytic heating temperature control limits (Rodenhizer 1987).
- 2,373 kL (673 kgal) of solids were accumulated in the tank by the end of 1977. The solids are identified as EVAP, RESID, and DSSF. These are all evaporator concentrates made from tank waste supernatants.
- At the end of 1979, supernatant from Tank 241-AX-101 was sent to the 242-A Evaporator. Evaporator product, potentially from a different source, was returned to the tank.
- In 1980, the tank was used to stage supernatant and first pass slurry to the 242-A Evaporator. The solids level was measured at 1,094 kL (289 kgal).
- At the end of 1980, the tank was filled with DSSF, bringing the solids level to 1,987 kL (525 kgal).
- Cooling of the waste caused additional salt precipitation, bringing the solids level to 2,831 kL (748 kgal).

From these observations, it appears that the waste layers identified in the HDW model generally represent the current solids inventory in this tank.

Of the alternatives available for establishing the composition of the waste in Tank 241-AX-101, the only practical method is to use sample data for the same waste from another tank. The SORWT Model groups, Tanks 241-A-101, 241-A-102, 241-A-103, and 241-AX-101 as similar tanks. Both Tanks 241-A-102 and 241-A-103 have been sampled. However, the history of Tank 241-A-102 is somewhat unique. Tank 241-A-102 was the 242-A Evaporator feed tank rather than a saltcake receiver tank during the time period that 241-AX-101 was filled.

A tank-by-tank review of the HDW model was completed to identify other tanks with the waste layers found in Tank 241-AX-101. Tanks 241-A-106 and 241-C-104 were found to contain some of the waste layers found in Tank 241-AX-101. However, Tank 241-A-106 has not been sampled and the layers in Tank 241-C-106 are too thin to discriminate from each other.

Relative to the expected waste types in Tank 241-AX-101, Tank 241-A-102 has less contribution from the SMMA1 layer and more contribution from the other layers. The relative contribution of the layers for these two tanks is compared in Table D3-6. Use of the Tank 241-A-102 data is also biased by this tank being the evaporator feed tank. In this capacity, it would tend to preferentially accumulate those salts that first precipitate, e.g., $NaNO_3$. Thus, the use of samples from both Tank 241-A-102 and Tank 241-A-103 is expected to better represent the saltcake present in 241-AX-101 than from 241-A-102 alone.

Table 11 compares the relative waste layers in Tanks 241-A-102 and 241-AX-101. This comparison shows that 91 percent of the waste in Tank 241-A-102 consists of SMMA1 and SMMA2 saltcakes from the 242-A evaporator, while 98 percent of the waste in Tank 241-AX-101 was derived from this source. Because Tank 241-A-102 was used as the evaporator feed tank, 241-A-102 waste could be enriched in those salts that first precipitate, e.g., $NaNO_3$.

Based on the projected types of waste of each tank, samples from Tank 241-A-102 appear to be generally representative of the SMMA1 saltcake wastes in Tank 241-AX-101.

Currently, the only practical method for estimating the composition in this tank is to use sample data for similar wastes in another tank. The SORWT Model generally identifies tanks with similar wastes. According to this model, Tanks 241-A-101, 241-A-102, 241-A-103, and 241-AX-101 have been placed into the same group of tanks with common wastes. While the sample population is limited, sample records do show that two core samples were obtained from Tank 241-A-102 in 1986 and two auger samples in 1996. Even though these wastes were derived from a common source, some differences could exist because Tank 241-A-102 was used as the 242-A evaporator feed tank when Tank 241-AX-101 was being filled with DSSF waste.

Table 12 provides the estimated composition profile for Tank 241-AX-101 waste based on the core sample and auger data from Tank 241-A-102 (Jo 1996). The waste inventory estimates are based on a waste volume of 2,831 kL (99,850 ft^3) (Table 1) and densities of 1.59 kg/L and 1.7 kg/L for the core sample and auger data, respectively. This table also provides composition data from each of the sampling events as well as the composite estimate for Tank 241-AX-101 waste. While sample recoveries were relatively low for the 1996 auger samples, the 1986 cores probably represent a reliable cross-section of the Tank 241-A-102 waste. The 1986 core sample estimate represents the average of two cores taken from riser 4. Core segment recoveries were reported to be 100 percent. Since the auger sample was taken from a different riser, the sample data was averaged to produce a composite estimate of the likely inventory in Tank 241-AX-101.

Table 13 provides a summary of the radionuclide concentrations and tank inventory estimates based on the total volume of waste in this tank (2,831 kL [99,850 ft^3]). These radionuclide inventory values were derived for 46 key radionuclides (Kupfer et al. 1997). Often waste sample analyses have only reported ^{90}Sr, ^{137}Cs, $^{239/240}Pu$, and total uranium (or total beta and total alpha), while other key radionuclides such as ^{60}Co, ^{99}Tc, ^{129}I, ^{154}Eu, ^{155}Eu, and ^{241}Am, etc., have been infrequently reported. For this reason it was necessary to derive most of the 46 key radionuclides by computer models. These models estimate radionuclide activity in batches of reactor fuel, account for the split of radionuclides to various separations plant waste streams, and track their movement with tank waste transactions. (Kupfer et al. 1997 and Watrous and Wootan 1997.) Model-generated values for radionuclides in any of the 177 tanks are reported in the HDW Rev. 4 model results (Agnew et al. 1997a). (No attempt has been made to ratio or normalize model results for all 46 radionuclides when values for measured radionuclides disagree with the model.) For a discussion of typical error between model-derived values and sample-derived values, see Kupfer et al. (1997). Radionuclide results in Table 13 have been decayed to December 31, 1999.

3.0 CHEMICAL/RADIONUCLIDE INVENTORY ESTIMATES AFTER RETRIEVAL

As part of this study, a best basis inventory was established for three different retrieval scenarios. The first scenario is based on retrieving waste to minimum of either the existing waste volume or a residual waste volume of 101.94 m^3 (3600 ft^3). The second scenario assumes retrieval to a residual waste volume of 10.2 m^3 (360 ft^3) which corresponds to the assumed 99 percent retrieval of waste to meet the Tri-Party Agreement (Ecology et al. 1990). The third scenario assumes retrieval to a residual waste volume of 1.02 m^3 (36 ft^3). The first and third scenarios represent the retrieval of all tank wastes to 90 percent and 99.9 percent respectively.

Table 14 contains a summary matrix of resultant saltcake and sludge volumes, and their fractional removal, following retrieval according to the three scenarios of 90 percent, 99 percent, and 99.9 percent retrieval.

Following retrieval according to the three scenarios presented in Table 14, the residual tank waste inventory has been evaluated and is presented in Tables 15 and 16 for chemical and radiological constituents, respectively.

4.0 BEST-BASIS LEAKAGE INVENTORY ESTIMATES FOR RETRIEVAL OF SINGLE-SHELL TANK 241-AX-101

Retrieval scenarios described in Section 3.0 provide residual inventories following fractional removal of any saltcake and sludges contained within Tank 241-AX-101. This section assumes two different leakage conditions for each retrieval scenario. The first leakage condition assumes up to 30.2 m^3 (8 kgal) of potential leakage, while the second leakage condition is based on an upper bounding estimate of 151.4 m^3 (40 kgal) of potential leakage. In each case, solution concentrations and inventories will be based on the limiting conditions for waste retrieval, either a maximum supernate concentration of five gram moles per liter sodium or a maximum value of 10 weight percent solids in the slurry, or the total volume of the retrieval solution. These limits were established to minimize the possible crystallization of sodium rich salts in the slurry transfer lines and slurry pumping problems for the slurry pumps and sluicers. The following estimates are based on the methodology that was established by the standard inventory task.

The solution concentrations resulting from dissolution and slurry with water of the tank waste to the three retrieval scenarios are provided in Tables 17 and 18 for nonradiological and radiological constituents, respectively. Table 17 also displays the limiting volume assessment required for application of sodium loading or solids loading limits and the minimum retrieval water to meet the limiting volume assessment based upon product specific gravities of either 1.17 or 1.18 for sodium limited or solids limited solutions.

Tables 19 and 20 contain the nonradiological and radiological, resultant leakage inventory estimates based upon 30.2 m^3 (8 kgal) and 151.4 m^3 (40 kgal) releases during retrieval.

5.0 TANK LEAKAGE

Tank 241-AX-101 is currently considered to be a sound tank with no compelling evidence of leakage. A total of eight dry wells have been drilled around the periphery of Tank 241-AX-101. Dry wells 11-01-04, 11-01-05, 11-01-09, and 11-01-10 have produced radiation counts more than 50 counts per second above background. If, during the course of spectral gamma logging, it is determined that some leakage did occur from this tank, the chemical and radionuclide source terms could be estimated from the available supernate composition data for this tank. A supernate sample was taken from this tank in October 1980 from which the potential leakage effects could be estimated. This data will not be included in this submittal because there is no evidence at the present time that this tank has ever leaked.

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Table 1. Estimated Inventory of Strontium Recovery Sludge Nonradioactive Components in Tank 241-AX-101 Waste Sludge

Analyte	Average SRR Sludge Concentration, M[a]	SRR Projected Inventory, kg[b]	Analyte	Average SRR Sludge Concentration, M[a]	SRR Projected Inventory, kg[b]
Density, g/mL	1.322	1.322	OH	3.96	765
Ca	0.137	62.2	Si as SiO_3	1.80	1,557
Cl	0.054	21.6	S as SO_4	0.088	95.7
TIC as CO_3	0.341	233	TOC	4.38	598
Fe	1.28	810	EDTA	0.129	428
K	0.012	5.18	NH_3	0.134	25.9
Na	6.46	1,688	H_2O	44.4	9,082
NO_2	0.558	291	Pu	9.07E-04	2.46
NO_3	3.88E-07	2.73E-04	Volume (kL)	11.4	11.4

NR = Not reported.
SRR = Strontium recovery sludge
[a] Composition based upon Hanford Defined Waste (Agnew et al. 1997a)
[b] Based upon a volume of 11.4 kL (3 kgal) of sludge in 241-AX-101.

Table 2. Estimated Inventory of Strontium Recovery Sludge Radioactive Components in Tank 241-AX-101 Waste Sludge (Decayed to January 1, 1994)

Analyte	Average SRR sludge concentration (Ci/L)[a]	SRR projected inventory (Ci)[b]	Analyte	Average SRR sludge concentration (Ci/L)[a]	SRR projected inventory (Ci)[b]
^{3}H	8.30 E-05	0.943	^{227}Ac	2.12 E-07	0.0024
^{14}C	6.77 E-06	0.077	^{228}Ra	1.86 E-13	2.11 E-09
^{59}Ni	6.10 E-04	6.93	^{229}Th	3.09 E-11	3.51 E-07
^{60}Co	1.37 E-05	0.156	^{231}Pa	3.17 E-07	0.0036
^{63}Ni	0.060	681	^{232}Th	2.51 E-15	2.85 E-11
^{79}Se	3.40 E-04	3.86	^{232}U	8.20 E-12	9.31 E-08
^{90}Sr	9.57	108,717	^{233}U	1.15 E-13	1.31 E-09
^{90}Y	9.57	108,717	^{234}U	3.43 E-08	3.90 E-04
^{93m}Nb	0.0013	14.3	^{235}U	1.34 E-09	1.52 E-05
^{93}Zr	0.0015	16.7	^{236}U	2.26 E-09	2.57 E-05
^{99}Tc	4.57 E-05	0.519	^{237}Np	1.45 E-07	0.0016
^{106}Ru	2.63 E-06	0.030	^{238}Pu	4.77 E-04	5.42
^{113m}Cd	0.0031	35.5	^{238}U	2.75 E-08	3.12 E-04
^{125}Sb	8.09 E-05	0.19	^{239}Pu	0.0128	145
^{126}Sn	5.46 E-04	6.20	^{240}Pu	0.00238	27.0
^{129}I	8.89 E-08	0.001	$^{239/240}Pu$	0.0152	171
^{134}Cs	9.76 E-06	0.111	^{241}Am	0.0144	164
^{137}Cs	0.177	2,006	^{241}Pu	0.0338	384
^{137m}Ba	0.167	1,898	^{242}Cm	1.21 E-05	0.137
^{151}Sm	1.27	14,439	^{242}Pu	1.99 E-07	0.0023
^{152}Eu	3.18 E-04	3.61	^{243}Am	7.55 E-07	0.0086
^{154}Eu	0.0075	84.9	^{243}Cm	1.09 E-06	0.0124
^{155}Eu	0.0195	221	^{244}Cm	4.42 E-05	0.502
^{226}Ra	4.10 E-08	4.66 E-04			

NR = Not reported
SRR = Strontium recovery sludge
[a] Composition based upon Hanford Defined Waste.
[b] Based upon a volume of 11.4 kL of sludge in 241-AX-101.

Table 3. SMMA1 Saltcake Composition and Inventory Projections for Tank 241-AX-101 Based on Core Samples from Tanks 241-A-102 and 241-A-103 and Auger Samples from Tank 241-A-102 (page 1 of 2)

Analyte	241-A-102 Sample Data		Tank 241-A-103 Core Sample Data (µg/g)[b]	Average Analyte Concentration in SMMA1 Saltcake (µg/g)	Estimated Inventory of SMMA1 saltcake in tank 241-AX-101 (kg)[c]
	1986 Core Sample (µg/g)[a]	1996 Auger Sample (µg/g)[a]			
Density	1.59	1.7	1.345	1.495	1.495
Ag	247	371	24.7	167	704
Al	23,265	31,700	16,570	22,026	92,863
As	NR	NR	NR	NR	NR
B	14.2	NR	22.2	18	76.8
Ba	882	139	575	543	2,289
Bi	1,738	336	176	607	2,558
Ca	2,592	690	1,716	1,678	7,075
Cd	65	NR	80	72	305
Cl	NR	NR	NR	NR	NR
TIC as CO_3	NR	21,700	NR	21,700	91,487
Cr	5,270	8,800	1,531	4,283	18,057
Cu	82.0	NR	12.3	47	199
F	NR	277	NR	277	1,168
Fe	13,936	19,600	355	8,561	36,095
Hg	NR	NR	NR	NR	NR
K	2,816	3,080	2,534	2,741	11,554
La	NR	103.0	NR	103	434
Mg	1,382	NR	795	1,088	4,589
Mn	2,151	3,380	124	1,445	6,091
Na	187,045	129,000	208,605	183,314	772,852
Ni	526	413	93.3	281	1,186
NO_2	NR	83,200	NR	83,200	350,772
NO_3	178,500	90,300	113,500	123,950	522,574
OH	NR	NR	NR	NR	NR
Pb	1,186	1,410	364	831	3,503
P as PO_4	16,061	4,906	NR	10,483	44,198
P	5,238	NR	2,170	3,704	15,617
Se	NR	NR	NR	NR	NR
Si as SiO_3	44,778	10,619	29,929	28,814	121,480
S as SO_4	NR	4,480	NR	4,480	18,888
S	NR	NR	NR	NR	NR

Table 3. SMMA1 Saltcake Composition and Inventory Projections for Tank 241-AX-101 Based on Core Samples from Tanks 241-A-102 and 241-A-103 and Auger Samples from Tank 241-A-102 (page 2 of 2)

Analyte	241-A-102 Sample Data		Tank 241-A-103 Core Sample Data (μg/g)[b]	Average Analyte Concentration in SMMA1 Saltcake (μg/g)	Estimated Inventory of SMMA1 saltcake in tank 241-AX-101 (kg)[c]
	1986 Core Sample (μg/g)[a]	1996 Auger Sample (μg/g)[a]			
Sr	97.6	31.5	12.0	38	161
TOC	7,570	14,850	7,885	9,548	40,252
Total U	1,041	35,300	1,435	9,803	41,327
Zn	105	NR	54.0	79	335
Zr	1,439	NR	209	824	3,474
EDTA	NR	NR	NR	NR	NR
NH_4	NR	NR	NR	NR	NR
Cr^{+6}	NR	NR	NR	NR	NR
CN	NR	NR	NR	NR	NR
H_2O	351,500	343,000	402,000	374,625	1,579,421
SMMA1 Volume (L)	128,701		1,374,075		2.82e+06

HDW = Hanford Defined Waste
NR = Not reported
SSR = Strontium recovery sludge
SMMA1 = Supernatant Mixing Model 242-A Evaporator saltcake generated from 1976 until 1980
TCR = Tank Characterization Report
[a] Jo et al. (1996)
[b] Based on mean of two composite core samples from tank 241-A-103 (Weiss and Schull 1988)
[c] Based on 2,820 kL of SMMA1 saltcake, with an average density of 1.495 kg/L. This estimate was derived by averaging the core and auger sample results for tank 241-A-102, and then averaging the results for tanks 241-A-102 and 241-A-103.

Table 4. Analytical Results and Tank Inventory Estimates for Radioactive Components in SMMA1 Saltcake in Tank 241-AX-101 Based on Core Samples from Tanks 241-A-102 and 241-A-103

Analyte	Tank 241-A-102 Sample Data		Tank 241-A-103 Core Sample Data uCi/g	Average Analyte Concentration in SMMA1 Saltcake uCi/g	Estimated Inventory of SMMA1 saltcake in tank 241-AX-103 Ci
	1986 Core Sample uCi/g	1996 Auger Sample uCi/g			
Decay Date	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99
^{14}C	0.0011	NR	0.0026	0.0019	7.83
^{60}Co	0.137	NR	0.015	0.0758	319
^{90}Sr	436	NR	35.2	236	993,039
^{90}Y	436	NR	35.2	236	993,039
^{99}Tc	0.100	NR	0.117	0.109	458
^{129}I	3.90e-05	NR	9.50e-06	2.42e-05	0.102
^{137}Cs	101.8	NR	147	124	524,882
^{137}mBa	96.3	NR	139	118	496,538
$^{239/240}Pu$	2.001	NR	0.130	1.065	4,491
^{241}Am	1.185	NR	0.119	0.652	2,749

HDW = Hanford Defined Waste
NR = Not reported
SMMA1 = Supernatant mixing model A1 salt sake
[a]Based on 2,820 kL of SMMA1 saltcake, with an average density of 1.495 kg/L. This estimate was derived by using the SMMA1 concentrations.

Table 5. Comparison of Sample and Process Based and Hanford Defined Waste Inventory Estimates for Nonradioactive Components in Tank 241-AX-101 (page 1 of 2)

Analyte	HDW Model (kg)[a]	Sample and Process Based (kg)[b]
Density	1.54	1.494
Heat load (kW)	10.39	4.19[c]
Ag	NR	7.04E+02
Al	1.16E+05	9.29E+04
As	NR	NR
B	NR	7.68E+01
Ba	NR	2.29E+03
Bi	6.54E+02	2.56E+03
Ca	3.24E+03	7.14E+03
Cd	NR	3.05E+02
Cl	2.11E+04	2.16E+01
TIC as CO_3	7.92E+04	9.17E+04
Cr	1.54E+04	1.81E+04
Cu	NR	1.99E+02
F	3.26E+03	1.17E+03
Fe	8.37E+03	3.69E+04
Hg	5.08E+00	NR
K	6.47E+03	1.16E+04
La	7.86E+00	4.34E+02
Mg	NR	4.59E+03
Mn	6.45E+02	6.09E+03
Na	7.91E+05	7.75E+05
Ni	8.82E+02	1.19E+03
NO_2	2.90E+05	3.51E+05
NO_3	6.71E+05	5.23E+05
OH	4.16E+05	7.65E+02
Pb	7.18E+02	3.50E+03
P as PO_4	2.25E+04	4.42E+04
P	7.34E+03	1.56E+04
Se	NR	NR
Si as SiO_3	[illegible]	1.23E+05
S as SO_4	7.06E+04	1.90E+04
S	2.36E+04	3.20E+01
Sr	7.48E+00	1.61E+02
TOC	5.63E+04	4.09E+04
Total U	7.71E+03	4.13E+04

Table 5. Comparison of Sample and Process Based and Hanford Defined Waste Inventory Estimates for Nonradioactive Components in Tank 241-AX-101 (page 2 of 2)

Analyte	HDW Model (kg)[a]	Sample and Process Based (kg)[b]
Zn	NR	3.35E+02
Zr	2.21E+01	3.47E+03
EDTA	2.66E+04	4.28E+02
NH_3	2.71E+03	2.59E+01
Cr^{+6}	NR	NR
CN	NR	NR
H_2O	2.67E+06	1.59E+06
Pu	6.25E+00	5.46E+00
Volume (kL)	2,831	2,831

HDW = Hanford Defined Waste
NR = Not reported
[a] Agnew et al. (1997a)
[b] Summation of Tables 1 and D-3
[c] Kummerer (1995)

Table 6. Comparison of Sample and Process Based and Hanford Defined Waste Inventory Estimates for Radioactive Components in Tank 241-AX-101 (page 1 of 2)

Analyte	HDW Model (Ci)	Sample and Process Based (Ci)
Decay Date	12/31/99	12/31/99
^{3}H	4.46E+02	9.43E-01
^{14}C	9.87E+01	7.91E+00
^{59}Ni	1.63E+01	6.93E+00
^{60}Co	5.76E+01	3.20E+02
^{63}Ni	1.55E+03	6.81E+02
^{79}Se	1.77E+01	3.86E+00
^{90}Sr	8.83E+05	1.10E+06
^{90}Y	8.83E+05	1.10E+06
^{93}mNb	2.20E+03	1.43E+01
^{93}Zr	8.35E+01	1.67E+01
^{99}Tc	7.53E+02	4.58E+02
^{106}Ru	1.14E-03	2.99E-02
^{113}mCd	2.84E+02	3.55E+01
^{125}Sb	1.26E+02	9.19E-01
^{126}Sn	2.73E+01	6.20E+00
^{129}I	1.45E+00	1.03E-01
^{134}Cs	1.52E+00	1.11E-01
^{135}Cs	NR	NR
^{137}Cs	6.57E+05	5.27E+05
^{137}mBa	6.21E+05	4.98E+05
^{151}Sm	6.10E+04	1.44E+04
^{152}Eu	1.57E+01	3.61E+00
^{154}Eu	1.42E+03	8.49E+01
^{155}Eu	5.64E+02	2.21E+02
^{226}Ra	1.10E-03	4.66E-04
^{227}Ac	5.10E-03	2.41E-03
^{228}Ra	4.97E-01	2.11E-09
^{229}Th	2.35E-02	3.51E-07
^{231}Pa	1.80E-02	3.60E-03
^{232}Th	1.10E-01	2.85E-11
^{232}U	2.83E+00	9.31E-08
^{233}U	1.15E+01	1.31E-09
^{234}U	1.84E+00	3.90E-04
^{235}U	7.29E-02	1.52E-05
^{236}U	5.93E-02	2.57E-05
^{237}Np	2.61E+00	1.65E-03

Table 6. Comparison of Sample and Process Based and Hanford Defined Waste Inventory Estimates for Radioactive Components in Tank 241-AX-101 (page 2 of 2)

Analyte	HDW Model (Ci)	Sample and Process Based (Ci)
Decay Date	12/31/99	12/31/99
^{238}Pu	1.23E+01	5.42E+00
^{238}U	2.57E+00	3.12E-04
^{239}Pu	3.68E+02	3.79E+03
^{240}Pu	6.71E+01	1.23E+03
$^{239/240}$Pu	4.35E+02	5.02E+03
^{241}Am	4.62E+02	2.91E+03
^{241}Pu	6.82E+02	3.84E+02
^{242}Cm	6.27E-05	1.37E-01
^{242}mAm	NR	NR
^{242}Pu	5.22E-03	2.26E-03
^{243}Am	1.90E-02	8.57E-03
^{243}Cm	5.45E-02	1.24E-02
^{244}Cm	9.11E-01	5.02E-01

HDW = Hanford Defined Waste

[a] Agnew et al. (1997a)

[b] Summation of Tables 2 and 4

Table 7. Waste Inventory of 241-AX-101 (Hanlon 1996)

Waste	Volume (kL)	Volume (cubic feet)
Sludge	11	400
Saltcake	2,820	99,450
Supernatant	30	0
Drainable liquid	1,211	42,720
Total waste	2,831	99,850

Table 8. Waste Transaction Information for Tank 241-AX-101 (Agnew et al. 1997b)

Waste source	Waste volume (kL)	Waste volume (kgal)
PUREX HLW, organic wash waste, B Plant Fission Product Waste	3,198	845
B Plant Fission Product Waste	12,933	3,417
Moved to tank A-102, AX-102, AX-103	-8,456	-2,234
PUREX HLW	3,229	853
Moved to A-102, AX-102	-1,737	-459
PUREX acid waste after Sr removal at B Plant	14,769	3,902
Moved to A-102, AX-103	-17,252	-4,558
PUREX sludge supernatant	4,031	1,065
Moved to AX-103, A-103	-3,274	-865
SRR waste	764	202
Tank sluiced to B Plant via AR Vault, AX-103	-2,055	-543
Sluiced tank empty except for 4.5 kL sludge heel		
EVAP	3,622	957
RESD, DSSF	10,288	2,718
To A-102	-10,746	-2,839
DSSF	2,737	723
Moved to AW-103	-2,998	-792
Saltwell liquid moved to AN-103	-53	-14
Total Waste Added post sluicing	16,646	4,398
Total Waste Removed post sluicing	-13,796	-3,645
Current Inventory	2,831	748

DSSF = Double-shell slurry feed
EVAP = Evaporator feed
HLW = High-level waste
RESD = Residual evaporator liquor
PUREX = Plutonium-uranium extraction (plant or process).

Table 9. Expected Solids for Tank 241-AX-101

Reference	Waste type
Anderson (1990)	[P, OWW, FP, B, PSS], Resid., DSSF, NCPLX, CPLX,
SORWT Model (Hill et al. 1995)	DSSF, NCPLX, EVAP
WSTRS (Agnew et al. 1997b)	[FP, SU, OWW, P, B, PL, PSS], SRR, EVAP, RESD, DSSF, NCPLX, CPLX
HDW Model (Agnew et al. 1997a)	SRR, P2, SMMA1

B = B Plant Waste
CPLX = Complexed waste
DSSF = Double-shell slurry feed
EVAP = Evaporator feed
FP = Fission product waste
HDW = Hanford Defined Waste
NCPLX = Non-complexed Waste
OWW = Organic Wash Waste
P, P2 = PUREX neutralized high-level waste
PL = PUREX low-level waste
PSS = PUREX sludge supernatant
Resid. = Residual
SORWT = Sort on radioactive waste type
SRR = Strontium recovery
SU = Supernatant
SMMA1 = Supernatant mixing model A1 salt sake
SMMA2 = Supernatant mixing model A2 saltcake
WSTRS = Waste status and transaction record summary

Table 10. Hanford Defined Waste Model Solids for Tank 241-AX-101

Hanford Defined Waste solids layer	kL	kgal
SRR	11	3
P2	38	10
SMMA1	2,872	735

P2 = PUREX neutralized high-level waste
SMMA1 = Supernatant Mixing Model A1 saltcake
SRR = Strontium recovery waste.

Table 11. Relative Volume of Layers in Tanks 241-A-102 and 241-AX-101

Waste type	Waste Volume in Tank 241-A-102, kL	Volume Percent in Tank 241-A-102	Waste Volume in Tank 241-AX-101, kL	Volume Percent in Tank 241-AX-101
SRR	11.3	8.1	11.3	0.4
SMMA1	71.9	51	2,820	99.6
SMMA2	56.8	40	0	0

SMMA1 = Supernatant Mixing Model A1 saltcake
SMMA2 = Supernatant Mixing Model A2 saltcake
SRR = Strontium recovery.

Table 12. Best-Basis Inventory of Waste from Single-Shell Tank 241-AX-101 (page 1 of 2)

	Sludge	Saltcake	Overall
Density (kg/m^3)	1,690	1,495	1,496
Volume (m^3)	11.4	2,820.1	2,831
Components (M)			Inventory (kg)
Ag	NR	2.31E-03	703.7
Al	8.26E+00	1.22E+00	95,393.7
As	NR	NR	NR
B	NR	NR	NR
Ba	7.00E-02	5.91E-03	2,398.1
Bi	NR	4.34E-03	2,557.9
Ca	2.28E+00	6.26E-02	8,110.6
Cd	5.00E-02	NR	63.8
Cl	5.37E-02	2.10E-01	21,021.6
TIC as CO_3	3.41E-01	5.41E-01	91,719.9
Cr	2.03E-01	1.23E-01	18,177.0
Cu	NR	NR	NR
F	NR	2.18E-02	1,167.8
Fe	1.90E+01	2.29E-01	48,129.9
Hg	NR	8.98E-06	5.1
K	1.17E-02	1.05E-01	11,559.7
La	NR	1.11E-03	434.2
Mg	5.70E-01	NR	157.3
Mn	2.82E-01	3.93E-02	6,267.1
Na	1.76E+01	1.19E+01	777,434.7
Ni	8.67E-01	7.17E-03	1,764.1
NO_2	8.34E-01	2.70E+00	351,207.6
NO_3	4.10E+00	2.99E+00	525,460.9
OH	5.60E+01	8.53E+00	419,807.9
Pb	NR	5.99E-03	3,502.7
P as PO_4	3.67E-01	1.65E-01	44,593.3
P	3.67E-01	8.40E-02	7,467.1
Se	NR	NR	NR
Si as SiO_3	1.01E+01	5.66E-01	130,193.8
S as SO_4	5.38E-01	6.97E-02	19,474.3
S	5.38E-01	2.58E-01	23,558.9
Sr	NR	6.53E-04	161.3
TOC	4.38E+00	1.19E+00	40,850.4
Total U	1.36E-05	6.16E-02	41,327.5

Table 12. Best-Basis Inventory of Waste from Single-Shell Tank 241-AX-101 (page 2 of 2)

	Sludge	Saltcake	Overall
Density (kg/m^3)	1,690	1,495	1,496
Volume (m^3)	11.4	2,820.1	2,831
Components (M)			Inventory (kg)
Zn	NR	NR	NR
Zr	NR	8.59E-05	22.1
EDTA	1.29E-01	3.18E-02	26,628.4
NH_3	1.34E-01	5.23E-02	2,535.9
Cr^{+6}	NR	NR	NR
CN	NR	NR	NR
H_2O	1.81E+02	3.11E+01	1,616,439.1
Total			4.31E+06

NR = Not reported

Table 13. Best-Basis Radionuclide Inventory Before Retrieval of Waste from Single-Shell Tank 241-AX-101 (page 1 of 2)

Components (Ci/L)	SLUDGE	SALTCAKE	INVENTORY (CI)
Decay Date	12/31/99	12/31/99	12/31/99
^{3}H	8.30E-05	NR	9.43E-01
^{14}C	6.77E-06	2.78E-06	7.91E+00
^{59}Ni	6.10E-04	NR	6.93E+00
^{60}Co	1.37E-05	1.13E-04	3.20E+02
^{63}Ni	6.00E-02	NR	6.81E+02
^{79}Se	3.40E-04	NR	3.86E+00
^{90}Sr	9.57E+00	3.52E-01	1.10E+06
^{90}Y	9.57E+00	3.52E-01	1.10E+06
^{93}mNb	1.26E-03	NR	1.43E+01
^{93}Zr	1.47E-03	NR	1.67E+01
^{99}Tc	4.57E-05	1.62E-04	4.58E+02
^{106}Ru	2.63E-06	NR	2.99E-02
^{113}mCd	3.13E-03	NR	3.55E+01
^{125}Sb	8.09E-05	NR	9.19E-01
^{126}Sn	5.46E-04	NR	6.20E+00
^{129}I	8.89E-08	3.63E-08	1.03E-01
^{134}Cs	9.76E-06	NR	1.11E-01
^{135}Cs	NR	NR	NR
^{137}Cs	1.77E-01	1.86E-01	5.27E+05
^{137}mBa	1.67E-01	1.76E-01	4.98E+05
^{151}Sm	1.27E+00	NR	1.44E+04
^{152}Eu	3.18E-04	NR	3.61E+00
^{154}Eu	7.47E-03	NR	8.49E+01
^{155}Eu	1.95E-02	NR	2.21E+02
^{226}Ra	4.10E-08	NR	4.66E-04
^{227}Ac	2.12E-07	NR	2.41E-03
^{228}Ra	1.86E-13	NR	2.11E-09
^{229}Th	3.09E-11	NR	3.51E-07
^{231}Pa	3.17E-07	NR	3.60E-03
^{232}Th	2.51E-15	NR	2.85E-11
^{232}U	8.20E-12	NR	9.31E-08
^{233}U	1.15E-13	NR	1.31E-09
^{234}U	3.43E-08	NR	3.90E-04
^{235}U	1.34E-09	NR	1.52E-05
^{236}U	2.26E-09	NR	2.57E-05
^{237}Np	1.45E-07	NR	1.65E-03

Table 13. Best-Basis Radionuclide Inventory Before Retrieval of Waste from Single-Shell Tank 241-AX-101 (page 2 of 2)

Components (Ci/L)	SLUDGE	SALTCAKE	INVENTORY (CI)
Decay Date	12/31/99	12/31/99	12/31/99
^{238}Pu	4.77E-04	NR	5.42E+00
^{238}U	2.75E-08	NR	3.12E-04
^{239}Pu	1.28E-02	NR	1.45E+02
^{240}Pu	3.38E-02	NR	3.84E+02
$^{239/240}Pu$	4.66E-02	1.59E-03	5.02E+03
^{241}Am	1.44E-02	9.75E-04	2.91E+03
^{241}Pu	3.38E-02	NR	3.84E+02
^{242}Cm	1.21E-05	NR	1.37E-01
^{242}mAm	NR	NR	NR
^{242}Pu	1.99E-07	NR	2.26E-03
^{243}Am	7.55E-07	NR	8.57E-03
^{243}Cm	1.09E-06	NR	1.24E-02
^{244}Cm	4.42E-05	NR	5.02E-01
Total			3.25E+06

Table 14. Retrieval Scenario Summary of Residual Waste and Fractional Removal

	Case I	Case II	Case III
Vol Base (m^3)	101.94	10.19	1.02
% Base	90.0%	99.0%	99.9%
Target (m^3)	101.94	10.19	1.02
Sludge (m^3)	11.36	10.19	1.02
Saltcake (m^3)	90.58	0.00	0.00
Sludge Removal	0.0%	10.2%	91.0%
SC Removal	96.8%	100.0%	100.0%

Table 15. Tank 241-AX-101 Nonradiological Waste Residual Inventory Following Retrieval (page 1 of 2)

Residual Waste (kg)	Case I	Case II	Case III
Target (m^3)	101.94	10.19	1.02
Sludge (m^3)	11.36	10.19	1.02
Saltcake (m^3)	90.58	0.00	0.00
Ag	2.26E+01		
Al	5.51E+03	2.27E+03	2.27E+02
As	NR	NR	NR
B	NR	NR	NR
Ba	1.83E+02	9.80E+01	9.80E+00
Bi	8.22E+01		
Ca	1.26E+03	9.30E+02	9.30E+01
Cd	6.38E+01	5.73E+01	5.73E+00
Cl	6.96E+02	1.94E+01	1.94E+00
TIC as CO3	3.17E+03	2.09E+02	2.09E+01
Cr	7.00E+02	1.08E+02	1.08E+01
Cu	NR	NR	NR
F	3.75E+01		
Fe	1.32E+04	1.08E+04	1.08E+03
Hg	1.63E-01		
K	3.76E+02	4.65E+00	4.65E-01
La	1.39E+01		
Mg	1.57E+02	1.41E+02	1.41E+01
Mn	3.71E+02	1.58E+02	1.58E+01
Na	2.94E+04	4.11E+03	4.11E+02
Ni	6.16E+02	5.19E+02	5.19E+01
NO2	1.17E+04	3.91E+02	3.91E+01
NO3	1.97E+04	2.59E+03	2.59E+02
OH	2.39E+04	9.70E+03	9.70E+02
Pb	1.13E+02		
P as PO4	1.82E+03	3.55E+02	3.55E+01
P	3.65E+02	1.16E+02	1.16E+01
Se	NR	NR	NR
Si as SiO3	1.26E+04	7.82E+03	7.82E+02
S as SO4	1.19E+03	5.27E+02	5.27E+01
S	9.46E+02	1.76E+02	1.76E+01
Sr	5.18E+00		
TOC	1.89E+03	5.37E+02	5.37E+01
Total U	1.33E+03	3.30E-02	3.30E-03

Table 15. Tank 241-AX-101 Nonradiological Waste Residual Inventory Following Retrieval (page 2 of 2)

Residual Waste (kg)	Case I	Case II	Case III
Zn	NR	NR	NR
Zr	7.10E-01		
EDTA	1.27E+03	3.85E+02	3.85E+01
NH3	1.07E+02	2.32E+01	2.32E+00
Cr+6	NR	NR	NR
CN	NR	NR	NR
H2O	8.78E+04	3.32E+04	3.32E+03
Total	2.19E+05	7.50E+04	7.50E+03

Table 16. Tank 241-AX-101 Radiological Waste Residual Inventory Following Retrieval (page 1 of 2)

Residual Waste (Ci)	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99
3H	9.43E-01	8.46E-01	8.46E-02
14C	7.69E-02	6.90E-02	6.90E-03
59Ni	6.93E+00	6.22E+00	6.22E-01
60Co	1.56E-01	1.40E-01	1.40E-02
63Ni	6.81E+02	6.12E+02	6.12E+01
79Se	3.86E+00	3.47E+00	3.47E-01
90Sr	1.09E+05	9.76E+04	9.76E+03
90Y	1.09E+05	9.76E+04	9.76E+03
93mNb	1.43E+01	1.28E+01	1.28E+00
93Zr	1.67E+01	1.50E+01	1.50E+00
99Tc	5.19E-01	4.66E-01	4.66E-02
106Ru	2.99E-02	2.68E-02	2.68E-03
113mCd	3.55E+01	3.19E+01	3.19E+00
125Sb	9.19E-01	8.25E-01	8.25E-02
126Sn	6.20E+00	5.57E+00	5.57E-01
129I	1.01E-03	9.06E-04	9.06E-05
134Cs	1.11E-01	9.95E-02	9.95E-03
135Cs	NR	NR	NR
137Cs	2.01E+03	1.80E+03	1.80E+02
137mBa	1.90E+03	1.70E+03	1.70E+02
151Sm	1.44E+04	1.30E+04	1.30E+03
152Eu	3.61E+00	3.24E+00	3.24E-01
154Eu	8.49E+01	7.62E+01	7.62E+00
155Eu	2.21E+02	1.99E+02	1.99E+01
226Ra	4.66E-04	4.18E-04	4.18E-05
227Ac	2.41E-03	2.16E-03	2.16E-04
228Ra	2.11E-09	1.90E-09	1.90E-10
229Th	3.51E-07	3.15E-07	3.15E-08
231Pa	3.60E-03	3.23E-03	3.23E-04
232Th	2.85E-11	2.56E-11	2.56E-12
232U	9.31E-08	8.36E-08	8.36E-09
233U	1.31E-09	1.17E-09	1.17E-10
234U	3.90E-04	3.50E-04	3.50E-05
235U	1.52E-05	1.37E-05	1.37E-06
236U	2.57E-05	2.30E-05	2.30E-06
237Np	1.65E-03	1.48E-03	1.48E-04

Table 16. Tank 241-AX-101 Radiological Waste Residual Inventory Following Retrieval (page 2 of 2)

Residual Waste (Ci)	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99
238Pu	5.42E+00	4.86E+00	4.86E-01
238U	3.12E-04	2.80E-04	2.80E-05
239Pu	1.45E+02	1.30E+02	1.30E+01
240Pu	3.84E+02	3.44E+02	3.44E+01
239/240Pu	5.29E+02	4.75E+02	4.75E+01
241Am	1.64E+02	1.47E+02	1.47E+01
241Pu	3.84E+02	3.44E+02	3.44E+01
242Cm	1.37E-01	1.23E-01	1.23E-02
242mAm	NR	NR	NR
242Pu	2.26E-03	2.03E-03	2.03E-04
243Am	8.57E-03	7.70E-03	7.70E-04
243Cm	1.24E-02	1.11E-02	1.11E-03
244Cm	5.02E-01	4.51E-01	4.51E-02
Total	2.38E+05	2.14E+05	2.14E+04

Table 17. Retrieval Scenario Product Solution Nonradiological Analyte Concentrations (page 1 of 2)

Limiting Vol (L)	6,507,475	6,727,521	6,759,731
Sludge [Solids Basis (L)]	0	40,344	358,900
Saltcake [Na Basis (L)]	6,507,475	6,727,521	6,759,731
Solution Concentrations (M)	Case I	Case II	Case III
Ag	9.70E-04	9.70E-04	9.65E-04
Al	5.12E-01	5.13E-01	5.22E-01
As			
B			
Ba	2.48E-03	2.49E-03	2.57E-03
Bi	1.82E-03	1.82E-03	1.81E-03
Ca	2.63E-02	2.66E-02	2.96E-02
Cd	1.49E-18	8.64E-06	7.65E-05
Cl	8.81E-02	8.81E-02	8.77E-02
TIC as CO3	2.27E-01	2.27E-01	2.26E-01
Cr	5.17E-02	5.17E-02	5.17E-02
Cu			
F	9.14E-03	9.14E-03	9.09E-03
Fe	9.61E-02	9.93E-02	1.25E-01
Hg	3.77E-06	3.76E-06	3.75E-06
K	4.40E-02	4.39E-02	4.37E-02
La	4.65E-04	4.65E-04	4.62E-04
Mg	1.70E-17	9.84E-05	8.72E-04
Mn	1.65E-02	1.65E-02	1.68E-02
Na	5.00E+00	5.00E+00	5.00E+00
Ni	3.01E-03	3.15E-03	4.32E-03
NO2	1.13E+00	1.13E+00	1.13E+00
NO3	1.25E+00	1.25E+00	1.25E+00
OH	3.58E+00	3.58E+00	3.64E+00
Pb	2.51E-03	2.51E-03	2.50E-03
P as PO4	6.92E-02	6.92E-02	6.94E-02
P	3.52E-02	3.53E-02	3.56E-02
Se			
Si as SiO3	2.37E-01	2.39E-01	2.52E-01
S as SO4	2.92E-02	2.93E-02	2.99E-02
S	1.08E-01	1.08E-01	1.09E-01
Sr	2.74E-04	2.74E-04	2.72E-04
TOC	4.98E-01	4.99E-01	5.02E-01

Table 17. Retrieval Scenario Product Solution Nonradiological Analyte Concentrations (page 2 of 2)

Limiting Vol (L)	6,507,475	6,727,521	6,759,731
Sludge [Solids Basis (L)]	0	40,344	358,900
Saltcake [Na Basis (L)]	6,507,475	6,727,521	6,759,731
Solution Concentrations (M)	Case I	Case II	Case III
Total U	2.58E-02	2.58E-02	2.57E-02
Zn			
Zr	3.60E-05	3.60E-05	3.58E-05
EDTA	1.33E-02	1.33E-02	1.35E-02
NH3	2.19E-02	2.19E-02	2.20E-02
Cr+6			
CN			
H2O	13.04	13.06	13.25
Retrieval H2O	32.23	32.23	32.27

Table 18. Retrieval Scenario Product Solution Radiological Analyte Concentrations (page 1 of 2)

Solution Concentrations (Ci/L)	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99
3H	2.47E-21	1.43E-08	1.27E-07
14C	1.16E-06	1.17E-06	1.17E-06
59Ni	1.81E-20	1.05E-07	9.33E-07
60Co	4.75E-05	4.75E-05	4.73E-05
63Ni	1.79E-18	1.04E-05	9.18E-05
79Se	1.01E-20	5.87E-08	5.20E-07
90Sr	1.48E-01	1.49E-01	1.62E-01
90Y	1.48E-01	1.49E-01	1.62E-01
93mNb	3.75E-20	2.18E-07	1.93E-06
93Zr	4.37E-20	2.54E-07	2.25E-06
99Tc	6.81E-05	6.81E-05	6.78E-05
106Ru	7.83E-23	4.54E-10	4.02E-09
113mCd	9.31E-20	5.41E-07	4.79E-06
125Sb	2.41E-21	1.40E-08	1.24E-07
126Sn	1.62E-20	9.43E-08	8.35E-07
129I	1.52E-08	1.52E-08	1.53E-08
134Cs	2.90E-22	1.69E-09	1.49E-08
135Cs			
137Cs	7.81E-02	7.81E-02	7.79E-02
137mBa	7.39E-02	7.38E-02	7.37E-02
151Sm	3.78E-17	2.20E-04	1.94E-03
152Eu	9.46E-21	5.49E-08	4.86E-07
154Eu	2.22E-19	1.29E-06	1.14E-05
155Eu	5.80E-19	3.37E-06	2.98E-05
226Ra	1.22E-24	7.08E-12	6.27E-11
227Ac	6.31E-24	3.66E-11	3.24E-10
228Ra	5.53E-30	3.21E-17	2.84E-16
229Th	9.19E-28	5.34E-15	4.73E-14
231Pa	9.43E-24	5.47E-11	4.85E-10
232Th	7.47E-32	4.34E-19	3.84E-18
232U	2.44E-28	1.42E-15	1.25E-14
233U	3.42E-30	1.99E-17	1.76E-16
234U	1.02E-24	5.92E-12	5.24E-11
235U	3.99E-26	2.31E-13	2.05E-12
236U	6.72E-26	3.90E-13	3.46E-12
237Np	4.31E-24	2.50E-11	2.22E-10

Table 18. Retrieval Scenario Product Solution Radiological Analyte Concentrations (page 2 of 2)

Solution Concentrations (Ci/L)	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99
238Pu	1.42E-20	8.24E-08	7.29E-07
238U	8.18E-25	4.75E-12	4.21E-11
239Pu	3.81E-19	2.21E-06	1.96E-05
240Pu	1.01E-18	5.84E-06	5.17E-05
239/240Pu	6.68E-04	6.76E-04	7.36E-04
241Am	4.09E-04	4.11E-04	4.29E-04
241Pu	1.01E-18	5.84E-06	5.17E-05
242Cm	3.60E-22	2.09E-09	1.85E-08
242mAm			
242Pu	5.92E-24	3.44E-11	3.04E-10
243Am	2.25E-23	1.30E-10	1.15E-09
243Cm	3.24E-23	1.88E-10	1.67E-09
244Cm	1.32E-21	7.63E-09	6.76E-08

Table 19. Tank 241-AX-101 Retrieval Scenario Nonradiological Constituent Leakage Estimate (page 1 of 2)

Release Volume (L)	30,283	30,283	30,283	151,413	151,413	151,413
Analyte (kg)	Case I	Case II	Case III	Case I	Case II	Case III
Ag	3.17E+00	3.17E+00	3.15E+00	1.58E+01	1.58E+01	1.58E+01
Al	4.18E+02	4.19E+02	4.26E+02	2.09E+03	2.10E+03	2.13E+03
As						
B						
Ba	1.03E+01	1.04E+01	1.07E+01	5.15E+01	5.18E+01	5.35E+01
Bi	1.15E+01	1.15E+01	1.15E+01	5.76E+01	5.76E+01	5.73E+01
Ca	3.19E+01	3.23E+01	3.59E+01	1.59E+02	1.62E+02	1.80E+02
Cd	5.06E-15	2.94E-02	2.60E-01	2.53E-14	1.47E-01	1.30E+00
Cl	9.46E+01	9.45E+01	9.42E+01	4.73E+02	4.73E+02	4.71E+02
TIC as CO3	4.12E+02	4.12E+02	4.11E+02	2.06E+03	2.06E+03	2.05E+03
Cr	8.13E+01	8.13E+01	8.14E+01	4.07E+02	4.07E+02	4.07E+02
Cu						
F	5.26E+00	5.26E+00	5.23E+00	2.63E+01	2.63E+01	2.62E+01
Fe	1.63E+02	1.68E+02	2.11E+02	8.13E+02	8.40E+02	1.05E+03
Hg	2.29E-02	2.29E-02	2.28E-02	1.14E-01	1.14E-01	1.14E-01
K	5.20E+01	5.20E+01	5.18E+01	2.60E+02	2.60E+02	2.59E+02
La	1.96E+00	1.95E+00	1.95E+00	9.78E+00	9.77E+00	9.73E+00
Mg	1.25E-14	7.25E-02	6.42E-01	6.24E-14	3.62E-01	3.21E+00
Mn	2.74E+01	2.75E+01	2.80E+01	1.37E+02	1.38E+02	1.40E+02
Na	3.48E+03	3.48E+03	3.48E+03	1.74E+04	1.74E+04	1.74E+04
Ni	5.34E+00	5.61E+00	7.67E+00	2.67E+01	2.80E+01	3.84E+01
NO2	1.58E+03	1.58E+03	1.57E+03	7.90E+03	7.90E+03	7.87E+03
NO3	2.35E+03	2.35E+03	2.35E+03	1.18E+04	1.18E+04	1.18E+04
OH	1.84E+03	1.85E+03	1.88E+03	9.21E+03	9.23E+03	9.38E+03
Pb	1.58E+01	1.58E+01	1.57E+01	7.89E+01	7.88E+01	7.85E+01
P as PO4	1.99E+02	1.99E+02	2.00E+02	9.95E+02	9.96E+02	9.98E+02
P	3.31E+01	3.31E+01	3.34E+01	1.65E+02	1.65E+02	1.67E+02
Se						
Si as SiO3	5.47E+02	5.51E+02	5.80E+02	2.74E+03	2.75E+03	2.90E+03
S as SO4	8.51E+01	8.53E+01	8.70E+01	4.25E+02	4.26E+02	4.35E+02
S	1.05E+02	1.05E+02	1.05E+02	5.26E+02	5.26E+02	5.27E+02
Sr	7.26E-01	7.26E-01	7.23E-01	3.63E+00	3.63E+00	3.61E+00
TOC	1.81E+02	1.81E+02	1.83E+02	9.06E+02	9.07E+02	9.14E+02
Total U	1.86E+02	1.86E+02	1.85E+02	9.31E+02	9.30E+02	9.26E+02
Zn						
Zr	9.95E-02	9.94E-02	9.90E-02	4.97E-01	4.97E-01	4.95E-01

Table 19. Tank 241-AX-101 Retrieval Scenario Nonradiological Constituent Leakage Estimate (page 2 of 2)

Release Volume (L)	30,283	30,283	30,283	151,413	151,413	151,413
Analyte (kg)	Case I	Case II	Case III	Case I	Case II	Case III
EDTA	1.18E+02	1.18E+02	1.19E+02	5.90E+02	5.91E+02	5.96E+02
NH3	1.13E+01	1.13E+01	1.13E+01	5.65E+01	5.66E+01	5.67E+01
Cr+6						
CN						
H2O	7.11E+03	7.13E+03	7.23E+03	3.56E+04	3.56E+04	3.61E+04
Retrieval water	1.76E+04	1.76E+04	1.76E+04	8.79E+04	8.79E+04	8.80E+04
Total (kg)	3.66E+04	3.67E+04	3.69E+04	1.83E+05	1.83E+05	1.84E+05

Table 20. Tank 241-AX-101 Retrieval Scenario Nonradiological Constituent Leakage Estimate (page 1 of 2)

Release Volume (L)	30,283	30,283	30,283	151,413	151,413	151,413
Analyte (Ci)	Case I	Case II	Case III	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99
3H	7.48E-17	4.34E-04	3.84E-03	3.74E-16	2.17E-03	1.92E-02
14C	3.53E-02	3.53E-02	3.54E-02	1.76E-01	1.76E-01	1.77E-01
59Ni	5.50E-16	3.19E-03	2.82E-02	2.75E-15	1.60E-02	1.41E-01
60Co	1.44E+00	1.44E+00	1.43E+00	7.19E+00	7.19E+00	7.16E+00
63Ni	5.41E-14	3.14E-01	2.78E+00	2.70E-13	1.57E+00	1.39E+01
79Se	3.06E-16	1.78E-03	1.57E-02	1.53E-15	8.89E-03	7.87E-02
90Sr	4.47E+03	4.52E+03	4.89E+03	2.24E+04	2.26E+04	2.45E+04
90Y	4.47E+03	4.52E+03	4.89E+03	2.24E+04	2.26E+04	2.45E+04
93mNb	1.14E-15	6.59E-03	5.83E-02	5.68E-15	3.30E-02	2.92E-01
93Zr	1.32E-15	7.68E-03	6.80E-02	6.62E-15	3.84E-02	3.40E-01
99Tc	2.06E+00	2.06E+00	2.05E+00	1.03E+01	1.03E+01	1.03E+01
106Ru	2.37E-18	1.38E-05	1.22E-04	1.18E-17	6.88E-05	6.09E-04
113mCd	2.82E-15	1.64E-02	1.45E-01	1.41E-14	8.19E-02	7.25E-01
125Sb	7.29E-17	4.23E-04	3.75E-03	3.64E-16	2.12E-03	1.87E-02
126Sn	4.92E-16	2.86E-03	2.53E-02	2.46E-15	1.43E-02	1.26E-01
129I	4.60E-04	4.61E-04	4.62E-04	2.30E-03	2.30E-03	2.31E-03
134Cs	8.79E-18	5.10E-05	4.52E-04	4.40E-17	2.55E-04	2.26E-03
135Cs						
137Cs	2.36E+03	2.36E+03	2.36E+03	1.18E+04	1.18E+04	1.18E+04
137mBa	2.24E+03	2.24E+03	2.23E+03	1.12E+04	1.12E+04	1.12E+04
151Sm	1.15E-12	6.65E+00	5.89E+01	5.73E-12	3.32E+01	2.94E+02
152Eu	2.87E-16	1.66E-03	1.47E-02	1.43E-15	8.32E-03	7.36E-02
154Eu	6.73E-15	3.91E-02	3.46E-01	3.37E-14	1.95E-01	1.73E+00
155Eu	1.76E-14	1.02E-01	9.02E-01	8.78E-14	5.10E-01	4.51E+00
226Ra	3.69E-20	2.14E-07	1.90E-06	1.85E-19	1.07E-06	9.49E-06
227Ac	1.91E-19	1.11E-06	9.82E-06	9.55E-19	5.54E-06	4.91E-05
228Ra	1.68E-25	9.73E-13	8.61E-12	8.38E-25	4.86E-12	4.31E-11
229Th	2.78E-23	1.62E-10	1.43E-09	1.39E-22	8.08E-10	7.15E-09
231Pa	2.86E-19	1.66E-06	1.47E-05	1.43E-18	8.29E-06	7.34E-05
232Th	2.26E-27	1.31E-14	1.16E-13	1.13E-26	6.56E-14	5.81E-13
232U	7.39E-24	4.29E-11	3.80E-10	3.69E-23	2.14E-10	1.90E-09
233U	1.04E-25	6.01E-13	5.33E-12	5.18E-25	3.01E-12	2.66E-11
234U	3.09E-20	1.79E-07	1.59E-06	1.55E-19	8.97E-07	7.94E-06
235U	1.21E-21	7.01E-09	6.21E-08	6.04E-21	3.50E-08	3.10E-07
236U	2.04E-21	1.18E-08	1.05E-07	1.02E-20	5.91E-08	5.23E-07

Table 20. Tank 241-AX-101 Retrieval Scenario Nonradiological Constituent Leakage Estimate (page 2 of 2)

Release Volume (L)	30,283	30,283	30,283	151,413	151,413	151,413
Analyte (Ci)	Case I	Case II	Case III	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99
237Np	1.31E-19	7.58E-07	6.71E-06	6.53E-19	3.79E-06	3.36E-05
238Pu	4.30E-16	2.49E-03	2.21E-02	2.15E-15	1.25E-02	1.10E-01
238U	2.48E-20	1.44E-07	1.27E-06	1.24E-19	7.19E-07	6.37E-06
239Pu	1.15E-14	6.69E-02	5.93E-01	5.76E-14	3.35E-01	2.96E+00
240Pu	3.04E-14	1.77E-01	1.56E+00	1.52E-13	8.84E-01	7.82E+00
239/240Pu	2.02E+01	2.05E+01	2.23E+01	1.01E+02	1.02E+02	1.11E+02
241Am	1.24E+01	1.24E+01	1.30E+01	6.19E+01	6.22E+01	6.49E+01
241Pu	3.04E-14	1.77E-01	1.56E+00	1.52E-13	8.84E-01	7.82E+00
242Cm	1.09E-17	6.33E-05	5.60E-04	5.45E-17	3.16E-04	2.80E-03
242mAm						
242Pu	1.79E-19	1.04E-06	9.21E-06	8.97E-19	5.20E-06	4.61E-05
243Am	6.80E-19	3.95E-06	3.50E-05	3.40E-18	1.97E-05	1.75E-04
243Cm	9.82E-19	5.70E-06	5.05E-05	4.91E-18	2.85E-05	2.52E-04
244Cm	3.98E-17	2.31E-04	2.05E-03	1.99E-16	1.16E-03	1.02E-02
Total	1.36E+04	1.37E+04	1.45E+04	6.78E+04	6.83E+04	7.23E+04

APPENDIX C

BEST-BASIS INVENTORY, RETRIEVAL INVENTORY, AND LEAKAGE INVENTORY ESTIMATES FOR RETRIEVAL OF WASTE FROM SINGLE-SHELL TANK 241-AX-102

D. W. Hendrickson, P.E.
S. L. Lambert, Ph.D.
SGN Eurisys Services Corporation
Richland, Washington

CONTENTS

The purpose of this study is to provide the best-basis estimate of the chemical and radiological waste inventory after retrieval of waste from the AX farm. As part of this effort, an evaluation of available information for Tank 241-AX-102 was performed and a best-basis inventory was established for three different retrieval scenarios. The first scenario is based on either retrieving at least 90 percent of the waste to a residual volume of 101.94 m^3 (3,600 ft^3) of waste, or the current volume if this volume is less than 101.94 m^3 (3,600 ft^3. The second scenario assumes 99 percent retrieval of waste from the tank to meet the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1990) (Tri-Party Agreement) milestone of 101.9 m^3 (360 ft^3) of residual waste, while the third scenario assumes 99.9 percent retrieval to a residual volume of 1.02 m^3 (36 ft^3) of waste. This study, detailed in the following sections, is based on the methodology that was established by the standard inventory task.

1.0 CHEMICAL INFORMATION SOURCES

Chemical and radionuclide inventory estimates are generally derived from one of three sources of information: (1) sample analysis and sample derived inventory estimates, (2) component inventories predicted by the Hanford Defined Waste (HDW) model based on process knowledge and historical tank transfer information, or (3) a tank-specific process estimate based on process flowsheets, reactor fuel data, essential materials records, or comparable sludge layers and sample information from other tanks.

A total of seven sampling events have occurred for Tank 241-AX-102. One sludge sample was taken in 1974, as the tank was being prepared for sluicing. The tank then contained 189,000 L (50 kgal) of sludge derived primarily from B Plant waste. The sample was analyzed for percent water, density, radionuclides, and a few metals. After sluicing (1976/1977), the tank contained a heel of approximately 26,000 L (7 kgal) of sludge. Six samples of the remaining sludge were analyzed for radionuclide content only.

After sluicing was completed, the tank was used as both a feed and slurry storage tank for the 242-A evaporator-crystallizer (1977 to 1980). The evaporator was processing complexed waste during that time. Analytical results for two liquid grab samples taken in early 1980 show the composition of the evaporator feed solution in the tank at that time. These results provide no quantitative estimates of the solids deposited on top of the sludge heel, but they do indicate the type of waste that was being stored in the tank.

In 1988, the tank was declared a leaker, and a liquid grab sample was taken to establish the composition of the liquid to be pumped out of the tank by salt well pumping. This sample contained no solids, but analysis of the liquid firmly identifies the waste as concentrated complexed (CC) waste (waste having a total organic carbon concentration over 10 g/L at the aluminate phase boundary). The composition of the solids deposited during the evaporator operations (approximately 98,000 L) can be assumed to be similar in composition to the solids deposited by CC wastes in double-shell Tanks 241-AN-107 and 241-AN-102, where the solids have been analyzed (Herting 1994a and 1996). The projected composition of these solids also generally matches, except for some of the minor components, the composition profile for SMMA1 saltcake from the 242-A evaporator, based on two cores and one auger sample from

Tank 241-A-102 and two core samples from Tank 241-A-103 (best-basis standard inventory for Tank 241-AX-103).

Two auger samples were also taken from the surface of Tank 241-AX-102 in February 1995, to support the safety assessment of the tank. Limited analyses were obtained from these samples.

2.0 CHEMICAL/RADIONUCLIDE INVENTORY ESTIMATES BEFORE RETRIEVAL

Hanlon (1996) estimates that Tank 241-AX-102 contains 26,500 L (7 kgal) of sludge, 110,000 L (29 kgal) of saltcake, and 11,000 L (3 kgal) of supernatant liquid. These values are based on the surface level measurements and tank photographs taken at the time the tank was pumped in 1988. More recent photographs show that there is no supernatant liquid left in the tank.

A 1993 report on waste level discrepancies (Swaney 1993) indicate that the surface reading used for the Hanlon volume estimates was probably high by 5.5 cm (2.18 in.) because the manual tape appeared to contact a small pipe protruding from the waste. No adjustment was made to the Hanlon inventory.

Current waste level readings are fairly consistent at 24 cm (9.5 in.). The drop in the surface level from 30.5 cm (12.02 in.) in 1993 to 24 cm (9.5 in.) in 1997 is probably due to evaporation of water, which is consistent with the photographic evidence of the disappearance of supernatant liquid. The bulk of the analytical data applies to the composition of the waste before the recent drying trend, so the earlier surface level reading (Swaney 1993) was used for the best-basis inventory evaluation.

According to the HDW model, Tank 241-AX-102 contains 23,000 L (6 kgal) of sludge, 125,000 L (33 kgal) of saltcake; and no supernatant liquid.

Table 1 shows a summary of the volume data available, and the data chosen for the best-basis inventory evaluation. The best-basis inventory will be estimated from 26.5 kL (934 ft^3) of sludge and 98.4 kL (3,470 ft^3) of saltcake.

Tables 2 and 3 provide the best-basis inventory estimates for the combined sludge and saltcake layers in Tank 241-AX-102 for nonradiological and radiological constituents, respectively. These estimates incorporated HDW model (Agnew et al. 1997a) estimates where sample data does not address the waste composition. The radionuclide inventory values were derived for 46 key radionuclides (Kupfer et al. 1997). Waste sample analyses have often only reported ^{90}Sr, ^{137}Cs, $^{239/240}$Pu, and total uranium (or total beta and total alpha), while other key radionuclides, such as ^{60}Co, ^{99}Tc, ^{129}I, ^{154}Eu, ^{155}Eu, and ^{241}Am, etc., have been infrequently reported. For this reason it was necessary to derive most of the 46 key radionuclides by computer models. These models estimate radionuclide activity in batches of reactor fuel, account for the split of radionuclides to various separations plant waste streams, and track their movement with tank waste transactions (Kupfer et al. 1997 and Watrous and Wootan 1997) Model-generated values for radionuclides in any of the 177 tanks are reported in the HDW Rev. 4 model results

(Agnew et al. 1997a). No attempt has been made to ratio or normalize model results for all 46 radionuclides when values for measured radionuclides disagree with the model. For a discussion of typical error between model-derived values and sample derived values see Kupfer et al. (1997).

2.1 CONTRIBUTING WASTE TYPES

There is general agreement among various sources that Tank 241-AX-102 contains two layers of waste, the bottom layer referred to as sludge and the top layer as saltcake. Each layer is discussed below.

2.1.1 Sludge Layer. The HDW model indicates that the sludge layer is composed of 3.8 kL (1 kgal) of PUREX low-level waste sludge (PL) and 19 kL (5 kgal) of B Plant waste (B) from strontium extraction operations.

One grab sample of sludge was taken in 1974 in preparation for sluicing the sludge from the tank. Six more samples were taken after the sluicing was completed, but analyses were limited to a few radionuclides. The ^{137}Cs and ^{90}Sr activities reported for the pre-sluicing sample were within the range of activities reported in the six post-sluicing samples, so the chemical analyses from the pre-sluicing sample are believed to be representative of the heel left after sluicing.

Tables 1 and 2 incorporate the composition as determined by adjusting the HDW model estimates to account for the apparent bias in percent water. The pre-sluicing sludge sample had a higher density and lower percent water than the HDW estimate. If the differences are assumed to have been caused by evaporation of water from the sludge, then both differences (density and percent water) are consistent.

The HDW concentrations were adjusted by algebraically calculating how much the concentrations would have changed when the water evaporated. The calculation is as follows, using sodium as an example:

Assume 100 g of sludge at 63.7% H_2O and 4.78% Na before evaporation.

Let x = weight of water lost during evaporation
a = weight of sludge after evaporation = 100 - x
b = weight of water in sludge after evaporation = 63.7 - x
c = wt% water after evaporation = 42.5% (sample result)
d = wt% Na after evaporation

Find d.

Solution:

c = 100b/a, or 42.5 = 100(63.7-x)/(100-x) ; x = 36.87
d = 100(4.78)/a = 478/(100-x) = 7.57% Na

Concentrations derived from the adjusted HDW model predictions are in general agreement with sampling data, but there are some noteworthy exceptions. Manganese was predicted to be absent in the sludge, but analyses show a significant concentration from the PUREX organic wash (OWW2) waste added to this tank. The HDW model predicted less ^{137}Cs and more ^{90}Sr than found in samples. The concentration of uranium in samples varied over a wide range, from 0.13 µg/g (1.7×10^{-6} lb/gal) to 990 µg/g (0.013 lb/gal), but all of the values were far less than the HDW model prediction.

2.1.2 Saltcake Layer

The saltcake layer of waste in the tank was deposited during the years 1977 to 1980, when the tank was being used in conjunction with 242-A Evaporator-Crystallizer Operations. The HDW model uses the Supernate Mixing Model (SMM) subroutine to predict an inventory of 125 kL (33 kgal) of saltcake.

In 1988, the tank was declared a leaker and a liquid grab sample was taken to establish the composition of the liquid to be pumped out of the tank by salt well pumping. This sample contained no solids, but analysis of the liquid firmly identifies the waste as CC waste (Table 4). Specific "markers" for CC waste include the concentrations of carbonate, total organic carbon (TOC), ^{241}Am, and ^{90}Sr, all of which are much higher in CC waste than in other types of liquid Hanford waste.

The composition of the solids deposited during evaporator operations (approximately 98.4 kL) can be assumed to be similar in composition to the solids deposited by CC wastes in double-shell Tanks 241-AN-102 and 241-AN-107, where the solids have been analyzed. The projected composition of these solids also generally matches, except for some of the minor components, the composition profile for SMMA1 saltcake from the 242-A evaporator, based on two cores and one auger sample from Tank 241-A-102 and two core samples from Tank 241-A-103 (best-basis standard inventory for Tank 241-AX-103). Table 5 shows a comparison of the compositions of the saltcake as predicted by the SMM subroutine and as determined by analysis in Tanks 241-AN-102 and 241-AN-107.

Agreement between SMM predictions and analytical data is generally good, but the SMM subroutine appears to have a tendency to underestimate the concentrations of sparingly soluble components (Fe, Pb, Ni, Mn) and overestimate concentrations of very soluble components (NO_3, NO_2, CO_3).

Two auger samples were taken from the surface of the 241-AX-102 waste in February 1995, to support the safety assessment of the tank. Limited analyses were obtained from these samples (Section 4). The moisture content of the auger samples (30.5 percent) was less than the SMM prediction (39.3 percent) and the 241-AN tank samples (average 42.3 percent). The lower moisture content is consistent with the drying trend in the tank that has caused the surface level to drop from 30.5 cm (12 in) in 1988 to the current 24.1 cm (9.5 in).

The nitrate concentration in the auger samples (172,000 µg/g) is higher than in 241-AN samples and slightly lower than in the SMM prediction. The nitrite concentration in the auger samples (40,700 µg/g) is slightly lower than sample average, but well below the SMM estimate. The TOC value for the auger samples (56,550 µg/g) is approximately twice the value from the

241-AN samples and five times the SMM prediction. The analytical values for the auger samples were not used in developing the best-estimate inventory because the inventory was based on the analytical data that represented the sludge at the time when the waste level in the tank was 30.5 cm (12 in.), i.e., before the sludge dried out due to evaporation of water.

3.0 CHEMICAL/RADIONUCLIDE INVENTORY ESTIMATES AFTER RETRIEVAL

As part of this study, a best basis inventory was established for three different retrieval scenarios. The first scenario is based on retrieving waste to minimum of either the existing waste volume or a residual waste volume of 101.94 m^3 (3600 ft^3). The second scenario assumes retrieval to a residual waste volume of 10.2 m^3 (360 ft^3) which corresponds to the assumed 99 percent retrieval of waste to meet the Tri-Party Agreement (Ecology et al. 1990). The third scenario assumes retrieval to a residual waste volume of 1.02 m^3 (36 ft^3). The first and third scenarios represent the retrieval of all tank wastes to 90 percent and 99.9 percent respectively.

3.1 CHEMICAL AND RADIONUCLIDE INVENTORIES BASED ON 90 PERCENT RETRIEVAL

The first retrieval scenario assumes that 90 percent of the waste will be retrieved to a residual volume of 101.94 m^3 (3,600 ft^3). Since the current sludge inventory is estimated to be 26.45 m^3 (934 ft^3) and overlying saltcake inventory 98.3 m^3 (3,470 ft^3), about 23.2 percent of the saltcake would have to be removed to meet this inventory target. Table 6 provides a summary of the chemical and radionuclide composition and tank inventory estimates based on the volume and density of the sludge layer (26.5 kL and 1.57 kg/L, respectively), and volume and density of the residual saltcake layer (75.6 kL and 1.5 kg/L, respectively). These values were derived from the best-basis standard inventory estimates for this tank.

Table 6 contains a summary matrix of resultant saltcake and sludge volumes, and their fractional removal, following retrieval according to the three scenarios of 90 percent, 99 percent, and 99.9 percent retrieval.

Following retrieval according to the three scenarios presented in Table 6, residual tank waste inventory has been evaluated and is presented in Tables 7 and 8 for chemical and radiological constituents, respectively.

4.0 BEST-BASIS LEAKAGE INVENTORY ESTIMATES FOR RETRIEVAL OF SINGLE-SHELL TANK 241-AX-102

Retrieval scenarios described in Section 3.0 provide residual inventories following fractional removal of any saltcake and sludges contained within Tank 241-AX-101. This section assumes two different leakage conditions for each retrieval scenario. The first leakage condition assumes up to 30.2 m^3 (8 kgal) of potential leakage, while the second leakage condition is based on an upper bounding estimate of 151.4 m^3 (40 kgal) of potential leakage. In each case, solution concentrations and inventories will be based on the limiting conditions for waste retrieval, either a maximum supernate concentration of five gram moles per liter sodium or a maximum value of 10 weight percent solids in the slurry, or the total volume of the retrieval solution. These limits were established to minimize the possible crystallization of sodium rich salts in the slurry transfer lines and slurry pumping problems for the slurry pumps and sluicers. The following estimates are based on the methodology that was established by the standard inventory task.

The solution concentrations resulting from dissolution and slurry with water of the tank waste to the three retrieval scenarios are provided in Tables 9 and 10 for nonradiological and radiological constituents, respectively. Table 9 also provides the limiting volume assessment required for application of sodium loading or solids loading limits and the minimum retrieval water to meet the limiting volume assessment based upon product-specific gravities of either 1.17 or 1.18 for sodium limited or solids limited solutions.

Tables 11 and 12 contain the nonradiological and radiological, resultant leakage inventory estimates based upon 30.2 m^3 (8 kgal) and 151.4 m^3 (40 kgal) releases during retrieval.

5.0 TANK LEAKAGE

In August 1988, Tank 241-AX-10 was declared an assumed leaker with 11.35 kL (3 kgal) of potential leakage. A liquid grab sample was taken in November 1988 to establish the composition of the liquid to be pumped out of the tank by saltwell pumping. This sample contained no solids, but analysis of the liquid firmly identifies the waste as CC waste (Table 4).

An occurrence report was filed April 9, 1975 detailing the observed radiation increase in dry well 11-04-11, located about 3.05 m (10 ft) northwest of Tank 241-AX-104. Apparently, a two-fold increase in radiation count was found at the 12.19 m (40 ft) level shortly after the well was drilled in January 1975. Based on auger testing of the soil, the soil around the vapor exhaust header was found to be highly contaminated, with readings as high as 3 RAD at contact. This finding relates to a similar finding near the vapor exhaust header joint between Tanks 241-AX-101 and 241-AX-102. If this is the leakage source of interest for Tank 241-AX-102, most of the leakage must have been caused by tank condensates that collected in the exhaust header system. Since the composition of this condensate is not known, we have no basis at the present time for estimating the chemical and radionuclide source terms for condensate leakage. However, upper bounding estimates could be developed from the supernate composition data for this tank and used as such to evaluate any condensate leakage that might have occurred at the vapor exhaust header between Tanks 241-AX-101 and 241-AX-102.

If the leakage event occurred during the mid to late 1980s as suggested by the 1988 leakage declaration, we should be able to generate reasonable estimates for the relevant source terms from the 1988 supernate composition data for this tank. The supernate composition and estimated inventories of chemicals and radionuclides that might have leaked from the tank during this period are summarized in Table 13.

6.0 REFERENCES

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Table 1. Volume Data (in kgal/kL) for Tank 241-AX-102 Sludge and Saltcake[a]

	Hanlon		Swaney		Agnew		Best-Basis	
	kgal	kL	kgal	kL	kgal	kL	kgal	kL
Sludge	7	26.5	--	--	6	23	7	26.5
Saltcake	29	110	--	--	33	125	26	98.4
Supernate	3	11	--	--	0	0	0	0
Total	39	148	33	125	39	148	33	125

[a] The terms "sludge" and "saltcake" both include the interstitial liquid associated with the solids, which are predominantly water-insoluble metal oxides/hydroxides in the sludge and water-soluble sodium salt crystals in the saltcake.

Table 2. Best-Basis Nonradiological Inventory Before Retrieval of Waste From Single-Shell Tank 241-AX-102 (page 1 of 2)

	Sludge	Saltcake	Overall
Density (kg/m^3)	1,570.0	1,500.0	1,514.8
Volume (m^3)	26.5	98.4	124.9
Components (M)			Inventory (kg)
Ag	NR	NR	NR
Al	1.80E+00	7.45E-01	3,262.9
As	NR	NR	NR
B	9.74E-03	7.98E-01	851.8
Ba	NR	NR	NR
Bi		1.59E-03	32.6
Ca	1.99E-01	2.12E-02	294.6
Cd	NR	2.16E-05	0.2
Cl	3.29E-02	8.48E-02	326.6
TIC as CO_3	4.52E-01	1.59E+00	10,092.5
Cr	4.49E-03	3.00E-02	159.7
Cu	NR	4.76E-03	29.8
F		9.47E-02	177.2
Fe	2.55E+00	5.91E-02	4,093.8
Hg		1.21E-05	0.2
K	7.19E-03	4.99E-02	199.4
La		3.31E-05	0.5
Mg	5.73E-05	1.32E-02	31.6
Mn	2.17E-01	1.13E-02	377.3
Na	5.17E+00	1.20E+01	30,288.1
Ni	9.15E-02	8.60E-03	192.0
NO_2	4.83E-01	1.48E+00	7,295.6
NO_3	5.77E-01	3.14E+00	20,140.3
OH	7.57E+00	8.72E+00	18,012.9
Pb	1.20E-05	1.92E-03	39.2
P as PO_4	2.44E-02	6.04E-02	626.3
P	4.07E-03	1.24E-01	381.0
Se	NR	NR	NR
Si as SiO_3	7.56E-01	3.65E-02	1,797.6
S as SO_4	3.42E-02	2.83E-01	2,759.0
S	2.15E-02	4.60E-02	163.3
Sr	5.70E-02	1.27E-05	132.4
TOC	7.43E-02	2.76E+00	3,286.2
Total U	6.56E-03	1.61E-02	419.1

Table 2. Best-Basis Nonradiological Inventory Before Retrieval of Waste From Single-Shell Tank 241-AX-102 (page 2 of 2)

	Sludge	Saltcake	Overall
Density (kg/m^3)	1,570.0	1,500.0	1,514.8
Volume (m^3)	26.5	98.4	124.9
Components (M)			Inventory (kg)
Zn	4.22E-03	1.64E-05	7.4
Zr	NR	1.50E-04	1.3
EDTA	NR	3.43E-02	987.0
NH_3	NR	NR	NR
Cr^{+6}	NR	NR	NR
CN	4.98E+01	1.34E+01	68,670.0
H_2O	1.79E-03	1.78E-02	3.24E+01
Total			1.75E+05

Table 3. Best-Basis Radiological Inventory Before Retrieval of Waste From Single-Shell Tank 241-AX-102 (page 1 of 2)

Components (Ci/L)	Sludge	Saltcake	Overall (Ci)
Decay Date	12/31/99	12/31/99	12/31/99
^{3}H	3.23E-05	3.20E-04	3.24E+01
^{14}C	9.96E-06	4.91E-05	5.09E+00
^{59}Ni	4.83E-05	2.89E-06	1.56E+00
^{60}Co	2.39E-05	6.08E-05	6.61E+00
^{63}Ni	5.02E-03	2.84E-04	1.61E+02
^{79}Se	1.82E-04	4.87E-06	5.29E+00
^{90}Sr	5.09E+00	1.46E-01	1.49E+05
^{90}Y	5.09E+00	1.46E-01	1.49E+05
^{93}mNb	5.25E-04	1.73E-05	1.56E+01
^{93}Zr	7.93E-04	2.40E-05	2.34E+01
^{99}Tc	6.60E-05	3.65E-04	3.76E+01
^{106}Ru	2.20E-05	1.05E-08	5.85E-01
^{113}mCd	3.96E-03	1.30E-04	1.18E+02
^{125}Sb	1.49E-04	2.72E-04	3.08E+01
^{126}Sn	2.88E-04	7.35E-06	8.34E+00
^{129}I	1.29E-07	7.05E-07	7.28E-02
^{134}Cs	1.15E-06	4.81E-06	5.04E-01
^{135}Cs	NR	NR	NR
^{137}Cs	7.04E-01	3.04E-01	4.86E+04
^{137}mBa	6.66E-01	2.87E-01	4.59E+04
^{151}Sm	5.23E-01	1.71E-02	1.55E+04
^{152}Eu	7.70E-04	6.33E-06	2.10E+01
^{154}Eu	5.89E-02	9.47E-04	1.65E+03
^{155}Eu	3.73E-02	3.75E-04	1.03E+03
^{226}Ra	8.11E-09	1.91E-10	2.34E-04
^{227}Ac	3.85E-08	1.19E-09	1.14E-03
^{228}Ra	3.22E-13	3.85E-07	3.79E-02
^{229}Th	3.02E-11	8.95E-09	8.82E-04
^{231}Pa	1.20E-09	5.68E-09	5.91E-04
^{232}Th	4.19E-15	3.92E-08	3.86E-03
^{232}U	1.57E-11	1.28E-06	1.26E-01
^{233}U	2.08E-13	4.90E-06	4.82E-01
^{234}U	5.59E-08	9.91E-07	9.90E-02
^{235}U	2.14E-09	3.96E-08	3.96E-03
^{236}U	4.30E-09	3.17E-08	3.23E-03
^{237}Np	2.13E-07	1.29E-06	1.33E-01

Table 3. Best-Basis Radiological Inventory Before Retrieval of Waste From Single-Shell Tank 241-AX-102 (page 2 of 2)

Components (Ci/L)	Sludge	Saltcake	Overall (Ci)
Decay Date	12/31/99	12/31/99	12/31/99
^{238}Pu	2.28E-03	1.95E-06	6.07E+01
^{238}U	4.19E-08	1.28E-06	1.27E-01
^{239}Pu	1.54E-02	6.34E-05	4.15E+02
^{240}Pu	5.55E-03	1.10E-05	1.48E+02
$^{239/240}$Pu	2.10E-02	7.44E-05	5.63E+02
^{241}Am	4.98E-02	8.04E-05	1.33E+03
^{241}Pu	1.58E-01	1.34E-04	4.19E+03
^{242}Cm	6.64E-05	2.35E-07	1.78E+00
^{242}mAm	NR	NR	NR
^{242}Pu	1.14E-06	7.42E-10	3.04E-02
^{243}Am	5.59E-06	3.09E-09	1.48E-01
^{243}Cm	8.15E-06	2.26E-08	2.18E-01
^{244}Cm	3.37E-04	1.75E-07	8.96E+00
Total			4.18E+05

Table 4. Comparison of 1988 Supernatant Liquid Sample from Tank 241-AX-102 with Supernatant Liquid Samples from Concentrated Complexed Waste Tanks 241-AN-102 and 241-AN-107 (concentrations in molarity except as noted)

Component	241-AX-102[a] (M)	241-AN-102[b] (M)	241-AN-107[c] (M)
NO_3	3.7	3.6	3.8
NO_2	1.4	1.8	1.1
CO_3	0.98	1.1	1.2
TOC (g/L)	36.8	26.3	42.9
Al	0.006	0.55	0.044
Ca	0.014	0.011	NR
Fe	0.033	NR	0.027
Na	7.32	11.2	8.6
^{241}Am (µCi/mL)	1.0	NR	0.63
$^{239/240}Pu$ (µCi/mL)	0.097	NR	0.034
^{137}Cs (µCi/mL)	350	382	253
^{90}Sr (µCi/mL)	175	74	93

[a] 1988 grab sample from Tank 241-AX-102.
[b] Herting 1993.
[c] Herting 1994b.

Table 5. Comparison of Supernate Mixing Model, Samples from Tanks 241-AN-102 and 241-AN-107 and Best-Basis Saltcake Composition Estimates for the Saltcake Layer in Tank 241-AX-102 (values in ug/g, except as noted)

Component	SMM estimates for 241-AX-102[a]	241-AN-102[b]	241-AN-102[c]	241-AN-107[d]	Best-Basis Saltcake Composition[e]
Density (g/mL)	1.53	1.53	1.50	1.47	1.50
Wt% H_2O	39.3	41.0	40.3	45.6	42.3
Na	169,000	177,000	234,000	140,500	184,000
Al	27,900	12,000	12,200	16,000	13,400
Fe	236	1,200	1,500	3,900	2,200
Cr	1,720	1,300	1,370	450	1,040
Pb	157	200	< 270	330	265
Ni	208	260	420	330	337
Mn	152	250	480	510	413
Ca	767	450	810	440	567
K	1,400	1,500	< 1,700	1,100	1,300
NO_3	183,000	136,000	112,000	142,000	130,000
NO_2	69,900	55,000	39,300	42,000	45,400
CO_3	92,000	80,000	61,500	49,000	63,500
PO_4	5,420	4,400	3,030	4,050	3,830
SO_4	16,300	20,000	25,900	8,400	18,100
F	873	1,250	< 890	1,150	1,200
Cl	4,620	2,600	2,060	1,350	2,000
TOC	11,800	23,000	16,300	27,000	22,100
$^{239/240}Pu$ (µCi/g)	0.05	NR	NR	0.085	0.085
^{137}Cs (µCi/g)	184	215	285	300	232[e]
^{90}Sr (µCi/g)	72	105	169	115	113[e]

[a] Agnew et al. (1996)
[b] based on grab samples taken in 1994 and 1995 (Herting 1996)
[c] based on core sample taken in 1990 (Douglas 1996)
[d] based on grab samples taken in 1994 (Herting 1994)
[e] average of analytical data in columns 3-5. Radionuclides decayed to December 31, 1999.

Table 6. Retrieval Scenario Summary of Residual Waste and Fractional Removal

	Case I	Case II	Case III
Volume Base (m^3)	101.94	10.19	1.02
% Base	90.0%	99.0%	99.9%
Target (m^3)	101.94	10.19	1.02
Sludge (m^3)	26.50	10.19	1.02
Saltcake (m^3)	75.44	0.00	0.00
Sludge Removal	0.0%	61.5%	96.2%
Saltcake Removal	23.3%	100.0%	100.0%

Table 7. Tank 241-AX-102 Nonradiological Waste Residual Inventory Following Retrieval (page 1 of 2)

Residual Waste (kg)	Case I	Case II	Case III
Target (m^3)	101.94	10.19	1.02
Sludge (m^3)	26.50	10.19	1.02
Saltcake (m^3)	75.44	0.00	0.00
Ag	NR	NR	NR
Al	2.80E+03	4.94E+02	4.94E+01
As	NR	NR	NR
B	6.54E+02	1.07E+00	1.07E-01
Ba	NR	NR	NR
Bi	2.50E+01	NR	NR
Ca	2.75E+02	8.11E+01	8.11E+00
Cd	1.83E-01	NR	NR
Cl	2.58E+02	1.19E+01	1.19E+00
TIC as CO_3	7.90E+03	2.76E+02	2.76E+01
Cr	1.24E+02	2.38E+00	2.38E-01
Cu	2.28E+01	NR	NR
F	1.36E+02	NR	NR
Fe	4.02E+03	1.45E+03	1.45E+02
Hg	1.83E-01	NR	NR
K	1.55E+02	2.86E+00	2.86E-01
La	3.46E-01	NR	NR
Mg	2.43E+01	1.42E-02	1.42E-03
Mn	3.63E+02	1.22E+02	1.22E+01
Na	2.40E+04	1.21E+03	1.21E+02
Ni	1.80E+02	5.47E+01	5.47E+00
NO_2	5.73E+03	2.26E+02	2.26E+01
NO_3	1.57E+04	3.65E+02	3.65E+01
OH	1.46E+04	1.31E+03	1.31E+02
Pb	3.01E+01	2.53E-02	2.53E-03
P as PO_4	4.94E+02	2.36E+01	2.36E+00
P	2.93E+02	1.28E+00	1.28E-01
Se	NR	NR	NR
Si as SiO_3	1.73E+03	5.87E+02	5.87E+01
S as SO_4	2.14E+03	3.35E+01	3.35E+00
S	1.29E+02	7.04E+00	7.04E-01
Sr	1.32E+02	5.09E+01	5.09E+00
TOC	2.52E+03	9.10E+00	9.10E-01
Total U	3.31E+02	1.59E+01	1.59E+00

Table 7. Tank 241-AX-102 Nonradiological Waste Residual Inventory Following Retrieval (page 2 of 2)

Residual Waste (kg)	Case I	Case II	Case III
Zn	7.38E+00	2.81E+00	2.81E-01
Zr	1.03E+00	NR	NR
EDTA	7.57E+02	NR	NR
NH_3	NR	NR	NR
Cr^{+6}	NR	NR	NR
CN	6.07E+04	1.32E+04	1.32E+03
H_2O	2.50E+01	3.29E-01	3.29E-02
Total	1.46E+05	1.95E+04	1.95E+03

Table 8. Tank 241-AX-102 Radiological Waste Residual Inventory Following Retrieval (page 1 of 2)

Residual Waste (Ci)	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99
^{3}H	2.50E+01	3.29E-01	3.29E-02
^{14}C	3.97E+00	1.02E-01	1.02E-02
^{59}Ni	1.50E+00	4.92E-01	4.92E-02
^{60}Co	5.22E+00	2.44E-01	2.44E-02
^{63}Ni	1.54E+02	5.12E+01	5.12E+00
^{79}Se	5.18E+00	1.85E+00	1.85E-01
^{90}Sr	1.46E+05	5.19E+04	5.19E+03
^{90}Y	1.46E+05	5.19E+04	5.19E+03
^{93}mNb	1.52E+01	5.35E+00	5.35E-01
^{93}Zr	2.28E+01	8.08E+00	8.08E-01
^{99}Tc	2.93E+01	6.73E-01	6.73E-02
^{106}Ru	5.85E-01	2.25E-01	2.25E-02
^{113}mCd	1.15E+02	4.04E+01	4.04E+00
^{125}Sb	2.45E+01	1.52E+00	1.52E-01
^{126}Sn	8.17E+00	2.93E+00	2.93E-01
^{129}I	5.66E-02	1.31E-03	1.31E-04
^{134}Cs	3.93E-01	1.17E-02	1.17E-03
^{135}Cs	NR	NR	NR
^{137}Cs	4.16E+04	7.17E+03	7.17E+02
^{137}mBa	3.93E+04	6.79E+03	6.79E+02
^{151}Sm	1.51E+04	5.33E+03	5.33E+02
^{152}Eu	2.09E+01	7.85E+00	7.85E-01
^{154}Eu	1.63E+03	6.00E+02	6.00E+01
^{155}Eu	1.02E+03	3.80E+02	3.80E+01
^{226}Ra	2.29E-04	8.27E-05	8.27E-06
^{227}Ac	1.11E-03	3.92E-04	3.92E-05
^{228}Ra	2.91E-02	3.28E-09	3.28E-10
^{229}Th	6.76E-04	3.08E-07	3.08E-08
^{231}Pa	4.60E-04	1.23E-05	1.23E-06
^{232}Th	2.96E-03	4.27E-11	4.27E-12
^{232}U	9.66E-02	1.60E-07	1.60E-08
^{233}U	3.69E-01	2.12E-09	2.12E-10
^{234}U	7.62E-02	5.69E-04	5.69E-05
^{235}U	3.05E-03	2.18E-05	2.18E-06
^{236}U	2.51E-03	4.39E-05	4.39E-06
^{237}Np	1.03E-01	2.17E-03	2.17E-04

Table 8. Tank 241-AX-102 Radiological Waste Residual Inventory Following Retrieval (page 2 of 2)

Residual Waste (Ci)	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99
^{238}Pu	6.06E+01	2.33E+01	2.33E+00
^{238}U	9.77E-02	4.27E-04	4.27E-05
^{239}Pu	4.14E+02	1.57E+02	1.57E+01
^{240}Pu	1.48E+02	5.66E+01	5.66E+00
$^{239/240}Pu$	5.62E+02	2.14E+02	2.14E+01
^{241}Am	1.33E+03	5.08E+02	5.08E+01
^{241}Pu	4.19E+03	1.61E+03	1.61E+02
^{242}Cm	1.78E+00	6.77E-01	6.77E-02
^{242}mAm	NR	NR	NR
^{242}Pu	3.04E-02	1.17E-02	1.17E-03
^{243}Am	1.48E-01	5.69E-02	5.69E-03
^{243}Cm	2.18E-01	8.31E-02	8.31E-03
^{244}Cm	8.95E+00	3.44E+00	3.44E-01
Total	3.97E+05	1.27E+05	1.27E+04

Table 9. Retrieval Scenario Product Solution Nonradiological Analyte Concentrations (page 1 of 2)

Limiting Vol (L)	55,115	264,884	413,948
Sludge [Solids Basis (L)]	0	264,884	413,948
Saltcake [Na Basis (L)]	55,115	252,952	262,438
Solution Concentrations (M)	Case I	Case II	Case III
Ag	NR	NR	NR
Al	3.11E-01	3.87E-01	2.88E-01
As	NR	NR	NR
B	3.33E-01	2.97E-01	1.90E-01
Ba	NR	NR	NR
Bi	6.61E-04	5.89E-04	3.77E-04
Ca	8.84E-03	2.01E-02	1.73E-02
Cd	9.01E-06	8.03E-06	5.14E-06
Cl	3.53E-02	3.35E-02	2.22E-02
TIC as CO_3	6.62E-01	6.18E-01	4.05E-01
Cr	1.25E-02	1.14E-02	7.41E-03
Cu	1.99E-03	1.77E-03	1.13E-03
F	3.95E-02	3.52E-02	2.25E-02
Fe	2.46E-02	1.79E-01	1.71E-01
Hg	5.05E-06	4.50E-06	2.88E-06
K	2.08E-02	1.90E-02	1.23E-02
La	1.38E-05	1.23E-05	7.86E-06
Mg	5.51E-03	4.91E-03	3.14E-03
Mn	4.70E-03	1.76E-02	1.61E-02
Na	5.00E+00	4.77E+00	3.17E+00
Ni	3.59E-03	8.83E-03	7.68E-03
NO_2	6.18E-01	5.80E-01	3.82E-01
NO_3	1.31E+00	1.20E+00	7.83E-01
OH	3.64E+00	3.71E+00	2.54E+00
Pb	8.00E-04	7.14E-04	4.57E-04
P as PO_4	2.52E-02	2.40E-02	1.59E-02
P	5.17E-02	4.63E-02	2.97E-02
Se	NR	NR	NR
Si as SiO_3	1.52E-02	6.01E-02	5.52E-02
S as SO_4	1.18E-01	1.07E-01	6.93E-02
S	1.92E-02	1.84E-02	1.23E-02
Sr	5.29E-06	3.51E-03	3.51E-03
TOC	1.15E+00	1.03E+00	6.61E-01
Total U	6.72E-03	6.39E-03	4.24E-03

Table 9. Retrieval Scenario Product Solution Nonradiological Analyte Concentrations (page 2 of 2)

Limiting Vol (L)	55,115	264,884	413,948
Sludge [Solids Basis (L)]	0	264,884	413,948
Saltcake [Na Basis (L)]	55,115	252,952	262,438
Solution Concentrations (M)	Case I	Case II	Case III
Zn	6.85E-06	2.66E-04	2.63E-04
Zr	6.24E-05	5.56E-05	3.56E-05
EDTA	1.43E-02	1.28E-02	8.16E-03
NH_3	NR	NR	NR
Cr^{+6}	NR	NR	NR
CN	5.59E+00	8.05E+00	6.25E+00
H_2O	0.01	0.01	0.00
Retrieval H_2O	32.37	31.47	38.89

Table 10. Retrieval Scenario Product Solution Radiological Analyte Concentrations (page 1 of 2)

Solution Concentrations (Ci/L)	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99
^{3}H	1.33E-04	1.21E-04	7.81E-05
^{14}C	2.05E-05	1.88E-05	1.23E-05
^{59}Ni	1.20E-06	4.05E-06	3.66E-06
^{60}Co	2.53E-05	2.40E-05	1.59E-05
^{63}Ni	1.19E-04	4.15E-04	3.77E-04
^{79}Se	2.03E-06	1.30E-05	1.23E-05
^{90}Sr	6.10E-02	3.68E-01	3.48E-01
^{90}Y	6.10E-02	3.68E-01	3.48E-01
^{93}mNb	7.20E-06	3.87E-05	3.64E-05
^{93}Zr	1.00E-05	5.77E-05	5.45E-05
^{99}Tc	1.52E-04	1.40E-04	9.08E-05
^{106}Ru	4.36E-09	1.36E-06	1.36E-06
^{113}mCd	5.42E-05	2.92E-04	2.75E-04
^{125}Sb	1.14E-04	1.10E-04	7.39E-05
^{126}Sn	3.06E-06	2.04E-05	1.94E-05
^{129}I	2.94E-07	2.70E-07	1.76E-07
^{134}Cs	2.00E-06	1.86E-06	1.21E-06
^{135}Cs	NR	NR	NR
^{137}Cs	1.27E-01	1.56E-01	1.16E-01
^{137}mBa	1.20E-01	1.48E-01	1.09E-01
^{151}Sm	7.14E-03	3.85E-02	3.63E-02
^{152}Eu	2.64E-06	4.97E-05	4.89E-05
^{154}Eu	3.95E-04	3.98E-03	3.85E-03
^{155}Eu	1.56E-04	2.44E-03	2.39E-03
^{226}Ra	7.96E-11	5.70E-10	5.45E-10
^{227}Ac	4.96E-10	2.81E-09	2.65E-09
^{228}Ra	1.61E-07	1.43E-07	9.16E-08
^{229}Th	3.73E-09	3.33E-09	2.13E-09
^{231}Pa	2.37E-09	2.18E-09	1.42E-09
^{232}Th	1.63E-08	1.46E-08	9.32E-09
^{232}U	5.34E-07	4.76E-07	3.04E-07
^{233}U	2.04E-06	1.82E-06	1.16E-06
^{234}U	4.13E-07	3.72E-07	2.39E-07
^{235}U	1.65E-08	1.49E-08	9.55E-09
^{236}U	1.32E-08	1.20E-08	7.80E-09
^{237}Np	5.38E-07	4.93E-07	3.20E-07

Table 10. Retrieval Scenario Product Solution Radiological Analyte Concentrations (page 2 of 2)

Solution Concentrations (Ci/L)	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99
^{238}Pu	8.13E-07	1.41E-04	1.41E-04
^{238}U	5.34E-07	4.78E-07	3.07E-07
^{239}Pu	2.64E-05	9.74E-04	9.65E-04
^{240}Pu	4.57E-06	3.46E-04	3.44E-04
$^{239/240}Pu$	3.10E-05	1.32E-03	1.31E-03
^{241}Am	3.35E-05	3.10E-03	3.09E-03
^{241}Pu	5.59E-05	9.76E-03	9.74E-03
^{242}Cm	9.78E-08	4.18E-06	4.14E-06
^{242}mAm	NR	NR	NR
^{242}Pu	3.09E-10	7.07E-08	7.06E-08
^{243}Am	1.29E-09	3.45E-07	3.45E-07
^{243}Cm	9.40E-09	5.10E-07	5.07E-07
^{244}Cm	7.29E-08	2.08E-05	2.08E-05

Table 11. Tank 241-AX-102 Retrieval Scenario Nonradiological Constituent Leakage Estimate (page 1 of 2)

Release Volume (L)	30,283	30,283	30,283	55,115	151,413	151,413
Analyte (kg)	Case I	Case II	Case III	Case I	Case II	Case III
Ag	NR	NR	NR	NR	NR	NR
Al	2.54E+02	3.17E+02	2.35E+02	4.62E+02	1.58E+03	1.18E+03
As	NR	NR	NR	NR	NR	NR
B	1.09E+02	9.73E+01	6.23E+01	1.98E+02	4.86E+02	3.12E+02
Ba	NR	NR	NR	NR	NR	NR
Bi	4.18E+00	3.73E+00	2.38E+00	7.61E+00	1.86E+01	1.19E+01
Ca	1.07E+01	2.44E+01	2.10E+01	1.95E+01	1.22E+02	1.05E+02
Cd	3.07E-02	2.73E-02	1.75E-02	5.58E-02	1.37E-01	8.74E-02
Cl	3.79E+01	3.60E+01	2.38E+01	6.90E+01	1.80E+02	1.19E+02
TIC as CO_3	1.20E+03	1.12E+03	7.36E+02	2.19E+03	5.61E+03	3.68E+03
Cr	1.97E+01	1.80E+01	1.17E+01	3.58E+01	8.99E+01	5.83E+01
Cu	3.82E+00	3.41E+00	2.18E+00	6.96E+00	1.70E+01	1.09E+01
F	2.27E+01	2.03E+01	1.30E+01	4.14E+01	1.01E+02	6.48E+01
Fe	4.17E+01	3.02E+02	2.89E+02	7.58E+01	1.51E+03	1.44E+03
Hg	3.07E-02	2.73E-02	1.75E-02	5.58E-02	1.37E-01	8.74E-02
K	2.46E+01	2.25E+01	1.46E+01	4.48E+01	1.12E+02	7.28E+01
La	5.80E-02	5.17E-02	3.31E-02	1.06E-01	2.58E-01	1.65E-01
Mg	4.05E+00	3.62E+00	2.31E+00	7.38E+00	1.81E+01	1.16E+01
Mn	7.83E+00	2.92E+01	2.67E+01	1.42E+01	1.46E+02	1.34E+02
Na	3.48E+03	3.32E+03	2.21E+03	6.34E+03	1.66E+04	1.10E+04
Ni	6.37E+00	1.57E+01	1.36E+01	1.16E+01	7.85E+01	6.82E+01
NO_2	8.60E+02	8.08E+02	5.32E+02	1.57E+03	4.04E+03	2.66E+03
NO_3	2.46E+03	2.26E+03	1.47E+03	4.48E+03	1.13E+04	7.35E+03
OH	1.87E+03	1.91E+03	1.31E+03	3.41E+03	9.55E+03	6.54E+03
Pb	5.02E+00	4.48E+00	2.87E+00	9.13E+00	2.24E+01	1.43E+01
P as PO_4	7.25E+01	6.89E+01	4.56E+01	1.32E+02	3.44E+02	2.28E+02
P	4.84E+01	4.34E+01	2.79E+01	8.82E+01	2.17E+02	1.39E+02
Se	NR	NR	NR	NR	NR	NR
Si as SiO_3	3.50E+01	1.38E+02	1.27E+02	6.37E+01	6.92E+02	6.36E+02
S as SO_4	3.43E+02	3.12E+02	2.02E+02	6.24E+02	1.56E+03	1.01E+03
S	1.86E+01	1.79E+01	1.19E+01	3.38E+01	8.93E+01	5.95E+01
Sr	1.40E-02	9.32E+00	9.31E+00	2.55E-02	4.66E+01	4.66E+01
TOC	4.18E+02	3.75E+02	2.40E+02	7.62E+02	1.87E+03	1.20E+03
Total U	4.84E+01	4.61E+01	3.05E+01	8.82E+01	2.30E+02	1.53E+02
Zn	1.36E-02	5.26E-01	5.21E-01	2.47E-02	2.63E+00	2.61E+00

Table 11. Tank 241-AX-102 Retrieval Scenario Nonradiological Constituent Leakage Estimate (page 2 of 2)

Release Volume (L)	30,283	30,283	30,283	55,115	151,413	151,413
Analyte (kg)	Case I	Case II	Case III	Case I	Case II	Case III
Zr	1.72E-01	1.54E-01	9.83E-02	3.14E-01	7.68E-01	4.91E-01
EDTA	1.27E+02	1.13E+02	7.22E+01	2.30E+02	5.64E+02	3.61E+02
NH_3	NR	NR	NR	NR	NR	NR
Cr^{+6}	NR	NR	NR	NR	NR	NR
CN	4.40E+03	6.34E+03	4.93E+03	8.02E+03	3.17E+04	2.46E+04
H_2O	4.04E+00	3.66E+00	2.36E+00	7.35E+00	1.83E+01	1.18E+01
Retrieval water	1.77E+04	1.72E+04	2.12E+04	3.21E+04	8.58E+04	1.06E+05
Total (kg)	3.32E+04	3.46E+04	3.37E+04	6.05E+04	1.73E+05	1.68E+05

Table 12. Tank 241-AX-102 Retrieval Scenario Radiological Constituent Leakage Estimate (page 1 of 2)

Release Volume (L)	30,283	30,283	30,283	55,115	151,413	151,413
Analyte (Ci)	Case I	Case II	Case III	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99
^{3}H	4.04E+00	3.66E+00	2.36E+00	7.35E+00	1.83E+01	1.18E+01
^{14}C	6.20E-01	5.71E-01	3.72E-01	1.13E+00	2.85E+00	1.86E+00
^{59}Ni	3.64E-02	1.23E-01	1.11E-01	6.63E-02	6.13E-01	5.54E-01
^{60}Co	7.67E-01	7.28E-01	4.82E-01	1.40E+00	3.64E+00	2.41E+00
^{63}Ni	3.59E+00	1.26E+01	1.14E+01	6.54E+00	6.28E+01	5.70E+01
^{79}Se	6.14E-02	3.93E-01	3.73E-01	1.12E-01	1.97E+00	1.87E+00
^{90}Sr	1.85E+03	1.11E+04	1.05E+04	3.36E+03	5.57E+04	5.27E+04
^{90}Y	1.85E+03	1.11E+04	1.05E+04	3.36E+03	5.57E+04	5.27E+04
^{93}mNb	2.18E-01	1.17E+00	1.10E+00	3.97E-01	5.86E+00	5.51E+00
^{93}Zr	3.03E-01	1.75E+00	1.65E+00	5.51E-01	8.73E+00	8.25E+00
^{99}Tc	4.60E+00	4.23E+00	2.75E+00	8.38E+00	2.11E+01	1.37E+01
^{106}Ru	1.32E-04	4.12E-02	4.12E-02	2.40E-04	2.06E-01	2.06E-01
^{113}mCd	1.64E+00	8.85E+00	8.32E+00	2.99E+00	4.42E+01	4.16E+01
^{125}Sb	3.44E+00	3.34E+00	2.24E+00	6.26E+00	1.67E+01	1.12E+01
^{126}Sn	9.27E-02	6.19E-01	5.89E-01	1.69E-01	3.09E+00	2.94E+00
^{129}I	8.90E-03	8.17E-03	5.32E-03	1.62E-02	4.09E-02	2.66E-02
^{134}Cs	6.07E-02	5.62E-02	3.67E-02	1.10E-01	2.81E-01	1.84E-01
^{135}Cs	NR	NR	NR	NR	NR	NR
^{137}Cs	3.84E+03	4.73E+03	3.50E+03	6.98E+03	2.37E+04	1.75E+04
^{137}mBa	3.63E+03	4.48E+03	3.31E+03	6.60E+03	2.24E+04	1.66E+04
^{151}Sm	2.16E+02	1.17E+03	1.10E+03	3.94E+02	5.84E+03	5.49E+03
^{152}Eu	7.99E-02	1.51E+00	1.48E+00	1.45E-01	7.53E+00	7.40E+00
^{154}Eu	1.20E+01	1.20E+02	1.17E+02	2.18E+01	6.02E+02	5.83E+02
^{155}Eu	4.73E+00	7.38E+01	7.23E+01	8.61E+00	3.69E+02	3.61E+02
^{226}Ra	2.41E-06	1.73E-05	1.65E-05	4.39E-06	8.64E-05	8.25E-05
^{227}Ac	1.50E-05	8.51E-05	8.03E-05	2.73E-05	4.26E-04	4.02E-04
^{228}Ra	4.86E-03	4.33E-03	2.77E-03	8.85E-03	2.17E-02	1.39E-02
^{229}Th	1.13E-04	1.01E-04	6.45E-05	2.06E-04	5.04E-04	3.23E-04
^{231}Pa	7.17E-05	6.62E-05	4.31E-05	1.30E-04	3.31E-04	2.16E-04
^{232}Th	4.95E-04	4.41E-04	2.82E-04	9.01E-04	2.21E-03	1.41E-03
^{232}U	1.62E-02	1.44E-02	9.22E-03	2.94E-02	7.20E-02	4.61E-02
^{233}U	6.18E-02	5.51E-02	3.53E-02	1.13E-01	2.76E-01	1.76E-01
^{234}U	1.25E-02	1.13E-02	7.24E-03	2.28E-02	5.63E-02	3.62E-02
^{235}U	5.00E-04	4.50E-04	2.89E-04	9.10E-04	2.25E-03	1.45E-03

Table 12. Tank 241-AX-102 Retrieval Scenario Radiological Constituent Leakage Estimate (page 2 of 2)

Release Volume (L)	30,283	30,283	30,283	55,115	151,413	151,413
Analyte (Ci)	Case I	Case II	Case III	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99
^{236}U	4.00E-04	3.65E-04	2.36E-04	7.28E-04	1.82E-03	1.18E-03
^{237}Np	1.63E-02	1.49E-02	9.69E-03	2.96E-02	7.46E-02	4.84E-02
^{238}Pu	2.46E-02	4.28E+00	4.27E+00	4.48E-02	2.14E+01	2.13E+01
^{238}U	1.62E-02	1.45E-02	9.30E-03	2.94E-02	7.24E-02	4.65E-02
^{239}Pu	8.00E-01	2.95E+01	2.92E+01	1.46E+00	1.47E+02	1.46E+02
^{240}Pu	1.39E-01	1.05E+01	1.04E+01	2.52E-01	5.23E+01	5.21E+01
$^{239/240}Pu$	9.39E-01	3.99E+01	3.96E+01	1.71E+00	2.00E+02	1.98E+02
^{241}Am	1.01E+00	9.38E+01	9.34E+01	1.85E+00	4.69E+02	4.67E+02
^{241}Pu	1.69E+00	2.96E+02	2.95E+02	3.08E+00	1.48E+03	1.47E+03
^{242}Cm	2.96E-03	1.26E-01	1.25E-01	5.39E-03	6.32E-01	6.27E-01
^{242}mAm	NR	NR	NR	NR	NR	NR
^{242}Pu	9.36E-06	2.14E-03	2.14E-03	1.70E-05	1.07E-02	1.07E-02
^{243}Am	3.90E-05	1.04E-02	1.04E-02	7.10E-05	5.22E-02	5.22E-02
^{243}Cm	2.85E-04	1.54E-02	1.54E-02	5.18E-04	7.72E-02	7.68E-02
^{244}Cm	2.21E-03	6.31E-01	6.30E-01	4.02E-03	3.15E+00	3.15E+00
Total	1.14E+04	3.33E+04	2.96E+04	2.08E+04	1.67E+05	1.48E+05

Table 13. 1988 Supernate Composition and Inventories of Chemicals and Radionuclides That Potentially Leaked from Tank 241-AX-102

Analyte	1988 Supernate Composition[a] (M)	Estimated Leakage from Tank 241-AX-102[b], kg (Ci)
Al	0.006	1.8
Bi	0	0
Ca	0.014	6.4
CO_3	0.98	689.9
Cr	0.004	2.4
Fe	0.033	20.9
K	0.002	0.88
Mg	0.0005	0.14
Mn	0.011	6.9
Na	7.32	1,912
Ni	0.009	6
NO_2	1.4	731
NO_3	3.7	2,605
Oxalate	36.8 g/L	418
PO_4	< 0.056	60.4
Si	0.0009	0.3
^{241}Am	980[c] (µCi/L)	11.1[c] Ci
$^{239/240}Pu$	97[c] (µCi/L)	1.1[c] Ci
^{137}Cs	265,265[c] (µCi/L)	3,012[c] Ci
^{60}Co	146[c] (µCi/L)	8.1[c] Ci
^{90}Sr	127,755[c] (µCi/L)	1,450[c] Ci

[a]Weiss, R. L., 1988, Analysis of Tank 241-AX-102 Sample, Memorandum to J. A. Eaker, WHC-SD-WM-ER-309.

[b]based on 11.3 kL (3 kgal) of potential leakage.

[c]radionuclides decayed to December 31, 1999.

APPENDIX D

BEST-BASIS INVENTORY, RETRIEVAL INVENTORY, AND LEAKAGE INVENTORY ESTIMATES FOR RETRIEVAL OF WASTE FROM SINGLE-SHELL TANK 241-AX-103

D. W. Hendrickson, P.E.
S. L. Lambert, Ph.D.
SGN Eurisys Services Corporation
Richland, Washington

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The purpose of this study is to provide the best-basis estimate of the chemical and radiological waste inventory after retrieval of waste from the 241-AX Tank Farm. As part of this effort, an evaluation of available information for Tank 241-AX-103 was performed and a best-basis inventory was established for two different retrieval scenarios. The first scenario is based on 99 percent retrieval of waste from the tank to meet the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990) milestone of 101.9 m^3 (360 ft^3) of residual waste. The alternate scenario assumes a retrieval of 90 percent of the waste to a volume of 101.94 m^3 (3,600 ft^3) of residual waste, or left at the current volume if this volume is less than 101.94 m^3 (3,600 ft^3). This study, detailed in the following sections, is based on the methodology that was established by the standard inventory task.

1.0 CHEMICAL INFORMATION SOURCES

Chemical and radionuclide inventory estimates are generally derived from one of three sources of information: (1) sample analysis and sample derived inventory estimates, (2) component inventories predicted by the HDW model based on process knowledge and historical tank transfer information, or (3) a tank-specific process estimate based on process flowsheets, reactor fuel data, essential materials records, or comparable sludge layers and sample information from other tanks.

Tank 241-AX-103 was sampled in September 1974 to determine the sludge composition prior to the 1976 sluicing campaign and again in September 1980 to establish the tank supernate composition before deactivation of the tank in 1981. Samples obtained prior to 1976 are of only limited value as most of the material was removed from this tank during the 1976 sluicing campaign. Similarly, supernate samples from the post 1976 period are of little interest because the supernate was transferred to Tank 241-A-102 during the fourth quarter of 1980, or removed via salt well pumping to Tank 241-AN-101 in 1987.

The waste history of this tank is provided in Anderson (1990) and Agnew et al. (1997a). Tank 241-AX-103 was initially used as a PUREX waste receiver from the first quarter of 1965 until the second quarter of 1966, with large transfers of PUREX (P2) waste and intermittent transfers of PUREX organic wash (OWW2) waste. Other transfers of PUREX organic wash (OWW2 and OWW3) waste occurred in 1966 and 1967, followed by transfers of B Plant (B) waste, PUREX low-level (PL1) waste, and supernate receipts from other tanks (241-A-104, 241-A-106, 241-AX-101, 241-AX-102, 241-AX-104 and 241-C-106). AR vault (AR) sludge was added in 1975, while the tank was sluiced from March 1976 until the beginning of 1977, removing about 310 kL (82 kgal) of sludge (Rodenhizer 1987). The tank was isolated and stabilized in early 1977 and deactivated in 1981, with the last salt well transfer occurring in 1987.

2.0 CHEMICAL/RADIONUCLIDE INVENTORY ESTIMATES BEFORE RETRIEVAL

After the 1976 sluicing campaign, the residual sludge level was found to be 15.2 cm (6 in.) at riser 9B. This level was measured again in November 1979 after dilute evaporator wastes were added to the tank and found to be 7.6 cm (3 in.) and 25.4 cm (10 in.) at risers 9D and 9E (Bendixsen 1980). Based on these values, approximately 15.2 cm (6 in.) of residual sludge must have been left in the tank after the 1976 sluicing campaign. This level is equivalent to a residual sludge inventory of 62.6 kL (16.5 kgal) in the 22.86 m (75 ft) diameter, flat bottom tank. This estimate is somewhat larger than the residual inventories reported by Anderson (0 to 6 kgal of sludge in 1980) and later by Agnew (14 kgal of sludge), based on the historical records for this tank (Anderson 1991, Agnew 1997b).

Approximately 1,635 kL (432 kgal) of 242-A evaporator concentrates were added to this tank in 1980, increasing the sludge and saltcake inventory to about 458 kL (121 kgal) (Agnew et al. 1997a). Because of salt well pumping, this inventory was later reduced to about 424 kL (112 kgal), which is consistent with the tank farm surveillance estimate 103.4 cm (40.7 in.) of solids, including 7.6 kL (2 kgal) of sludge and 416.4 kL (110 kgal) of saltcake (Hanlon 1993). The Hanlon estimate is also consistent with current waste level measurements for this tank, 102.9-cm (40.5-in.) of waste as of January 1993, including a one-inch offset for the FIC plummet (Swaney 1993). Based on the 1979 sludge level measurements, it appears that the Hanlon sludge and saltcake estimates should be modified to match the 1979 sludge level data for this tank, 62.6 kL (16.5 kgal) of sludge and 361.4 kL (95.5 kgal) of saltcake. The best-basis standard inventory is based on the tank farm surveillance waste volume (424 kL), with revised inventory estimates of 62.6 kL (16.5 kgal) of sludge and 361.4 kL (95.5 kgal) of saltcake. This inventory is equivalent to 2,208 cubic feet of PUREX P2 sludge and 12,476 cubic feet of SMMA1 saltcake from the 242-A evaporator.

The residual sludge in Tank 241-AX-103 is considered to be similar in composition to the residual sludge in Tank 241-AX-104. Both tanks received PUREX high-level (P2) waste starting in 1965, while Tank 241-AX-103 received small transfers of PUREX organic wash (OWW2) waste during this period. Both tanks were also sluiced in 1976 and 1977, leaving only a small heel of residual sludge (16.5 and 7 kgal, respectively, in Tanks 241-AX-103 and 241-AX-104). A small sample of residual sludge was obtained from Tank 241-AX-104 after the 1976 sluicing campaign. The characteristics of this sludge were found to be consistent with the expected composition profile at PUREX P2 waste (best-basis inventory discussion for Tank 241-AX-104). Based on this analogy, it appears that this sample could also be used to estimate the residual waste composition profile for Tank 241-AX-103, with appropriate adjustments to OWW2 waste.

According to the HDW model, 3.9 volume percent of the P2 waste and 1.1 volume percent of the OWW2 waste are expected to precipitate as sludge in the primary receiver tank (Agnew 1997a). Based on the volume of such transfers in 1965 and 1966, it appears that PUREX P2 waste could make up as much as 92 percent of the sludge and OWW2 waste eight percent of the sludge in Tank 241-AX-103 (92.5 kgal of P2 sludge and 9.0 kgal of OWW2 sludge theoretically deposited in 1965 and 1966).

About 3,092 kL (817 kgal) of OWW2 waste were transferred to this tank in 1965 and 1966 (Agnew 1997b). OWW2 waste contained about 0.004 g moles/L of MnO_2 and 3.5E-05 kg/L of uranium (Anderson 1990). Based on these values, about 680 kg of Mn and 111 kg of uranium must have been added with OWW2 waste in 1965 and 1966. As all but 62.6 kL (16.5 kgal) of sludge were removed during the 1976 sluicing campaign, only about 16 percent of the OWW2 waste should be in the tank (16.5 kgal/92.5 kgal + 9 kgal). Thus, 109 kg of Mn and 18 kg of uranium may have been added to the residual sludge layer from OWW2 waste.

2.1 SLUDGE LAYER

Since the residual sludge layers in Tanks 241-AX-103 and 241-AX-104 were derived from a common source, the 1977 grab sample from Tank 241-AX-104 will be used in this analysis to estimate the waste composition profile for Tank 241-AX-103. The 1977 grab sample concentrations from Tank 241-AX-104 for both the washed sludge and the wash solution are listed in Tables 1 and 2 for nonradioactive and radioactive components, respectively. The grab sample concentrations for Tank 241-AX-104 are reported on a "per liter of sludge" basis. The Tank 241-AX-103 sludge layer inventory for Tank 241-AX-102, summarized in Tables 1 and 2, is calculated by multiplying the sum of the washed sludge and wash solution concentrations in Tank 241-AX-104 sludge by the volume of the sludge in Tank 241-AX-103 (62.6 kL [16.5 kgal]), with the indicated corrections for manganese and uranium from OWW2 waste (109 kg of manganese and 18 kg of uranium from OWW2 sludge).

2.2 SALTCAKE LAYER

During the second and third quarters of 1980, approximately 1,635 kL (432 kgal) of evaporator concentrates were added to Tank 241-AX-103 from the 242-A evaporator-crystallizer. After this transfer, the waste inventory increased to 458 kL (121 kgal), and later because of salt well pumping, gradually decreased to the present inventory of 424 kL (112 kgal) (Agnew 1997a, Hanlon 1993, Swaney 1993). Some 361.4 kL (95.5 kgal) of this inventory is due to the accumulation of saltcake from the 242-A evaporator. This saltcake is referred to as SMMA1 saltcake in the HDW model. While saltcake compositions probably varied from batch to batch (depending on the source of concentrated supernate), large volumes of saltcake were also added to Tanks 241-A-102 and 241-A-103 during this same time period. These tanks are of interest because both tanks were sluiced in 1976 to a residual inventory of only 4 to 11 kL (1 to 3 kgal) of sludge and both were sampled after receiving large volumes of 242-A evaporator saltcake in 1977-1980.

Tank 241-A-102 was sluiced in 1964, 1972-1974, and once again in 1976 to a residual heel of about 11 kL (3 kgal) of strontium recovery (SRR) sludge (Anderson 1990, Agnew 1997a). Based on the HDW model, this tank currently contains 11 kL (3 kgal) of SRR sludge and 128.7 kL (34 kgal) of SMMA1 saltcake, values which are generally consistent with the current inventory estimates for this tank (147.6 kL or 39 kgal according to Swaney 1993 and 155 kL or 41 kgal in Hanlon 1993). Thus, 92 percent of this waste apparently consists of 242-A evaporator saltcake. Two full-depth core samples were obtained from riser 4 in 1986 and two auger samples, the first from riser 19 in June 1995 and the second from riser 5 in March 1996, were also obtained for safety screening analysis. Core segment recoveries were determined to be nearly 100 percent for each core. Composite samples from the two 1986 cores and 1996 auger sample were analyzed to determine the chemical and radionuclide composition of the waste. The analytical results are summarized in the TCR (Morris 1996).

Table 3 shows the projected inventory of key components in the residual SRR sludge layer in Tank 241-A-102, based on the HDW model. This model assumes that 11.3 kL (3 kgal) of SRR sludge were left in this tank, and that this sludge has an average density of 1.322 kg/L.

Tank 241-A-103 was also sluiced in the 1960s, in 1974, and once again in 1976, to a residual sludge heel of 11.3 kL (3 kgal) of AR vault (AR) sludge (Anderson 1990, Agnew 1997b). According to the HDW model, this tank currently contains 11 kL (3 kgal) of AR sludge and 1,374 kL (363 kgal) of SMMA1 saltcake from the 242-A evaporator, values which are generally consistent with current inventory projections for this tank (1,430 kL or 378 kgal based on Swaney 1993 and 1,400 kL or 370 kgal in Hanlon 1993). Consequently, about 99.2 percent of this waste apparently consists of 242-A evaporator saltcake. Two full-depth core samples were taken from risers 12 and 17 of this tank in March 1986. Excellent recoveries were obtained for each core. Composite samples from each core were analyzed to determine chemical and radionuclide composition of the waste, with the results summarized in the data transmittal package for this tank (Weiss and Schull 1988).

Table 4 summarizes the SMMA1 saltcake compositions derived from Tanks 241-A-102 and 241-A-103. Saltcake inventory estimates for Tank 241-AX-103 are based on 361.4 kL (95.5 kgal) of saltcake, with an average density of 1.4975 kg/L from sample data. This estimate is reasonably consistent with the average density of 1.5133 derived from the HDW model for SMMA1 saltcake in Tanks 241-A-102, 241-A-103, and 241-AX-103.

Table 5 summarizes the mean radionuclide concentrations and tank inventory estimates for SMMA1 saltcake based on core and auger samples from Tanks 241-A-102 and 241-A-103. Radionuclide results in Table 5 have been decayed to January 1, 1994. Further decay is provided in the best-basis inventory tables. The original analytical values for Tank 241-A-102 may be found in the tank characterization report (Morris 1996), and for Tank 241-A-103, in the data transmittal package for this tank (Weiss and Schull 1988a).

2.3 BEST-BASIS INVENTORY

Based on this analysis, a best-basis inventory was developed. The full-depth core samples and auger samples (of SMMA1 saltcake) from Tanks 241-A-102 and 241-A-103, together with the 1977 sample (of PUREX P2 waste) from Tank 241-AX-104 were used to generate estimates for the chemical and radionuclide components in this waste. This waste consists primarily of SMMA1 saltcake from the 242-A evaporator and a small volume of PUREX high-level (P2) sludge and PUREX organic wash (OWW2) sludge waste from Al-clad fuel. Once the best-basis inventories were determined, the hydroxide inventory was calculated by performing a charge balance with the valences of other analytes. In some cases, this approach requires that other analyte (e.g., sodium or nitrate) inventories be adjusted to achieve the charge balance. During such adjustments, the number of significant figures is not increased. This charge balance approach is consistent with that used by Agnew et al. (1997a).

Best-basis radionuclide values were derived for 46 key radionuclides (Kupfer et al. 1997). Waste sample analyses have often only reported ^{90}Sr, ^{137}Cs, $^{239/240}Pu$, and total uranium (or total beta and total alpha), while other key radionuclides, such as ^{60}Co, ^{99}Tc, ^{129}I, ^{154}Eu, ^{155}Eu, and ^{241}Am, etc., have been infrequently reported. For this reason it was necessary to derive most of the 46 key radionuclides by computer models. These models estimate radionuclide activity in batches of reactor fuel, account for the split of radionuclides to various separations plant waste streams, and track their movement with tank waste transactions. (Kupfer et al. 1997 and Watrous and Wootan 1997.) Model-generated values for radionuclides in any of the 177 tanks are reported in the HDW Rev. 4 model results (Agnew et al. 1997a). (No attempt has been made to ratio or normalize model results for all 46 radionuclides when values for measured radionuclides disagree with the model.) For a discussion of typical error between model-derived values and sample-derived values (Kupfer et al. 1997).

The best-basis inventory for Tank 241-AX-103 is presented in Tables 6 and 7. A medium level of confidence is assigned to the chemicals and radionuclides in these tables because of the good comparisons found between the sample-based and HDW model-based estimates for many of the saltcake components, including Al, Cl, CO_3, Cr, NO_3, NO_2, and Na.

3.0 CHEMICAL/RADIONUCLIDE INVENTORY ESTIMATES AFTER RETRIEVAL

As part of this study, a best basis inventory was established for three different retrieval scenarios. The first scenario is based on retrieving waste to minimum of either the existing waste volume or a residual waste volume of 101.94 m^3 (3600 ft^3). The second scenario assumes retrieval to a residual waste volume of 10.2 m^3 (360 ft^3) which corresponds to the assumed 99 percent retrieval of waste to meet the Tri-Party Agreement (Ecology et al. 1990). The third scenario assumes retrieval to a residual waste volume of 1.02 m^3 (36 ft^3). The first and third scenarios represent the retrieval of all tank wastes to 90 percent and 99.9 percent respectively.

Table 8 contains a summary matrix of resultant saltcake and sludge volumes, and their fractional removal, following retrieval according to the three scenarios of 90 percent, 99 percent, and 99.9 percent retrieval.

Following retrieval according to the three scenarios presented in Table 8, residual tank waste inventory has been evaluated and is presented in Tables 9 and 10 for chemical and radiological constituents, respectively.

4.0 BEST-BASIS LEAKAGE INVENTORY ESTIMATES FOR RETRIEVAL OF SINGLE-SHELL TANK 241-AX-103

The retrieval scenarios described in Section 3.0 provide residual inventories following fractional removal of any saltcake and sludges contained within Tank 241-AX-101. This section assumes two different leakage conditions for each retrieval scenario. The first leakage condition assumes up to 30.2 m^3 (8 kgal) of potential leakage, while the second leakage condition is based on an upper bounding estimate of 151.4 m^3 (40 kgal) of potential leakage. In each case, solution concentrations and inventories will be based on the limiting conditions for waste retrieval, either a maximum supernate concentration of five gram moles per liter sodium or a maximum value of 10 weight percent solids in the slurry, or the total volume of the retrieval solution. These limits were established to minimize the possible crystallization of sodium rich salts in the slurry transfer lines and slurry pumping problems for the slurry pumps and sluicers. The following estimates are based on the methodology that was established by the standard inventory task.

The solution concentrations resulting from dissolution and slurry with water of the tank waste to the three retrieval scenarios are provided in Tables 11 and 12 for nonradiological and radiological constituents. Table 11 also displays the limiting volume assessment required for application of sodium loading or solids loading limits and the minimum retrieval water to meet the limiting volume assessment based upon product-specific gravities of either 1.17 or 1.18 for sodium limited or solids limited solutions.

Tables 13 and 14 contain the nonradiological and radiological, resultant leakage inventory estimates based upon 30.2 m^3 (1,066.5 ft^3) and 151.4 m^3 (5,346.7 ft^3) releases during retrieval.

5.0 TANK LEAKAGE

Tank 241-AX-103 is currently considered to be a sound tank with no compelling evidence of leakage. A total of six dry wells have been drilled around the periphery of Tank 241-AX-103. Dry wells 11-03-02, 11-03-07, and 11-03-09 have produced radiation counts more than 50 counts per second above background. If, during the course of spectral gamma logging, it is determined that some leakage did occur from this tank, the chemical and radionuclide source terms could be estimated from the available supernate composition data for this tank. Supernate samples were taken from this tank in October 1974 and April 1980, which should bracket any potential leakage event. This data will not be included in this submittal because there is presently no evidence that this tank has ever leaked.

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Table 1. Analytical Results and Sludge Inventory Estimates for Nonradioactive Components in Tank 241-AX-103

Component	1977 Sludge Concentration (M)[a]	1977 Wash Solution Concentration (M)[b]	Sludge Layer Inventory in Tank 241-AX-103 (kg)[c]
Density	1.80	g/mL	
Al	2.465	0.013	4,182
Ba	0.021	NR	180.4
Ca	0.642	NR	1608
Cd	0.015	NR	105.5
Cr	0.061	NR	198.4
Fe	5.31	NR	18,549
Mg	0.171	NR	260
Mn	0.0845	NR	399
Na	2.99	0.337	4,784
Ni	0.26	NR	955
NO_2	NR	0.083	239
NO_3	< 1.140	0.09	< 4770
OH	NR	15.6	16,595
P as PO_4	0.11	NR	653
P	0.11	NR	213.1
Si as SiO_3	2.485	NR	11,826
S as SO_4	0.125	0.01	811
S	0.125	0.01	271
Total U	1.79E-05	NR	18.27
H_2O	40.97	NR	46,162
Pu (g/L)	0.213	NR	13

[a] Average of two KOH fusion determinations from September 1977 grab sample (Starr 1977).

[b] Wash solution composition based on mass of washed sludge (1.8 g/mL).

[c] Sludge inventory based on 26.6 kL of sludge with an average density of 1.80 kg/L.

Table 2. Analytical Results and Sludge Inventory Estimates for Radioactive Components in Tank 241-AX-103

Component	1977 Sludge Concentration (Ci/L)	1977 Wash Solution Concentration (Ci/L)	Sludge Layer Inventory in Tank 241-AX-103 (Ci)
Decay	12/31/99	12/31/99	12/31/99
^{60}Co	0.0059	NR	372
^{90}Sr	51.5	0.0133	3.22E+06
^{90}Y	51.5	0.0133	3.22E+06
^{125}Sb	0.0024	NR	148
^{137}Cs	1.063	0.0086	66,821
^{137}mBa	1.006	0.0081	63,212
^{154}Eu	0.0434	NR	2713
^{155}Eu	0.0279	NR	1744
$^{239/240}Pu$	0.0132	NR	824

[a] Based on decayed mean of 1977 sludge sample (Starr 1977)
[b] Based on decayed mean of 1977 wash solution results (Starr 1977)
[c] Sludge inventory based on 62.5 kL (16.5 kgal) of sludge with a density of 1.80 kg/L.

Table 3. Projected Inventory of SRR Components in Tank 241-A-102 and Percent of Total Inventory Due to SRR Sludge

Analyte	Average Concentration[a], (ug/g)	Projected Inventory in SRR Sludge[b], (kg)	Sample-Based Inventory in Tank 241-A-102[c], (kg)	Percent Due to SRR Sludge
Ca	4,146	62	410	15.1 %
CO_3	15,490	232	5,724	4.1 %
Fe	53,951	809	4,358	18.6 %
NO_3	19,406	291	21,949	1.3 %
Si	14,075	211	2,563	8.2 %
Na	112,406	1,687	40,087	4.2 %

[a] Based on the concentration of SRR sludge in the HDW model (Agnew et. al. 1997a).
[b] Based on 11.3 kL (3 kgal) of waste with an average density of 1.322 kg/L (Agnew et al. 1997a).
[c] Based on average analyte concentrations from 1986 core samples and 1996 auger sample, with a total waste inventory of 139.7 kL (37 kgal) and average waste density of 1.645 kg/L.

Table 4. SMMA1 Saltcake Composition and Inventory Projections for Tank 241-AX-103 Based on Core Samples from Tanks 241-A-102 and 241-A-103 and Auger Samples from Tank 241-A-102 (page 1 of 2)

Analyte	241-A-102 Sample Data[a]		Tank 241-A-103 Core Sample Data (μg/g)[b]	Average Analyte Concentration in SMMA1 Saltcake μg/g	Estimated Inventory of SMMA1 Saltcake in Tank 241-AX-103 (kg)[c]
	1986 Core Sample (μg/g)	1996 Auger Sample (μg/g)			
Density	1.59	1.7	1.345	1.495	1.495
Ag	247	371	24.7	167	90
Al	23,265	31,700	16,570	22,026	11,904
As	NR	NR	NR	NR	NR
B	14.2	NR	22.2	18.2	9.9
Ba	882	139	575	543	293
Bi	1,738	336	176	607	328
Ca	2,592	690	1,716	1,678	907
Cd	65	NR	80	72	39
Cl	NR	NR	NR	NR	NR
TIC as CO_3	NR	21,700	NR	21,700	11,728
Cr	5,270	8,800	1,531	4,283	2,315
Cu	82	NR	12.3	47	25
F	NR	277	NR	277	150
Fe	13,936	19,600	355	8,561	4,627
Hg	NR	NR	NR	NR	NR
K	2,816	3,080	2,534	2,741	1,481
La	NR	103	NR	103	56
Mg	1,382	NR	795	1,088	588
Mn	2,151	3,380	124	1,445	781
Na	187,045	129,000	208,605	183,314	99,071
Ni	526	413	93	281	152
NO_2	NR	83,200	NR	83,200	44,965
NO_3	178,500	90,300	113,500	123,950	66,988
OH	NR	NR	NR	NR	NR
Pb	1,186	1,410	364	831	449
P as PO_4	16,061	4,906	6,655	8,569	4,631
P	5,238	NR	2,170	3,704	2,002
Se	NR	NR	NR	NR	NR
Si as SiO_3	44,778	10,619	29,929	28,814	15,572
S as SO_4	NR	4,480	NR	4,480	2,421
S	NR	NR	NR	NR	NR
Sr	98	31.5	12.0	38.3	20.7

Table 4. SMMA1 Saltcake Composition and Inventory Projections for Tank 241-AX-103 Based on Core Samples from Tanks 241-A-102 and 241-A-103 and Auger Samples from Tank 241-A-102 (page 2 of 2)

Analyte	241-A-102 Sample Data[a]		Tank 241-A-103 Core Sample Data (µg/g)[b]	Average Analyte Concentration in SMMA1 Saltcake µg/g	Estimated Inventory of SMMA1 Saltcake in Tank 241-AX-103 (kg)[c]
	1986 Core Sample (µg/g)	1996 Auger Sample (µg/g)			
TOC	7,570	14,850	7,885	9,548	5,160
Total U	1,041	35,300	1,435	9,803	5,298
Zn	105	NR	54	79	43
Zr	1,439	NR	209	824	445
EDTA	NR	NR	NR	NR	NR
NH_3	NR	NR	NR	NR	NR
Cr^{+6}	NR	NR	NR	NR	NR
CN	NR	NR	NR	NR	NR
H_2O	351,500	343,000	402,000	374,625	202,463
SMMA1 Volume (L)					361,500

HDW = Hanford Defined Waste

NR = Not reported.

[a] Based on the TCR (Morris 1996)

[b] Based on mean of two composite core samples from tank 241-A-103 (Weiss and Schull 1988b)

[c] Based on 361,500 L (95.5 kgal) of SMMA1 saltcake, with an average density of 1.495 kg/L. This estimate was derived by averaging the core and auger sample results for tank 241-A-102, and then averaging the results for tanks 241-A-102 and 241-A-103.

Table 5. Analytical Results and Tank Inventory Estimates for Radioactive Components in SMMA1 Saltcake in Tank 241-AX-103 Based on Core Samples from Tanks 241-A-102 and 241-A-103

Analyte	Tank 241-A-102 Sample Data		Tank 241-A-103 Core Sample Data (μCi/g)	Average Analyte Concentration in SMMA1 Saltcake (μCi/g)	Estimated Inventory of SMMA1 Saltcake in Tank 241-AX-103 (Ci)[c]
	1986 Core Sample (μCi/g)[a]	1996 Auger Sample (μCi/g)[b]			
Decay Date	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99
^{14}C	0.0011	NR	0.0026	0.0019	1.004
^{60}Co	0.137	NR	0.015	0.076	40.95
^{90}Sr	436	NR	35.2	236	127,296
^{90}Y	436	NR	35.2	236	127,296
^{99}Tc	0.100	NR	0.117	0.109	58.7
^{129}I	0.000039	NR	0.000019	2.9E-05	0.016
^{137}Cs	101.8	NR	147	124	67,284
^{137m}Ba	96.3	NR	139	118	63,650
$^{239/240}Pu$	2.001	NR	0.130	1.065	576
^{241}Am	1.185	NR	0.119	0.652	352

HDW = Hanford Defined Waste
NR = Not reported.
[a] Based on the TCR (Morris 1996)
[b] Based on mean of two composite core samples from tank 241-A-103 (Weiss and Schull 1988b)
[c] Based on 361,500 L (95.5 kgal) of SMMA1 saltcake, with an average density of 1.495 kg/L. This estimate was derived by averaging the core and auger sample results for tank 241-A-102, and then averaging the results for tanks 241-A-102 and 241-A-103.

Table 6. Best-Basis Nonradiological Inventory Before Retrieval of Waste from Single-Shell Tank 241-AX-103 (page 1 of 2)

	Sludge	Saltcake	Overall
Density (kg/m^3)	1,800.0	1,495.0	1,540.0
Volume (m^3)	62.5	361.5	424.0
Components (M)			Inventory (kg)
Ag	NR	2.31E-03	90.2
Al	2.48E+00	1.22E+00	16,086.0
As	NR	NR	NR
B	NR	2.52E-03	9.8
Ba	2.10E-02	5.91E-03	473.8
Bi	NR	4.34E-03	327.9
Ca	6.41E-01	6.26E-02	2,515.2
Cd	1.50E-02	9.61E-04	144.5
Cl	1.79E-02	1.96E-01	2,549.6
TIC as CO_3	NR	5.41E-01	11,727.6
Cr	6.10E-02	1.23E-01	2,513.1
Cu	NR	1.11E-03	25.5
F	NR	2.18E-02	149.7
Fe	5.31E+00	2.29E-01	23,176.0
Hg	NR	8.12E-06	0.6
K	NR	1.05E-01	1,481.2
La	NR	1.11E-03	55.7
Mg	1.71E-01	6.70E-02	848.2
Mn	1.16E-01	3.93E-02	1,180.2
Na	3.33E+00	1.19E+01	103,854.8
Ni	2.60E-01	7.17E-03	1,106.7
NO_2	8.30E-02	2.70E+00	45,203.7
NO_3	NR	2.99E+00	66,987.8
OH	1.56E+01	NR	16,595.4
Pb	NR	5.99E-03	449.0
P as PO_4	1.10E-01	1.35E-01	5,284.5
P	1.10E-01	1.79E-01	2,215.0
Se	NR	NR	NR
Si as SiO_3	2.48E+00	5.66E-01	27,398.5
S as SO_4	1.35E-01	6.97E-02	3,232.3
S	1.35E-01	NR	270.7
Sr	NR	6.53E-04	20.7
TOC	NR	1.19E+00	5,159.9
Total U	1.23E-03	6.16E-02	5,316.0

Table 6. Best-Basis Nonradiological Inventory Before Retrieval of Waste from Single-Shell Tank 241-AX-103 (page 2 of 2)

	Sludge	Saltcake	Overall
Density (kg/m^3)	1,800.0	1,495.0	1,540.0
Volume (m^3)	62.5	361.5	424.0
Components (M)			Inventory (kg)
Zn	NR	1.82E-03	42.9
Zr	NR	1.35E-02	445.3
EDTA	NR	2.63E-02	2,780.0
NH_3	2.28E-01	4.87E-02	543.0
Cr^{+6}	NR	NR	NR
CN	NR	NR	NR
H_2O	4.10E+01	3.11E+01	2.49E+05
Total			5.99E+05

Table 7. Best-Basis Radiological Inventory Before Retrieval of Waste From Single-Shell Tank 241-AX-103 (page 1 of 2)

Components (Ci/L)	Sludge	Saltcake	Inventory (Ci)
Decay Date	12/31/99	12/31/99	12/31/99
^{3}H	1.08E-04	2.02E-04	7.98E+01
^{14}C	NR	2.78E-06	1.00E+00
^{59}Ni	9.99E-05	1.62E-06	6.84E+00
^{60}Co	5.94E-03	1.13E-04	4.13E+02
^{63}Ni	1.00E-02	1.60E-04	6.85E+02
^{79}Se	9.45E-05	3.13E-06	7.04E+00
^{90}Sr	5.15E+01	3.52E-01	3.35E+06
^{90}Y	5.15E+01	3.52E-01	3.35E+06
^{93}mNb	3.26E-04	1.11E-05	2.44E+01
^{93}Zr	4.33E-04	1.54E-05	3.27E+01
^{99}Tc	NR	1.62E-04	5.87E+01
^{106}Ru	3.23E-07	7.22E-09	2.28E-02
^{113}mCd	1.85E-03	8.41E-05	1.46E+02
^{125}Sb	2.37E-03	NR	1.48E+02
^{126}Sn	1.47E-04	4.73E-06	1.09E+01
^{129}I	NR	4.34E-08	1.57E-02
^{134}Cs	6.62E-06	3.29E-06	1.60E+00
^{135}Cs	NR	NR	NR
^{137}Cs	1.07E+00	1.86E-01	1.34E+05
^{137}mBa	1.01E+00	1.76E-01	1.27E+05
^{151}Sm	3.52E-01	1.10E-02	2.60E+04
^{152}Eu	1.08E-04	4.09E-06	8.21E+00
^{154}Eu	4.34E-02	NR	2.71E+03
^{155}Eu	2.79E-02	NR	1.74E+03
^{226}Ra	6.27E-09	1.21E-10	4.36E-04
^{227}Ac	3.37E-08	7.47E-10	2.38E-03
^{228}Ra	5.68E-14	3.15E-07	1.14E-01
^{229}Th	8.86E-12	7.33E-09	2.65E-03
^{231}Pa	7.61E-08	3.57E-09	6.05E-03
^{232}Th	5.12E-15	3.40E-08	1.23E-02
^{232}U	7.11E-12	9.43E-07	3.41E-01
^{233}U	1.68E-13	3.62E-06	1.31E+00
^{234}U	8.76E-08	5.98E-07	2.21E-01
^{235}U	3.66E-09	2.37E-08	8.81E-03
^{236}U	2.40E-09	1.93E-08	7.11E-03
^{237}Np	3.05E-07	8.33E-07	3.20E-01

Table 7. Best-Basis Radiological Inventory Before Retrieval of Waste From Single-Shell Tank 241-AX-103 (page 2 of 2)

Components (Ci/L)	Sludge	Saltcake	Inventory (Ci)
Decay Date	12/31/99	12/31/99	12/31/99
^{238}Pu	7.99E-05	1.25E-06	5.45E+00
^{238}U	8.54E-08	8.30E-07	3.05E-01
^{239}Pu	2.06E-03	4.09E-05	1.44E+02
^{240}Pu	3.95E-04	7.08E-06	2.73E+01
$^{239/240}Pu$	1.32E-02	1.59E-03	1.40E+03
^{241}Am	NR	9.75E-04	3.52E+02
^{241}Pu	5.69E-03	8.66E-05	3.87E+02
^{242}Cm	2.97E-06	1.37E-07	2.36E-01
^{242}mAm	NR	NR	NR
^{242}Pu	3.29E-08	4.76E-10	2.23E-03
^{243}Am	9.98E-08	2.06E-09	6.98E-03
^{243}Cm	2.29E-07	1.28E-08	1.89E-02
^{244}Cm	7.02E-06	1.11E-07	4.79E-01
Total			6.99E+06

Table 8. Retrieval Scenario Summary of Residual Waste and Fractional Removal

	Case I	Case II	Case III
Vol Base (m^3)	101.94	10.19	1.02
% Base	90.0%	99.0%	99.9%
Target (m^3)	101.94	10.19	1.02
Sludge (m^3)	62.55	10.19	1.02
Saltcake (m^3)	39.39	0.00	0.00
Sludge Removal	0.0%	83.7%	98.4%
Saltcake Removal	89.1%	100.0%	100.0%

Table 9. Tank 241-AX-103 Nonradiological Waste Residual Inventory Following Retrieval (page 1 of 2)

Residual Waste (kg)	Case I	Case II	Case III
Target (m^3)	101.94	10.19	1.02
Sludge (m^3)	62.55	10.19	1.02
Saltcake (m^3)	39.39	0.00	0.00
Ag	9.83E+00	0	0
Al	5.48E+03	6.82E+02	6.82E+01
As	NR	NR	NR
B	1.07E+00	0	0
Ba	2.12E+02	2.94E+01	2.94E+00
Bi	3.57E+01	0	0
Ca	1.71E+03	2.62E+02	2.62E+01
Cd	1.10E+02	1.72E+01	1.72E+00
Cl	3.13E+02	6.45E+00	6.45E-01
TIC as CO_3	1.28E+03	0	0
Cr	4.51E+02	3.23E+01	3.23E+00
Cu	2.78E+00	0	0
F	1.63E+01	0	0
Fe	1.91E+04	3.02E+03	3.02E+02
Hg	6.42E-02	0	0
K	1.61E+02	0	0
La	6.07E+00	0	0
Mg	3.24E+02	4.24E+01	4.24E+00
Mn	4.84E+02	6.51E+01	6.51E+00
Na	1.56E+04	7.80E+02	7.80E+01
Ni	9.71E+02	1.56E+02	1.56E+01
NO_2	5.14E+03	3.89E+01	3.89E+00
NO_3	7.30E+03	0	0
OH	1.66E+04	2.70E+03	2.70E+02
Pb	4.89E+01	0	0
P as PO_4	1.16E+03	1.06E+02	1.06E+01
P	4.31E+02	3.47E+01	3.47E+00
Se	NR	NR	NR
Si as SiO_3	1.35E+04	1.93E+03	1.93E+02
S as SO_4	1.07E+03	1.32E+02	1.32E+01
S	2.71E+02	4.41E+01	4.41E+00
Sr	2.25E+00	0	0
TOC	5.62E+02	0	0
Total U	5.96E+02	2.98E+00	2.98E-01

Table 9. Tank 241-AX-103 Nonradiological Waste Residual Inventory Following Retrieval (page 2 of 2)

Residual Waste (kg)	Case I	Case II	Case III
Zn	4.68E+00	0	0
Zr	4.85E+01	0	0
EDTA	3.03E+02	0	0
NH_3	2.76E+02	3.96E+01	3.96E+00
Cr^{+6}	NR	NR	NR
CN	NR	NR	NR
H_2O	6.82E+04	7.52E+03	7.52E+02
Total	1.61E+05	1.76E+04	1.76E+03

Table 10. Tank 241-AX-103 Radiological Waste Residual Inventory Following Retrieval (page 1 of 2)

Residual Waste (Ci)	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99
^{3}H	1.47E+01	1.10E+00	1.10E-01
^{14}C	1.09E-01	0	0
^{59}Ni	6.31E+00	1.02E+00	1.02E-01
^{60}Co	3.76E+02	6.06E+01	6.06E+00
^{63}Ni	6.33E+02	1.02E+02	1.02E+01
^{79}Se	6.03E+00	9.63E-01	9.63E-02
^{90}Sr	3.24E+06	5.25E+05	5.25E+04
^{90}Y	3.24E+06	5.25E+05	5.25E+04
^{93}mNb	2.08E+01	3.32E+00	3.32E-01
^{93}Zr	2.77E+01	4.42E+00	4.42E-01
^{99}Tc	6.40E+00	0	0
^{106}Ru	2.05E-02	3.29E-03	3.29E-04
^{113}mCd	1.19E+02	1.89E+01	1.89E+00
^{125}Sb	1.48E+02	2.41E+01	2.41E+00
^{126}Sn	9.41E+00	1.50E+00	1.50E-01
^{129}I	1.71E-03	0	0
^{134}Cs	5.44E-01	6.75E-02	6.75E-03
^{135}Cs	NR	NR	NR
^{137}Cs	7.42E+04	1.09E+04	1.09E+03
^{137}mBa	7.01E+04	1.03E+04	1.03E+03
^{151}Sm	2.24E+04	3.59E+03	3.59E+02
^{152}Eu	6.89E+00	1.10E+00	1.10E-01
^{154}Eu	2.71E+03	4.42E+02	4.42E+01
^{155}Eu	1.74E+03	2.84E+02	2.84E+01
^{226}Ra	3.97E-04	6.39E-05	6.39E-06
^{227}Ac	2.14E-03	3.44E-04	3.44E-05
^{228}Ra	1.24E-02	5.79E-10	5.79E-11
^{229}Th	2.89E-04	9.03E-08	9.03E-09
^{231}Pa	4.90E-03	7.76E-04	7.76E-05
^{232}Th	1.34E-03	5.22E-11	5.22E-12
^{232}U	3.72E-02	7.25E-08	7.25E-09
^{233}U	1.43E-01	1.71E-09	1.71E-10
^{234}U	2.90E-02	8.93E-04	8.93E-05
^{235}U	1.16E-03	3.73E-05	3.73E-06
^{236}U	9.08E-04	2.44E-05	2.44E-06
^{237}Np	5.19E-02	3.11E-03	3.11E-04

Table 10. Tank 241-AX-103 Radiological Waste Residual Inventory Following Retrieval (page 2 of 2)

Residual Waste (Ci)	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99
^{238}Pu	5.05E+00	8.15E-01	8.15E-02
^{238}U	3.80E-02	8.70E-04	8.70E-05
^{239}Pu	1.31E+02	2.10E+01	2.10E+00
^{240}Pu	2.50E+01	4.03E+00	4.03E-01
$^{239/240}Pu$	8.87E+02	1.34E+02	1.34E+01
^{241}Am	3.84E+01	0	0
^{241}Pu	3.59E+02	5.80E+01	5.80E+00
^{242}Cm	1.91E-01	3.03E-02	3.03E-03
^{242}mAm	NR	NR	NR
^{242}Pu	2.08E-03	3.36E-04	3.36E-05
^{243}Am	6.32E-03	1.02E-03	1.02E-04
^{243}Cm	1.48E-02	2.33E-03	2.33E-04
^{244}Cm	4.43E-01	7.15E-02	7.15E-03
Total	6.64E+06	1.08E+06	1.08E+05

Table 11. Retrieval Scenario Product Solution Nonradiological Analyte Concentrations (page 1 of 2)

Limiting Vol (L)	767,953	896,704	902,809
Sludge [Solids Basis (L)]	0	437,294	513,924
Saltcake [Na Basis (L)]	767,953	896,704	902,809
Solution Concentrations (M)	Case I	Case II	Case III
Ag	9.70E-04	9.33E-04	9.26E-04
Al	5.12E-01	6.37E-01	6.58E-01
As	NR	NR	NR
B	1.06E-03	1.02E-03	1.01E-03
Ba	2.48E-03	3.61E-03	3.80E-03
Bi	1.82E-03	1.75E-03	1.74E-03
Ca	2.63E-02	6.27E-02	6.88E-02
Cd	4.03E-04	1.26E-03	1.41E-03
Cl	8.21E-02	8.00E-02	7.96E-02
TIC as CO_3	2.27E-01	2.18E-01	2.16E-01
Cr	5.17E-02	5.32E-02	5.35E-02
Cu	4.65E-04	4.47E-04	4.44E-04
F	9.14E-03	8.79E-03	8.73E-03
Fe	9.61E-02	4.02E-01	4.54E-01
Hg	3.41E-06	3.27E-06	3.25E-06
K	4.40E-02	4.22E-02	4.20E-02
La	4.65E-04	4.47E-04	4.44E-04
Mg	2.81E-02	3.70E-02	3.85E-02
Mn	1.65E-02	2.26E-02	2.37E-02
Na	5.00E+00	5.00E+00	5.00E+00
Ni	3.01E-03	1.81E-02	2.06E-02
NO_2	1.13E+00	1.09E+00	1.09E+00
NO_3	1.25E+00	1.20E+00	1.20E+00
OH	NR	9.11E-01	1.06E+00
Pb	2.51E-03	2.42E-03	2.40E-03
P as PO_4	5.66E-02	6.08E-02	6.15E-02
P	7.50E-02	7.85E-02	7.91E-02
Se	NR	NR	NR
Si as SiO_3	2.37E-01	3.73E-01	3.96E-01
S as SO_4	2.92E-02	3.60E-02	3.71E-02
S	NR	7.88E-03	9.20E-03
Sr	2.74E-04	2.63E-04	2.61E-04
TOC	4.98E-01	4.79E-01	4.76E-01
Total U	2.58E-02	2.49E-02	2.47E-02

Table 11. Retrieval Scenario Product Solution Nonradiological Analyte Concentrations (page 2 of 2)

Limiting Vol (L)	767,953	896,704	902,809
Sludge [Solids Basis (L)]	0	437,294	513,924
Saltcake [Na Basis (L)]	767,953	896,704	902,809
Solution Concentrations (M)	Case I	Case II	Case III
Zn	7.61E-04	7.32E-04	7.27E-04
Zr	5.66E-03	5.44E-03	5.41E-03
EDTA	1.10E-02	1.06E-02	1.05E-02
NH_3	2.04E-02	3.30E-02	3.51E-02
Cr^{+6}	NR	NR	NR
CN	NR	NR	NR
H_2O	13.04	14.92	15.24
Retrieval H_2O	32.23	29.89	29.50

Table 12. Retrieval Scenario Product Solution Radiological Analyte Concentrations (page 1 of 2)

Solution Concentrations (Ci/L)	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99
^{3}H	8.47E-05	8.77E-05	8.82E-05
^{14}C	1.16E-06	1.12E-06	1.11E-06
^{59}Ni	6.80E-07	6.49E-06	7.46E-06
^{60}Co	4.75E-05	3.93E-04	4.50E-04
^{63}Ni	6.69E-05	6.50E-04	7.47E-04
^{79}Se	1.31E-06	6.78E-06	7.69E-06
^{90}Sr	1.48E-01	3.15E+00	3.65E+00
^{90}Y	1.48E-01	3.15E+00	3.65E+00
^{93}mNb	4.64E-06	2.35E-05	2.67E-05
^{93}Zr	6.46E-06	3.15E-05	3.57E-05
^{99}Tc	6.81E-05	6.55E-05	6.50E-05
^{106}Ru	3.03E-09	2.18E-08	2.49E-08
^{113}mCd	3.53E-05	1.42E-04	1.60E-04
^{125}Sb		1.38E-04	1.61E-04
^{126}Sn	1.98E-06	1.05E-05	1.19E-05
^{129}I	1.82E-08	1.75E-08	1.74E-08
^{134}Cs	1.38E-06	1.71E-06	1.77E-06
^{135}Cs	NR	NR	NR
^{137}Cs	7.81E-02	1.37E-01	1.47E-01
^{137}mBa	7.39E-02	1.30E-01	1.39E-01
^{151}Sm	4.62E-03	2.50E-02	2.84E-02
^{152}Eu	1.72E-06	7.93E-06	8.97E-06
^{154}Eu	NR	2.53E-03	2.96E-03
^{155}Eu	NR	1.63E-03	1.90E-03
^{226}Ra	5.06E-11	4.15E-10	4.75E-10
^{227}Ac	3.13E-10	2.27E-09	2.60E-09
^{228}Ra	1.32E-07	1.27E-07	1.26E-07
^{229}Th	3.07E-09	2.96E-09	2.94E-09
^{231}Pa	1.50E-09	5.88E-09	6.62E-09
^{232}Th	1.43E-08	1.37E-08	1.36E-08
^{232}U	3.96E-07	3.80E-07	3.78E-07
^{233}U	1.52E-06	1.46E-06	1.45E-06
^{234}U	2.51E-07	2.46E-07	2.45E-07
^{235}U	9.96E-09	9.78E-09	9.75E-09
^{236}U	8.08E-09	7.90E-09	7.87E-09
^{237}Np	3.49E-07	3.54E-07	3.54E-07

Table 12. Retrieval Scenario Product Solution Radiological Analyte Concentrations (page 2 of 2)

Solution Concentrations (Ci/L)	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99
^{238}Pu	5.23E-07	5.17E-06	5.95E-06
^{238}U	3.48E-07	3.40E-07	3.38E-07
^{239}Pu	1.72E-05	1.37E-04	1.57E-04
^{240}Pu	2.97E-06	2.59E-05	2.97E-05
$^{239/240}Pu$	6.68E-04	1.41E-03	1.54E-03
^{241}Am	4.09E-04	3.93E-04	3.90E-04
^{241}Pu	3.63E-05	3.67E-04	4.23E-04
^{242}Cm	5.77E-08	2.29E-07	2.58E-07
^{242}mAm	NR	NR	NR
^{242}Pu	2.00E-10	2.11E-09	2.44E-09
^{243}Am	8.63E-10	6.65E-09	7.62E-09
^{243}Cm	5.37E-09	1.85E-08	2.07E-08
^{244}Cm	4.65E-08	4.55E-07	5.23E-07

Table 13. Tank 241-AX-103 Retrieval Scenario Nonradiological Constituent Leakage Estimate (page 1 of 2)

Release Volume (L)	30,283	30,283	30,283	151,413	151,413	151,413
Analyte (kg)	Case I	Case II	Case III	Case I	Case II	Case III
Ag	3.17E+00	3.05E+00	3.03E+00	1.58E+01	1.52E+01	1.51E+01
Al	4.18E+02	5.20E+02	5.37E+02	2.09E+03	2.60E+03	2.69E+03
As	NR	NR	NR	NR	NR	NR
B	3.46E-01	3.33E-01	3.30E-01	1.73E+00	1.66E+00	1.65E+00
Ba	1.03E+01	1.50E+01	1.58E+01	5.15E+01	7.50E+01	7.90E+01
Bi	1.15E+01	1.11E+01	1.10E+01	5.76E+01	5.54E+01	5.50E+01
Ca	3.19E+01	7.61E+01	8.35E+01	1.59E+02	3.80E+02	4.17E+02
Cd	1.37E+00	4.30E+00	4.79E+00	6.86E+00	2.15E+01	2.40E+01
Cl	8.82E+01	8.59E+01	8.55E+01	4.41E+02	4.29E+02	4.27E+02
TIC as CO_3	4.12E+02	3.96E+02	3.93E+02	2.06E+03	1.98E+03	1.97E+03
Cr	8.13E+01	8.38E+01	8.42E+01	4.07E+02	4.19E+02	4.21E+02
Cu	8.95E-01	8.60E-01	8.54E-01	4.47E+00	4.30E+00	4.27E+00
F	5.26E+00	5.06E+00	5.02E+00	2.63E+01	2.53E+01	2.51E+01
Fe	1.63E+02	6.81E+02	7.67E+02	8.13E+02	3.40E+03	3.84E+03
Hg	2.07E-02	1.99E-02	1.98E-02	1.03E-01	9.95E-02	9.88E-02
K	5.20E+01	5.00E+01	4.97E+01	2.60E+02	2.50E+02	2.48E+02
La	1.96E+00	1.88E+00	1.87E+00	9.78E+00	9.40E+00	9.34E+00
Mg	2.07E+01	2.72E+01	2.83E+01	1.03E+02	1.36E+02	1.42E+02
Mn	2.74E+01	3.77E+01	3.94E+01	1.37E+02	1.88E+02	1.97E+02
Na	3.48E+03	3.48E+03	3.48E+03	1.74E+04	1.74E+04	1.74E+04
Ni	5.34E+00	3.21E+01	3.66E+01	2.67E+01	1.61E+02	1.83E+02
NO_2	1.58E+03	1.53E+03	1.52E+03	7.90E+03	7.63E+03	7.58E+03
NO_3	2.35E+03	2.26E+03	2.25E+03	1.18E+04	1.13E+04	1.12E+04
OH	NR	4.69E+02	5.48E+02	NR	2.35E+03	2.74E+03
Pb	1.58E+01	1.52E+01	1.51E+01	7.89E+01	7.58E+01	7.53E+01
P as PO_4	1.63E+02	1.75E+02	1.77E+02	8.14E+02	8.74E+02	8.84E+02
P	7.03E+01	7.36E+01	7.42E+01	3.52E+02	3.68E+02	3.71E+02
Se	NR	NR	NR	NR	NR	NR
Si as SiO_3	5.47E+02	8.60E+02	9.13E+02	2.74E+03	4.30E+03	4.56E+03
S as SO_4	8.51E+01	1.05E+02	1.08E+02	4.25E+02	5.23E+02	5.40E+02
S	NR	7.65E+00	8.93E+00	NR	3.83E+01	4.47E+01
Sr	7.26E-01	6.98E-01	6.94E-01	3.63E+00	3.49E+00	3.47E+00
TOC	1.81E+02	1.74E+02	1.73E+02	9.06E+02	8.71E+02	8.65E+02
Total U	1.86E+02	1.79E+02	1.78E+02	9.31E+02	8.97E+02	8.92E+02
Zn	1.51E+00	1.45E+00	1.44E+00	7.54E+00	7.24E+00	7.20E+00

Table 13. Tank 241-AX-103 Retrieval Scenario Nonradiological Constituent Leakage Estimate (page 2 of 2)

Release Volume (L)	30,283	30,283	30,283	151,413	151,413	151,413
Analyte (kg)	Case I	Case II	Case III	Case I	Case II	Case III
Zr	1.56E+01	1.50E+01	1.49E+01	7.82E+01	7.52E+01	7.47E+01
EDTA	9.77E+01	9.39E+01	9.32E+01	4.88E+02	4.69E+02	4.66E+02
NH_3	1.05E+01	1.70E+01	1.81E+01	5.27E+01	8.50E+01	9.04E+01
Cr^{+6}	NR	NR	NR	NR	NR	NR
CN	NR	NR	NR	NR	NR	NR
H_2O	7.11E+03	8.14E+03	8.31E+03	3.56E+04	4.07E+04	4.16E+04
Retrieval water	1.76E+04	1.63E+04	1.61E+04	8.79E+04	8.15E+04	8.05E+04
Total (kg)	3.47E+04	3.58E+04	3.59E+04	1.73E+05	1.79E+05	1.80E+05

Table 14. Tank 241-AX-103 Retrieval Scenario Radiological Constituent Leakage Estimate (page 1 of 2)

Release Volume (L)	30,283	30,283	30,283	151,413	151,413	151,413
Analyte (Ci)	Case I	Case II	Case III	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99
^{3}H	2.56E+00	2.66E+00	2.67E+00	1.28E+01	1.33E+01	1.34E+01
^{14}C	3.53E-02	3.39E-02	3.37E-02	1.76E-01	1.70E-01	1.68E-01
^{59}Ni	2.06E-02	1.96E-01	2.26E-01	1.03E-01	9.82E-01	1.13E+00
^{60}Co	1.44E+00	1.19E+01	1.36E+01	7.19E+00	5.94E+01	6.82E+01
^{63}Ni	2.03E+00	1.97E+01	2.26E+01	1.01E+01	9.84E+01	1.13E+02
^{79}Se	3.97E-02	2.05E-01	2.33E-01	1.99E-01	1.03E+00	1.16E+00
^{90}Sr	4.47E+03	9.54E+04	1.11E+05	2.24E+04	4.77E+05	5.53E+05
^{90}Y	4.47E+03	9.54E+04	1.11E+05	2.24E+04	4.77E+05	5.53E+05
^{93}mNb	1.41E-01	7.12E-01	8.07E-01	7.03E-01	3.56E+00	4.04E+00
^{93}Zr	1.96E-01	9.54E-01	1.08E+00	9.79E-01	4.77E+00	5.41E+00
^{99}Tc	2.06E+00	1.98E+00	1.97E+00	1.03E+01	9.91E+00	9.84E+00
^{106}Ru	9.17E-05	6.59E-04	7.54E-04	4.59E-04	3.30E-03	3.77E-03
^{113}mCd	1.07E+00	4.31E+00	4.85E+00	5.34E+00	2.15E+01	2.42E+01
^{125}Sb		4.18E+00	4.88E+00		2.09E+01	2.44E+01
^{126}Sn	6.01E-02	3.18E-01	3.62E-01	3.00E-01	1.59E+00	1.81E+00
^{129}I	5.51E-04	5.29E-04	5.26E-04	2.75E-03	2.65E-03	2.63E-03
^{134}Cs	4.18E-02	5.19E-02	5.36E-02	2.09E-01	2.59E-01	2.68E-01
^{135}Cs	NR	NR	NR	NR	NR	NR
^{137}Cs	2.36E+03	4.16E+03	4.46E+03	1.18E+04	2.08E+04	2.23E+04
^{137}mBa	2.24E+03	3.94E+03	4.22E+03	1.12E+04	1.97E+04	2.11E+04
^{151}Sm	1.40E+02	7.56E+02	8.59E+02	6.99E+02	3.78E+03	4.30E+03
^{152}Eu	5.20E-02	2.40E-01	2.72E-01	2.60E-01	1.20E+00	1.36E+00
^{154}Eu	NR	7.67E+01	8.95E+01	NR	3.83E+02	4.48E+02
^{155}Eu	NR	4.93E+01	5.75E+01	NR	2.46E+02	2.88E+02
^{226}Ra	1.53E-06	1.26E-05	1.44E-05	7.66E-06	6.28E-05	7.20E-05
^{227}Ac	9.49E-06	6.88E-05	7.87E-05	4.74E-05	3.44E-04	3.93E-04
^{228}Ra	4.01E-03	3.85E-03	3.82E-03	2.00E-02	1.92E-02	1.91E-02
^{229}Th	9.31E-05	8.95E-05	8.89E-05	4.66E-04	4.48E-04	4.45E-04
^{231}Pa	4.53E-05	1.78E-04	2.00E-04	2.27E-04	8.91E-04	1.00E-03
^{232}Th	4.32E-04	4.15E-04	4.13E-04	2.16E-03	2.08E-03	2.06E-03
^{232}U	1.20E-02	1.15E-02	1.14E-02	5.99E-02	5.76E-02	5.72E-02
^{233}U	4.60E-02	4.42E-02	4.39E-02	2.30E-01	2.21E-01	2.20E-01
^{234}U	7.59E-03	7.45E-03	7.43E-03	3.79E-02	3.72E-02	3.71E-02
^{235}U	3.01E-04	2.96E-04	2.95E-04	1.51E-03	1.48E-03	1.48E-03
^{236}U	2.45E-04	2.39E-04	2.38E-04	1.22E-03	1.20E-03	1.19E-03

Table 14. Tank 241-AX-103 Retrieval Scenario Radiological Constituent Leakage Estimate (page 2 of 2)

Release Volume (L)	30,283	30,283	30,283	151,413	151,413	151,413
Analyte (Ci)	Case I	Case II	Case III	Case I	Case II	Case III
Decay Date	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99
^{237}Np	1.06E-02	1.07E-02	1.07E-02	5.29E-02	5.35E-02	5.36E-02
^{238}Pu	1.58E-02	1.57E-01	1.80E-01	7.92E-02	7.83E-01	9.01E-01
^{238}U	1.05E-02	1.03E-02	1.02E-02	5.27E-02	5.14E-02	5.12E-02
^{239}Pu	5.20E-01	4.15E+00	4.75E+00	2.60E+00	2.07E+01	2.38E+01
^{240}Pu	8.99E-02	7.85E-01	9.01E-01	4.50E-01	3.92E+00	4.50E+00
$^{239/240}Pu$	2.02E+01	4.27E+01	4.65E+01	1.01E+02	2.14E+02	2.32E+02
^{241}Am	1.24E+01	1.19E+01	1.18E+01	6.19E+01	5.95E+01	5.91E+01
^{241}Pu	1.10E+00	1.11E+01	1.28E+01	5.50E+00	5.56E+01	6.40E+01
^{242}Cm	1.75E-03	6.94E-03	7.80E-03	8.73E-03	3.47E-02	3.90E-02
^{242}mAm	NR	NR	NR	NR	NR	NR
^{242}Pu	6.04E-06	6.40E-05	7.37E-05	3.02E-05	3.20E-04	3.69E-04
^{243}Am	2.61E-05	2.02E-04	2.31E-04	1.31E-04	1.01E-03	1.15E-03
^{243}Cm	1.63E-04	5.61E-04	6.27E-04	8.13E-04	2.80E-03	3.14E-03
^{244}Cm	1.41E-03	1.38E-02	1.58E-02	7.04E-03	6.88E-02	7.92E-02
Total	1.37E+04	2.00E+05	2.31E+05	6.85E+04	9.99E+05	1.15E+06

APPENDIX E

BEST-BASIS INVENTORY, RETRIEVAL INVENTORY, AND LEAKAGE INVENTORY ESTIMATES FOR RETRIEVAL OF WASTE FROM SINGLE-SHELL TANK 241-AX-104

D. W. Hendrickson, P.E.
S. L. Lambert, Ph.D.
SGN Eurisys Services Corporation
Richland, Washington

CONTENTS

The purpose of this study is to provide the best-basis estimate of the chemical and radiological waste inventory after retrieval of waste from the 241-AX Tank Farm. As part of this effort, an evaluation of available information for Tank 241-AX-104 was performed and a best-basis inventory was established for three different retrieval scenarios. The first scenario is based on retrieving at least 90 percent of the waste to a residual volume of 101.94 m^3 (3,600 ft^3) of waste, or the current volume if this volume is less than 101.94 m^3 (3,600 ft^3). The second scenario assumes 99 percent retrieval of waste from the tank to meet the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990) milestone of 10.19 m^3 (360 ft^3) of residual waste, while the third scenario assumes 99.9 percent retrieval to a residual volume of 1.02 m^3 (36 ft^3) of waste. This study, detailed in the following sections, is based on the methodology that was established by the standard inventory task.

1.0 CHEMICAL INFORMATION SOURCES

Chemical and radionuclide inventory estimates are generally derived from one of three sources of information: (1) sample analysis and sample derived inventory estimates, (2) component inventories predicted by the HDW model based on process knowledge and historical tank transfer information, or (3) a tank-specific process estimate based on process flowsheets, reactor fuel data, essential materials records, or comparable sludge layers and sample information from other tanks.

Tank 241-AX-104 was most recently sampled in September 1977 to determine the composition of the residual sludge after the 1977 sluicing campaign. A 10-ml sample of this sludge was delivered to the laboratory and analyzed to determine the chemical and radionuclide composition of the waste. The sample was water washed and digested by potassium hydroxide (KOH) fusion in a zirconium crucible to dissolve the solids. Analyses performed included inductively coupled plasma spectroscopy (ICP) analysis of metals, ion chromatographic (IC) analysis of anions, and mass spectroscopy for analysis of radionuclides. Other laboratory analyses included percent moisture, bulk density and particle density, and size distribution. An aliquot of the wash solution was also analyzed for soluble metals, anions, and radionuclides. This data can be used to compute component inventories by multiplying the concentration of an analyte by the volume and density of the sludge in the tank. Samples obtained prior to 1977 are of limited value because these samples reflect the composition of the waste before the 1977 sluicing campaign.

The waste history of this tank is provided in Anderson (1990). Tank 241-AX-104 was used primarily as a PUREX waste receiver from the third quarter of 1966 until the second quarter of 1969, followed by the receipt and transfer of various supernates from or to other tanks. The remaining supernate was pumped out for cesium recovery during the third quarter of 1976, while most of the sludge (196.2 kL [52 kgal]) was sluiced for strontium recovery during the second and third quarters of 1977. A second sluicing campaign was conducted during the first quarter of 1978 to remove most of the residual sludge from this tank (Rodenhizer 1987). Tank 241-AX-104 was declared an assumed leaker in 1977, with an estimated leakage volume of 30.2 kL (8 kgal). A solids volume reevaluation was made in May 1978 and once again in April 1984, with interim stabilization being completed in December 1982.

2.0 CHEMICAL AND RADIONUCLIDE INVENTORY ESTIMATES

As of January 1993, the average sludge depth in this tank was determined to be 6.98 cm (2.75-inch) (Swaney 1993). This depth is slightly higher than the tank farm surveillance estimate (6.48 cm) (Hanlon 1996). Based on this estimate (6.98 cm), Tank 241-AX-104 contains about 28.7 kL (7.58 kgal) of waste (in the 22.86 m [75 ft] diameter, flat bottom tank). All of this waste apparently consists of sludge. This inventory is about eight percent higher than the tank farm surveillance estimate of 26.5 kL (7 kgal) (Hanlon 1996). For purposes of this analysis, the current inventory will be based on the tank farm surveillance estimate (26.5 kL of sludge), which is equivalent to 934 cubic feet of residual waste.

2.1 SLUDGE LAYER

Table 1 provides a summary of the washed sludge analyses from the 1977 sludge sample and best-basis tank inventory estimates based on the volume and density of the sludge (26.5 kL [7 kgal] and 1.8 kg/L, respectively), together with the wash solution components. Wash solution results from the 1977 sample are shown in this table and are referenced to the mass of the washed sludge (4.8 ml of solids washed with 15.7 ml of H_2O). Because this sample is the only one obtained after the 1977 sluicing campaign, this sample will be used to estimate the current waste composition in the tank.

Table 2 provides a summary of the mean sludge radionuclide concentrations and tank inventory estimates based on the 1977 grab sample from this tank. Wash solution results are presented as well referenced to the mass of washed sludge. Original analytical values are referenced in Starr (1977).

2.2 BEST-BASIS INVENTORY BEFORE RETRIEVAL

Based on this analysis, a best-basis inventory was developed. The 1977 grab sample was used to generate estimates for the chemical and radionuclide components in this waste. This waste mostly consists of PUREX high-level waste from Al-clad fuel.

Best-basis radionuclide values were derived for 46 key radionuclides (Kupfer et al. 1997). Often, waste sample analyses have only reported ^{90}Sr, ^{137}Cs, $^{239/240}$Pu, and total uranium (or total beta and total alpha), while other key radionuclides, such as ^{60}Co, ^{99}Tc, ^{129}I, ^{154}Eu, ^{155}Eu, and ^{241}Am, etc., have been infrequently reported. For this reason it was necessary to derive most of the 46 key radionuclides by computer models. These models estimate radionuclide activity in batches of reactor fuel, account for the split of radionuclides to various separations plant waste streams, and track their movement with tank waste transactions. (Kupfer et al. 1997 and Watrous and Wootan 1997.) Model generated values for radionuclides in any of the 177 tanks are reported in the HDW Rev. 4 model results (Agnew et al. 1997a). (No attempt has been made to ratio or normalize model results for all 46 radionuclides when values for measured radionuclides disagree with the model.) (For a discussion of typical error between model-derived values and sample-derived values [Kupfer et al. 1997]). The best-basis inventory for Tank 241-AX-104 is presented in Tables 3 and 4.

3.0 CHEMICAL/RADIONUCLIDE INVENTORY ESTIMATES AFTER RETRIEVAL

As part of this study, a best basis inventory was established for three different retrieval scenarios. The first scenario is based on retrieving waste to minimum of either the existing waste volume or a residual waste volume of 101.94 m^3 (3600 ft^3). The second scenario assumes retrieval to a residual waste volume of 10.2 m^3 (360 ft^3) which corresponds to the assumed 99 percent retrieval of waste to meet the Tri-Party Agreement (Ecology et al. 1990). The third scenario assumes retrieval to a residual waste volume of 1.02 m^3 (36 ft^3). The first and third scenarios represent the retrieval of all tank wastes to 90 percent and 99.9 percent respectively.

Table 5 contains a summary matrix of resultant saltcake and sludge volumes, and their fractional removal, following retrieval according to the three scenarios of 90 percent, 99 percent, and 99.9 percent retrieval.

Following retrieval according to the three scenarios presented in Table 5, the residual tank waste inventory was evaluated and is presented in Tables 6 and 7 for chemical and radiological constituents, respectively.

4.0 BEST-BASIS LEAKAGE INVENTORY ESTIMATES FOR RETRIEVAL OF SINGLE-SHELL TANK 241-AX-104

Retrieval scenarios described in Section 3.0 provide residual inventories following fractional removal of any saltcake and sludges contained within Tank 241-AX-101. This section assumes two different leakage conditions for each retrieval scenario. The first leakage condition assumes up to 30.2 m^3 (8 kgal) of potential leakage, while the second leakage condition is based on an upper bounding estimate of 151.4 m^3 (40 kgal) of potential leakage. In each case, solution concentrations and inventories will be based on the limiting conditions for waste retrieval, either a maximum supernate concentration of five gram moles per liter sodium or a maximum value of 10 weight percent solids in the slurry, or the total volume of the retrieval solution. These limits were established to minimize the possible crystallization of sodium rich salts in the slurry transfer lines and slurry pumping problems for the slurry pumps and sluicers. The following estimates are based on the methodology that was established by the standard inventory task.

The solution concentrations resulting from dissolution and slurry, with water, of the tank waste according to the three retrieval scenarios are provided in Tables 8 and 9 for nonradiological and radiological constituents, respectively. Table 8 also displays the limiting volume assessment required for application of sodium loading or solids loading limits and the minimum retrieval water required to meet the limiting volume assessment based upon product-specific gravities of either 1.17 or 1.18 for sodium limited or solids limited solutions.

Tables 10 and 11 contain the nonradiological and radiological, resultant leakage inventory estimates based upon 30.2 m^3 (8 kgal) and 151.4 m^3 (40 kgal) releases during retrieval.

5.0 TANK LEAKAGE

Tank 241-AX-104 was declared an assumed leaker in 1977 with an estimated leakage volume of 30.2 kL (8 kgal). An occurrence report was filed April 9, 1975 detailing the observed radiation increase in dry well 11-04-11, located about 3.05 m (10 ft) northwest of Tank 241-AX-104. Apparently, a two-fold increase in radiation count was found at the 12.19 m (40 ft) level shortly after the well was drilled in January 1975. Based on auger testing of the soil, the soil around the vapor exhaust header was found to be highly contaminated, with readings as high as 3 RAD at contact. If this is the leakage source of interest, most of the leakage must have been caused by tank condensates that collected in the exhaust header system. Since the composition of this condensate is not known, we have no basis at the present time for estimating the chemical and radionuclide source terms for condensate leakage. Upper bounding estimates, however, could be developed from the supernate composition data for this tank to evaluate potential leakage effects from this tank.

If leakage occurred at the tank boundary, we should be able to generate reasonable source term estimates from the supernate composition. Based on the dry well response characteristics, it appears that most of the leakage may have occurred during between 1973 and 1974. This tank was initially used as a PUREX waste receiver from the third quarter of 1966 until the second quarter of 1969, followed by the transfer or receipt of various supernates to or from other tanks. Since the only available sample data is from solids rather than liquid samples, other sources of information will be needed to estimate the supernate composition in the tank during the leakage episode. From the fourth quarter of 1972 to the first quarter of 1976, Tank 241-AX-104 received several supernate transfers, including 4,845 kL (1,280 kgal) of AR vault supernate from Tank 241-A-104, 552 kL (146 kgal) of dilution water, and 227 kL (60 kgal) of AR vault and B Plant low-level (BL) supernates from Tank 241-AX-103. These supernate transactions are summarized in Table 12.

During the fourth quarter of 1972, the volume of waste in Tank 241-AX-104 was reduced to as little as 416 kL (110 kgal), including 178 kL (47 kgal) of sludge and 238 kL (63 kgal) of supernate (Agnew et al., 1996). Large volumes (393 kgal) of water were added to this tank in 1970 and most of the supernate (1,270 kgal) was removed during the fourth quarter of 1972. The remaining supernate (63 kgal) is assumed to be in equilibrium with the dominant wastes in this tank. According to the HDW model, the dominant waste consisted of PUREX high-level (P2) waste that composed about 94 percent of the total sludge volume in this tank. The supernate composition in equilibrium with this waste can be estimated from the 1977 sludge washing results based on the PUREX wastes that were left in this tank after the 1977 sluicing campaign. These results are summarized in Table 9.

From the fourth quarter of 1972 to the second quarter of 1974, it appears that 93 percent of the supernate in this tank was directly or indirectly derived from AR vault supernates transferred from Tank 241-A-104. The composition of this supernate was measured in 1974, the results of which are summarized in Table 10. Also included is the estimated composition of the combined supernate from the fourth quarter of 1972 to the second quarter of 1974, together with the estimated chemical and radiological source terms for any leakage that may have occurred during this period.

From the third quarter of 1974 to the first quarter of 1976, the supernate sources included 1,688 kL (446 kgal) of AR vault supernate from Tank 241-A-104, 227 kL (60 kgal) of AR vault and B Plant low-level (BL) supernate from Tank 241-AX-103, 204 kL (54 kgal) of residual supernate from the 1972-74 period, and 552 kL (146 kgal) of dilution water. Thus, about 74 percent of the supernate was directly of indirectly derived from AR vault supernates transferred from Tanks 241-A-104 and 241-AX-103. Table 11 provides a summary of the estimated supernate composition in Tank 241-AX-104 and leakage source terms from the third quarter of 1974 to the first quarter of 1976.

6.0 REFERENCES

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Table 1. Analytical Results and Sludge Inventory Estimates for Nonradioactive Components in Tank 241-AX-104

Component	1977 Sludge Concentration (M)[a]	1977 Wash Solution Concentration (M)[b]	Total Tank Inventory (kg)
Density	1.80 g/mL		
Al	2.465	0.013	1,778
Ba	0.021	NR	76.7
Ca	0.642	NR	684
Cd	0.015	NR	44.8
Cr	0.061	NR	84.4
Fe	5.31	NR	7,887
Mg	0.171	NR	111
Mn	0.0845	NR	123
Na	2.99	0.337	2,034
Ni	0.26	NR	406
NO_2	NR	0.083	102
NO_3	1.14	0.09	<2,028
OH	NR	15.6	7,056
P as PO_4	0.11	NR	278
P	0.11	NR	90.6
Si as SiO_3	2.485	NR	5,028
S as SO_4	0.125	0.01	345
S	0.125	0.01	115
U	1.79E-05	NR	0.11
H_2O	40.97	NR	19,628
Pu	0.213	NR	1,354
Volume (kL)	26.6		

[a] Average of two KOH fusion determinations from September 1977 grab sample (Starr 1977).
[b] Wash solution composition based on mass of washed sludge (1.8 g/mL).
[c] Tank inventory based on 26.6 kL of sludge with an average density of 1.80 kg/L.

Table 2. Analytical Results and Sludge Inventory Estimates for Nonradioactive Components in Tank 241-AX-104

Component	1977 Sludge Concentration (Ci/L)[a]	1977 Wash Solution Concentration (Ci/L)[b]	Total Tank Inventory (Ci)[c]
Decay	12/31/99	12/31/99	12/31/99
^{60}Co	0.0059	NR	157
^{90}Sr	51.5	0.0133	1.36E+06
^{90}Y	51.5	0.0133	1.36E+06
^{125}Sb	0.0024	NR	63
^{137}Cs	1.063	0.0086	28,266
^{137}mBa	1.006	0.0081	26,611
^{154}Eu	0.0434	NR	1148
^{155}Eu	0.0279	NR	738
$^{239/240}$Pu	0.0132	NR	349

[a] Average of two KOH fusion determinations from September 1977 grab sample (Starr 1977).

[b] Wash solution composition based on mass of washed sludge (1.8 g/mL).

[c] Tank inventory based on 26.6 kL of sludge with an average density of 1.80 kg/L.

Table 3. Best-Basis Nonradiological Inventory Before Retrieval of Waste From Single-Shell Tank 241-AX-104 (page 1 of 2)

	Sludge	Saltcake	Overall
Density (kg/m^3)	1,800.0	0.0	1,800.0
Volume (m^3)	26.5	0.0	26.5
Components (M)			Inventory (kg)
Ag	NR	NA	NR
Al	2.49E+00	NA	1,780.0
As	NR	NA	NR
B	NR	NA	NR
Ba	2.10E-02	NA	76.3
Bi	NR	NA	NR
Ca	6.45E-01	NA	684.0
Cd	1.50E-02	NA	44.6
Cl	1.16E-01	NA	109.0
TIC as CO_3	2.43E-01	NA	386.0
Cr	6.10E-02	NA	83.9
Cu	NR	NA	NR
F	NR	NA	NR
Fe	5.34E+00	NA	7,890.0
Hg	NR	NA	NR
K	3.40E+00	NA	3,516.0
La	NR	NA	NR
Mg	1.71E-01	NA	110.0
Mn	8.45E-02	NA	122.8
Na	4.03E+00	NA	2,450.0
Ni	2.60E-01	NA	403.8
NO_2	8.38E-02	NA	102.0
NO_3	1.24E+00	NA	2,030.0
OH	2.58E+01	NA	11,600.0
Pb	1.99E-02	NA	109.0
P as PO_4	1.11E-01	NA	278.0
P	1.10E-01	NA	90.2
Se	NR	NA	NR
Si as SiO_3	2.50E+00	NA	5,038.7
S as SO_4	1.35E-01	NA	343.1
S	1.35E-01	NA	114.5
Sr	1.25E-02	NA	29.0
TOC	NR	NA	NR
Total U	1.79E-05	NA	0.11

Table 3. Best-Basis Nonradiological Inventory Before Retrieval of Waste From Single-Shell Tank 241-AX-104 (page 2 of 2)

	Sludge	Saltcake	Overall
Density (kg/m^3)	1,800.0	0.0	1,800.0
Volume (m^3)	26.5	0.0	26.5
Components (M)			Inventory (kg)
Zn	NR	NA	NR
Zr	NR	NA	NR
EDTA	NR	NA	NR
NH_3	NR	NA	NR
Cr^{+6}	NR	NA	NR
CN	NR	NA	NR
H_2O	4.10E+01	NA	19,527.1
Pu	2.13E-01	NA	1,347.0

Table 4. Best-Basis Radiological Inventory Before Retrieval of Waste From Single-Shell Tank 241-AX-104 (page 1 of 2)

Components (Ci/L)	Sludge	Saltcake	Overall (Ci)
Decay	12/31/99	12/31/99	12/31/99
^{3}H	1.28E-04	NA	3.38E+00
^{14}C	2.38E-05	NA	6.30E-01
^{59}Ni	1.18E-04	NA	3.12E+00
^{60}Co	5.94E-03	NA	1.57E+02
^{63}Ni	1.18E-02	NA	3.13E+02
^{79}Se	1.11E-04	NA	2.95E+00
^{90}Sr	5.15E+01	NA	1.36E+06
^{90}Y	5.15E+01	NA	1.36E+06
^{93}mNb	3.85E-04	NA	1.02E+01
^{93}Zr	5.14E-04	NA	1.36E+01
^{99}Tc	1.69E-04	NA	4.47E+00
^{106}Ru	3.82E-07	NA	1.01E-02
^{113}mCd	2.20E-03	NA	5.82E+01
^{125}Sb	2.37E-03	NA	6.26E+01
^{126}Sn	1.74E-04	NA	4.61E+00
^{129}I	3.27E-07	NA	8.64E-03
^{134}Cs	7.82E-06	NA	2.07E-01
^{135}Cs	NR	NA	NR
^{137}Cs	1.07E+00	NA	2.83E+04
^{137}mBa	1.01E+00	NA	2.66E+04
^{151}Sm	4.16E-01	NA	1.10E+04
^{152}Eu	1.27E-04	NA	3.36E+00
^{154}Eu	4.34E-02	NA	1.15E+03
^{155}Eu	2.79E-02	NA	7.38E+02
^{226}Ra	7.41E-09	NA	1.96E-04
^{227}Ac	4.01E-08	NA	1.06E-03
^{228}Ra	6.69E-14	NA	1.77E-09
^{229}Th	1.05E-11	NA	2.77E-07
^{231}Pa	8.99E-08	NA	2.38E-03
^{232}Th	6.05E-15	NA	1.60E-10
^{232}U	8.39E-12	NA	2.22E-07
^{233}U	1.98E-13	NA	5.24E-09
^{234}U	1.04E-07	NA	2.74E-03
^{235}U	4.31E-09	NA	1.14E-04

Table 4. Best-Basis Radiological Inventory Before Retrieval of Waste From Single-Shell Tank 241-AX-104 (page 2 of 2)

Components (Ci/L)	Sludge	Saltcake	Overall (Ci)
Decay	12/31/99	12/31/99	12/31/99
^{236}U	2.82E-09	NA	7.47E-05
^{237}Np	3.61E-07	NA	9.54E-03
^{238}Pu	9.45E-05	NA	2.50E+00
^{238}U	1.01E-07	NA	2.67E-03
^{239}Pu	2.45E-03	NA	6.47E+01
^{240}Pu	4.65E-04	NA	1.23E+01
$^{239/240}Pu$	1.32E-02	NA	3.49E+02
^{241}Am	3.85E-03	NA	1.02E+02
^{241}Pu	6.73E-03	NA	1.78E+02
^{242}Cm	3.51E-06	NA	9.29E-02
^{242}mAm	NR	NA	NR
^{242}Pu	3.89E-08	NA	1.03E-03
^{243}Am	1.18E-07	NA	3.12E-03
^{243}Cm	2.70E-07	NA	7.14E-03
^{244}Cm	8.28E-06	NA	2.19E-01
Total			2.79E+06

Table 5. Retrieval Scenario Summary of Residual Waste and Fractional Removal

	Case I	Case II	Case III
Vol Base (m^3)	101.94	10.19	1.02
% Base	90.0%	99.0%	99.9%
Target (m^3)	26.46	10.19	1.02
Sludge (m^3)	26.46	10.19	1.02
Saltcake (m^3)	0.00	0.00	0.00
Sludge Removal	0.0%	61.5%	96.1%
Saltcake Removal	NA	NA	NA
NA = Not Applicable. No saltcake identified in tank.			

Table 6. Tank 241-AX-104 Nonradiological Waste Residual Inventory Following Retrieval (page 1 of 2)

Residual Waste (kg)	Case I	Case II	Case III
Target (m^3)	26.46	10.19	1.02
Sludge (m^3)	26.46	10.19	1.02
Saltcake (m^3)	0.00	0.00	0.00
Ag	NR	NR	NR
Al	1.78E+03	6.86E+02	6.86E+01
As	NR	NR	NR
B	NR	NR	NR
Ba	7.63E+01	2.94E+01	2.94E+00
Bi	NR	NR	NR
Ca	6.84E+02	2.64E+02	2.64E+01
Cd	4.46E+01	1.72E+01	1.72E+00
Cl	1.09E+02	4.20E+01	4.20E+00
TIC as CO_3	3.86E+02	1.49E+02	1.49E+01
Cr	8.39E+01	3.23E+01	3.23E+00
Cu	NR	NR	NR
F	NR	NR	NR
Fe	7.89E+03	3.04E+03	3.04E+02
Hg	NR	NR	NR
K	3.52E+03	1.35E+03	1.35E+02
La	NR	NR	NR
Mg	1.10E+02	4.24E+01	4.24E+00
Mn	1.23E+02	4.73E+01	4.73E+00
Na	2.45E+03	9.44E+02	9.44E+01
Ni	4.04E+02	1.56E+02	1.56E+01
NO_2	1.02E+02	3.93E+01	3.93E+00
NO_3	2.03E+03	7.82E+02	7.82E+01
OH	1.16E+04	4.47E+03	4.47E+02
Pb	1.09E+02	4.20E+01	4.20E+00
P as PO_4	2.78E+02	1.07E+02	1.07E+01
P	9.02E+01	3.47E+01	3.47E+00
Se	NR	NR	NR
Si as SiO_3	5.04E+03	1.94E+03	1.94E+02
S as SO_4	3.43E+02	1.32E+02	1.32E+01
S	1.15E+02	4.41E+01	4.41E+00
Sr	2.90E+01	1.12E+01	1.12E+00
TOC	NR	NR	NR
Total U	1.12E-01	4.33E-02	4.33E-03

Table 6. Tank 241-AX-104 Nonradiological Waste Residual Inventory Following Retrieval (page 2 of 2)

Residual Waste (kg)	Case I	Case II	Case III
Target (m^3)	26.46	10.19	1.02
Sludge (m^3)	26.46	10.19	1.02
Saltcake (m^3)	0.00	0.00	0.00
Zn	NR	NR	NR
Zr	NR	NR	NR
EDTA	NR	NR	NR
NH_3	NR	NR	NR
Cr^{+6}	NR	NR	NR
CN	NR	NR	NR
H_2O	1.95E+04	7.52E+03	7.52E+02
Pu	1.35E+03	5.19E+02	5.19E+01

Table 7. Tank 241-AX-104 Radiological Waste Residual Inventory Following Retrieval (page 1 of 2)

Residual Waste (Ci)	Case I	Case II	Case III
Decay	12/31/99	12/31/99	12/31/99
^{3}H	3.38E+00	1.30E+00	1.30E-01
^{14}C	6.30E-01	2.43E-01	2.43E-02
^{59}Ni	3.12E+00	1.20E+00	1.20E-01
^{60}Co	1.57E+02	6.06E+01	6.06E+00
^{63}Ni	3.13E+02	1.21E+02	1.21E+01
^{79}Se	2.95E+00	1.14E+00	1.14E-01
^{90}Sr	1.36E+06	5.25E+05	5.25E+04
^{90}Y	1.36E+06	5.25E+05	5.25E+04
^{93}mNb	1.02E+01	3.93E+00	3.93E-01
^{93}Zr	1.36E+01	5.24E+00	5.24E-01
^{99}Tc	4.47E+00	1.72E+00	1.72E-01
^{106}Ru	1.01E-02	3.89E-03	3.89E-04
^{113}mCd	5.82E+01	2.24E+01	2.24E+00
^{125}Sb	6.26E+01	2.41E+01	2.41E+00
^{126}Sn	4.61E+00	1.78E+00	1.78E-01
^{129}I	8.64E-03	3.33E-03	3.33E-04
^{134}Cs	2.07E-01	7.98E-02	7.98E-03
^{135}Cs	NR	NR	NR
^{137}Cs	2.83E+04	1.09E+04	1.09E+03
^{137}mBa	2.66E+04	1.03E+04	1.03E+03
^{151}Sm	1.10E+04	4.24E+03	4.24E+02
^{152}Eu	3.36E+00	1.29E+00	1.29E-01
^{154}Eu	1.15E+03	4.42E+02	4.42E+01
^{155}Eu	7.38E+02	2.84E+02	2.84E+01
^{226}Ra	1.96E-04	7.55E-05	7.55E-06
^{227}Ac	1.06E-03	4.08E-04	4.08E-05
^{228}Ra	1.77E-09	6.82E-10	6.82E-11
^{229}Th	2.77E-07	1.07E-07	1.07E-08
^{231}Pa	2.38E-03	9.17E-04	9.17E-05
^{232}Th	1.60E-10	6.16E-11	6.16E-12
^{232}U	2.22E-07	8.55E-08	8.55E-09
^{233}U	5.24E-09	2.02E-09	2.02E-10
^{234}U	2.74E-03	1.06E-03	1.06E-04
^{235}U	1.14E-04	4.39E-05	4.39E-06
^{236}U	7.47E-05	2.88E-05	2.88E-06
^{237}Np	9.54E-03	3.68E-03	3.68E-04

Table 7. Tank 241-AX-104 Radiological Waste Residual Inventory Following Retrieval (page 2 of 2)

Residual Waste (Ci)	Case I	Case II	Case III
Decay	12/31/99	12/31/99	12/31/99
^{238}Pu	2.50E+00	9.63E-01	9.63E-02
^{238}U	2.67E-03	1.03E-03	1.03E-04
^{239}Pu	6.47E+01	2.49E+01	2.49E+00
^{240}Pu	1.23E+01	4.74E+00	4.74E-01
$^{239/240}$Pu	3.49E+02	1.34E+02	1.34E+01
^{241}Am	1.02E+02	3.93E+01	3.93E+00
^{241}Pu	1.78E+02	6.86E+01	6.86E+00
^{242}Cm	9.29E-02	3.58E-02	3.58E-03
^{242}mAm	NR	NR	NR
^{242}Pu	1.03E-03	3.97E-04	3.97E-05
^{243}Am	3.12E-03	1.20E-03	1.20E-04
^{243}Cm	7.14E-03	2.75E-03	2.75E-04
^{244}Cm	2.19E-01	8.44E-02	8.44E-03
Total	2.79E+06	1.08E+06	1.08E+05

Table 8. Retrieval Scenario Product Solution Nonradiological Analyte Concentrations (page 1 of 2)

Limiting Vol (L)	0	193,725	302,998
Sludge [Solids Basis (L)]	0	193,725	302,998
Saltcake [Na Basis (L)]	0	13,102	20,493
Solution Concentrations (M)	Case I	Case II	Case III
Ag	NA[1]	NR	NR
Al	NA	2.09E-01	2.09E-01
As	NA	NR	NR
B	NA	NR	NR
Ba	NA	1.76E-03	1.76E-03
Bi	NA	NR	NR
Ca	NA	5.42E-02	5.42E-02
Cd	NA	1.26E-03	1.26E-03
Cl	NA	9.76E-03	9.76E-03
TIC as CO_3	NA	2.04E-02	2.04E-02
Cr	NA	5.12E-03	5.12E-03
Cu	NA	NR	NR
F	NA	NR	NR
Fe	NA	4.48E-01	4.48E-01
Hg	NA	NR	NR
K	NA	2.85E-01	2.85E-01
La	NA	NR	NR
Mg	NA	1.44E-02	1.44E-02
Mn	NA	7.09E-03	7.09E-03
Na	NA	3.38E-01	3.38E-01
Ni	NA	2.18E-02	2.18E-02
NO_2	NA	7.04E-03	7.04E-03
NO_3	NA	1.04E-01	1.04E-01
OH	NA	2.16E+00	2.16E+00
Pb	NA	1.67E-03	1.67E-03
P as PO_4	NA	9.29E-03	9.29E-03
P	NA	9.24E-03	9.24E-03
Se	NA	NR	NR
Si as SiO_3	NA	2.10E-01	2.10E-01
S as SO_4	NA	1.13E-02	1.13E-02
S	NA	1.13E-02	1.13E-02
Sr	NA	1.05E-03	1.05E-03

[1] NA = Not Applicable, no retrieval required.

Table 8. Retrieval Scenario Product Solution Nonradiological Analyte Concentrations (page 2 of 2)

Limiting Vol (L)	0	193,725	302,998
Sludge [Solids Basis (L)]	0	193,725	302,998
Saltcake [Na Basis (L)]	0	13,102	20,493
Solution Concentrations (M)	Case I	Case II	Case III
TOC	NA	NR	NR
Total U	NA	1.50E-06	1.50E-06
Zn	NA	NR	NR
Zr	NA	NR	NR
EDTA	NA	NR	NR
NH_3	NA	NR	NR
Cr^{+6}	NA	NR	NR
CN	NA	NR	NR
H_2O	NA	3.44	3.44
Retrieval H_2O	NA	50.85	50.85

Table 9. Retrieval Scenario Product Solution Radiological Analyte Concentrations (page 1 of 2)

Solution Concentrations (Ci/L)	Case I	Case II	Case III
Decay	12/31/99	12/31/99	12/31/99
^{3}H	NA	1.07E-05	1.07E-05
^{14}C	NA	2.00E-06	2.00E-06
^{59}Ni	NA	9.90E-06	9.90E-06
^{60}Co	NA	4.99E-04	4.99E-04
^{63}Ni	NA	9.93E-04	9.93E-04
^{79}Se	NA	9.36E-06	9.36E-06
^{90}Sr	NA	4.32E+00	4.32E+00
^{90}Y	NA	4.32E+00	4.32E+00
^{93}mNb	NA	3.24E-05	3.24E-05
^{93}Zr	NA	4.32E-05	4.32E-05
^{99}Tc	NA	1.42E-05	1.42E-05
^{106}Ru	NA	3.20E-08	3.20E-08
^{113}mCd	NA	1.85E-04	1.85E-04
^{125}Sb	NA	1.99E-04	1.99E-04
^{126}Sn	NA	1.46E-05	1.46E-05
^{129}I	NA	2.74E-08	2.74E-08
^{134}Cs	NA	6.57E-07	6.57E-07
^{135}Cs	NA	NR	NR
^{137}Cs	NA	8.97E-02	8.97E-02
^{137}mBa	NA	8.44E-02	8.44E-02
^{151}Sm	NA	3.49E-02	3.49E-02
^{152}Eu	NA	1.07E-05	1.07E-05
^{154}Eu	NA	3.64E-03	3.64E-03
^{155}Eu	NA	2.34E-03	2.34E-03
^{226}Ra	NA	6.22E-10	6.22E-10
^{227}Ac	NA	3.36E-09	3.36E-09
^{228}Ra	NA	5.62E-15	5.62E-15
^{229}Th	NA	8.79E-13	8.79E-13
^{231}Pa	NA	7.55E-09	7.55E-09
^{232}Th	NA	5.08E-16	5.08E-16
^{232}U	NA	7.04E-13	7.04E-13
^{233}U	NA	1.66E-14	1.66E-14
^{234}U	NA	8.69E-09	8.69E-09
^{235}U	NA	3.62E-10	3.62E-10
^{236}U	NA	2.37E-10	2.37E-10
^{237}Np	NA	3.03E-08	3.03E-08

Table 9. Retrieval Scenario Product Solution Radiological Analyte Concentrations (page 2 of 2)

Solution Concentrations (Ci/L)	Case I	Case II	Case III
Decay	12/31/99	12/31/99	12/31/99
^{238}Pu	NA	7.93E-06	7.93E-06
^{238}U	NA	8.47E-09	8.47E-09
^{239}Pu	NA	2.05E-04	2.05E-04
^{240}Pu	NA	3.90E-05	3.90E-05
$^{239/240}$Pu	NA	1.11E-03	1.11E-03
^{241}Am	NA	3.24E-04	3.24E-04
^{241}Pu	NA	5.65E-04	5.65E-04
^{242}Cm	NA	2.95E-07	2.95E-07
^{242}mAm	NA	NR	NR
^{242}Pu	NA	3.27E-09	3.27E-09
^{243}Am	NA	9.90E-09	9.90E-09
^{243}Cm	NA	2.27E-08	2.27E-08
^{244}Cm	NA	6.95E-07	6.95E-07

Table 10. Tank 241-AX-104 Retrieval Scenario Nonradiological Constituent Leakage Estimate (page 1 of 2)

Release Volume (L)	0	30,283	30,283	0	151,413	151,413
Analyte (kg)	Case I	Case II	Case III	Case I	Case II	Case III
Ag	NA	NR	NR	NA	NR	NR
Al	NA	1.71E+02	1.71E+02	NA	8.55E+02	8.55E+02
As	NA	NR	NR	NA	NR	NR
B	NA	NR	NR	NA	NR	NR
Ba	NA	7.33E+00	7.33E+00	NA	3.67E+01	3.67E+01
Bi	NA	NR	NR	NA	NR	NR
Ca	NA	6.57E+01	6.57E+01	NA	3.29E+02	3.29E+02
Cd	NA	4.29E+00	4.29E+00	NA	2.14E+01	2.14E+01
Cl	NA	1.05E+01	1.05E+01	NA	5.24E+01	5.24E+01
TIC as CO_3	NA	3.71E+01	3.71E+01	NA	1.85E+02	1.85E+02
Cr	NA	8.06E+00	8.06E+00	NA	4.03E+01	4.03E+01
Cu	NA	NR	NR	NA	NR	NR
F	NA	NR	NR	NA	NR	NR
Fe	NA	7.58E+02	7.58E+02	NA	3.79E+03	3.79E+03
Hg	NA	NR	NR	NA	NR	NR
K	NA	3.38E+02	3.38E+02	NA	1.69E+03	1.69E+03
La	NA	NR	NR	NA	NR	NR
Mg	NA	1.06E+01	1.06E+01	NA	5.28E+01	5.28E+01
Mn	NA	1.18E+01	1.18E+01	NA	5.90E+01	5.90E+01
Na	NA	2.35E+02	2.35E+02	NA	1.18E+03	1.18E+03
Ni	NA	3.88E+01	3.88E+01	NA	1.94E+02	1.94E+02
NO_2	NA	9.80E+00	9.80E+00	NA	4.90E+01	4.90E+01
NO_3	NA	1.95E+02	1.95E+02	NA	9.75E+02	9.75E+02
OH	NA	1.11E+03	1.11E+03	NA	5.57E+03	5.57E+03
Pb	NA	1.05E+01	1.05E+01	NA	5.24E+01	5.24E+01
P as PO_4	NA	2.67E+01	2.67E+01	NA	1.34E+02	1.34E+02
P	NA	8.66E+00	8.66E+00	NA	4.33E+01	4.33E+01
Se	NA	NR	NR	NA	NR	NR
Si as SiO_3	NA	4.84E+02	4.84E+02	NA	2.42E+03	2.42E+03
S as SO_4	NA	3.30E+01	3.30E+01	NA	1.65E+02	1.65E+02
S	NA	1.10E+01	1.10E+01	NA	5.50E+01	5.50E+01
Sr	NA	2.79E+00	2.79E+00	NA	1.39E+01	1.39E+01
TOC	NA	NR	NR	NA	NR	NR
Total U	NA	1.08E-02	1.08E-02	NA	5.40E-02	5.40E-02
Zn	NA	NR	NR	NA	NR	NR

Table 10. Tank 241-AX-104 Retrieval Scenario Nonradiological Constituent Leakage Estimate (page 2 of 2)

Release Volume (L)	0	30,283	30,283	0	151,413	151,413
Analyte (kg)	Case I	Case II	Case III	Case I	Case II	Case III
Zr	NA	NR	NR	NA	NR	NR
EDTA	NA	NR	NR	NA	NR	NR
NH_3	NA	NR	NR	NA	NR	NR
Cr^{+6}	NA	NR	NR	NA	NR	NR
CN	NA	NR	NR	NA	NR	NR
H_2O	NA	1.88E+03	1.88E+03	NA	9.38E+03	9.38E+03
Retrieval water	NA	2.77E+04	2.77E+04	NA	1.39E+05	1.39E+05
Total (kg)		3.32E+04	3.32E+04		1.66E+05	1.66E+05

Table 11. Tank 241-AX-104 Retrieval Scenario Radiological Constituent Leakage Estimate (page 1 of 2)

Release Volume (L)	0	30,283	30,283	0	151,413	151,413
Analyte (Ci)	Case I	Case II	Case III	Case I	Case II	Case III
Decay	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99
^{3}H	NA	3.25E-01	3.25E-01	NA	1.62E+00	1.62E+00
^{14}C	NA	6.05E-02	6.05E-02	NA	3.03E-01	3.03E-01
^{59}Ni	NA	3.00E-01	3.00E-01	NA	1.50E+00	1.50E+00
^{60}Co	NA	1.51E+01	1.51E+01	NA	7.55E+01	7.55E+01
^{63}Ni	NA	3.01E+01	3.01E+01	NA	1.50E+02	1.50E+02
^{79}Se	NA	2.83E-01	2.83E-01	NA	1.42E+00	1.42E+00
^{90}Sr	NA	1.31E+05	1.31E+05	NA	6.55E+05	6.55E+05
^{90}Y	NA	1.31E+05	1.31E+05	NA	6.55E+05	6.55E+05
^{93}mNb	NA	9.80E-01	9.80E-01	NA	4.90E+00	4.90E+00
^{93}Zr	NA	1.31E+00	1.31E+00	NA	6.53E+00	6.53E+00
^{99}Tc	NA	4.30E-01	4.30E-01	NA	2.15E+00	2.15E+00
^{106}Ru	NA	9.71E-04	9.71E-04	NA	4.85E-03	4.85E-03
^{113}mCd	NA	5.59E+00	5.59E+00	NA	2.80E+01	2.80E+01
^{125}Sb	NA	6.02E+00	6.02E+00	NA	3.01E+01	3.01E+01
^{126}Sn	NA	4.43E-01	4.43E-01	NA	2.21E+00	2.21E+00
^{129}I	NA	8.30E-04	8.30E-04	NA	4.15E-03	4.15E-03
^{134}Cs	NA	1.99E-02	1.99E-02	NA	9.95E-02	9.95E-02
^{135}Cs	NA	NR	NR	NA	NR	NR
^{137}Cs	NA	2.72E+03	2.72E+03	NA	1.36E+04	1.36E+04
^{137}mBa	NA	2.56E+03	2.56E+03	NA	1.28E+04	1.28E+04
^{151}Sm	NA	1.06E+03	1.06E+03	NA	5.29E+03	5.29E+03
^{152}Eu	NA	3.23E-01	3.23E-01	NA	1.61E+00	1.61E+00
^{154}Eu	NA	1.10E+02	1.10E+02	NA	5.51E+02	5.51E+02
^{155}Eu	NA	7.09E+01	7.09E+01	NA	3.54E+02	3.54E+02
^{226}Ra	NA	1.88E-05	1.88E-05	NA	9.42E-05	9.42E-05
^{227}Ac	NA	1.02E-04	1.02E-04	NA	5.09E-04	5.09E-04
^{228}Ra	NA	1.70E-10	1.70E-10	NA	8.50E-10	8.50E-10
^{229}Th	NA	2.66E-08	2.66E-08	NA	1.33E-07	1.33E-07
^{231}Pa	NA	2.29E-04	2.29E-04	NA	1.14E-03	1.14E-03
^{232}Th	NA	1.54E-11	1.54E-11	NA	7.69E-11	7.69E-11
^{232}U	NA	2.13E-08	2.13E-08	NA	1.07E-07	1.07E-07
^{233}U	NA	5.04E-10	5.04E-10	NA	2.52E-09	2.52E-09
^{234}U	NA	2.63E-04	2.63E-04	NA	1.32E-03	1.32E-03
^{235}U	NA	1.10E-05	1.10E-05	NA	5.48E-05	5.48E-05

Table 11. Tank 241-AX-104 Retrieval Scenario Radiological Constituent Leakage Estimate (page 2 of 2)

Release Volume (L)	0	30,283	30,283	0	151,413	151,413
Analyte (Ci)	Case I	Case II	Case III	Case I	Case II	Case III
Decay	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99
^{236}U	NA	7.18E-06	7.18E-06	NA	3.59E-05	3.59E-05
^{237}Np	NA	9.17E-04	9.17E-04	NA	4.58E-03	4.58E-03
^{238}Pu	NA	2.40E-01	2.40E-01	NA	1.20E+00	1.20E+00
^{238}U	NA	2.57E-04	2.57E-04	NA	1.28E-03	1.28E-03
^{239}Pu	NA	6.22E+00	6.22E+00	NA	3.11E+01	3.11E+01
^{240}Pu	NA	1.18E+00	1.18E+00	NA	5.91E+00	5.91E+00
$^{239/240}Pu$	NA	3.35E+01	3.35E+01	NA	1.67E+02	1.67E+02
^{241}Am	NA	9.80E+00	9.80E+00	NA	4.90E+01	4.90E+01
^{241}Pu	NA	1.71E+01	1.71E+01	NA	8.55E+01	8.55E+01
^{242}Cm	NA	8.93E-03	8.93E-03	NA	4.46E-02	4.46E-02
^{242}mAm	NA	NR	NR	NA	NR	NR
^{242}Pu	NA	9.90E-05	9.90E-05	NA	4.95E-04	4.95E-04
^{243}Am	NA	3.00E-04	3.00E-04	NA	1.50E-03	1.50E-03
^{243}Cm	NA	6.86E-04	6.86E-04	NA	3.43E-03	3.43E-03
^{244}Cm	NA	2.10E-02	2.10E-02	NA	1.05E-01	1.05E-01
Total		2.68E+05	2.68E+05		1.34E+06	1.34E+06

Table 12. Supernate Transfers to Tank 241-AX-104

Date	Transfer Volume, kL (kgal)	Total Volume in Tank 241-AX-104, kL (kgal)	Waste Type	Source
4th Quarter 1972	2,146 (567)	2,525 (667)	AR Supernate	241-A-104
1st Quarter 1973	1,010 (267)	3,123 (825)	AR Supernate	241-A-104
3rd Quarter 1974	553 (146)	973 (257)	Water	Water
3rd Quarter 1974	1,688 (446)	2,660 (703)	AR Supernate	241-A-104
3rd Quarter 1974	227 (60)	2,888 (763)	AR/BL Supernate	241-AX-103

Table 13. Estimated Supernate Composition in Equilibrium with Solids in Tank 241-AX-104 during the Fourth Quarter of 1972

Component/Radionuclide	1977 Wash Solution Concentration[a], ug/g (uCi/g)	Tank Supernate Composition, ug/ml (uCi/ml)
Al	195	262
NO_3	3,100	4,163
NO_2	2,120	2,847
Na	4,310	5,788
SO_4	530	712
^{90}Sr	4.38[b] uCi/g	5.89 uCi/ml
^{137}Cs	2.61[b] uCi/g	3.50 uCi/ml

[a] Wash solution composition based on mass of washed solids (Starr 1977)

[b] Decayed to December 31, 1999

[c] Based on 178 kL (47 kgal) of sludge, with an average density of 1.8 kg/L and 238 kL (63 kgal) of supernate in equilibrium with this sludge

Table 14. Composition of Tank 241-A-104 Supernate, Composition of Combined Supernates in Tank 241-AX-104 and Leakage Source Terms from the Fourth Quarter of 1972 to the Second Quarter of 1974

Component/ Radionuclide	Tank 241-A-104 Supernate Composition[a], ug/ml (uCi/ml)	Estimated Composition of Tank 241-AX-104 Supernate[b], ug/ml (uCi/ml)	Leakage Source Terms for Tank 241-AX-104[c], kg (Ci)
Al	163	170	5.1 kg
OH	8,160	7,589	229.2 kg
NO_3	NR	82,275[d]	2,491 kg
NO_2	NR	40,665[d]	1,231 kg
Na	65,320	61,150	1,846.7 kg
^{90}Sr	NR	0.41 uCi/ml	12.4 Ci
^{134}Cs	0.26 uCi/ml	0.24 uCi/ml	7.3 Ci
^{137}Cs	195 uCi/ml	181 uCi/ml	5,466 Ci

a Based on letter from R.L. Walser to R.E. Wheeler, 1974, Analysis of Tank Farm Sample T-2893: Tank 104-A, WHC-SD-WM-ER-308, radionuclides decayed to December 31, 1999.

b Based on 93 volume percent supernate from Tank 241-A-104 and 7 volume percent supernate in equilibrium with Tank 241-AX-104 solids (Table 6).

c Based on 30.2 kL (8 kgal) of supernate that might have leaked during this period.

d NO_3 and NO_2 based on 60%/40% split found in Tank 241-AX-104 supernate normalized to the moles of free Na in the combined supernate.

Table 15. Supernate Composition in Tank 241-AX-104 and Leakage Source Terms from the Third Quarter of 1974 to the First Quarter of 1976

Component/ Radionuclide	Estimated Composition of Tank 241-AX-104 Supernate[a], ug/ml (uCi/ml)	Leakage Source Terms for Tank 241-AX-104[b], kg (Ci)
Al	123	3.7 kg
OH	6,074	183.9 kg
NO_3	65,415[c]	1990 kg
NO_2	32,347[c]	979 kg
Na	48,656	1,473 kg
^{90}Sr	0.03 uCi/ml	0.91 Ci
^{134}Cs	0.19 uCi/ml	5.9 Ci
^{137}Cs	145 uCi/ml	4,395 Ci

[a] Based on 67 volume percent supernate from Tank 241-A-104 (Table 7), 25 volume percent water and 8 percent residual supernate from Tank 241-AX-104 (Table 7).

[b] Based on 30.2 kL (8 kgal) of supernate that might have leaked during this period.

[c] NO_3 and NO_2 based on 60%/40% split found in Tank 241-AX-104 supernate normalized to the moles of free Na in the combined supernate.

All radionuclides decayed to December 31, 1999.

APPENDIX F

REPORT OF BEST-ESTIMATE PAST RELEASE VADOSE ZONE CONTAMINATION OF THE 241-AX TANK FARM

Provided by:

Columbia Energy & Environmental Services, Inc.
1207 George Washington Way, Suite 12
Richland, WA 99352

CONTENTS

FIGURES:

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FIGURES (cont'd):

TABLES:

The purpose of this study is to provide a best-estimate of the chemical and radiological waste inventory which has been released to the vadose zone in and about the 241-AX Tank Farm. As part of this effort, an evaluation of available information for operations within the tank farm was performed including recent analyses of vadose zone gamma-emitting isotope contamination at thirty-two dry wells. A best-estimate based upon the source, time, nature, extent, and composition of the contaminant streams has been developed which employs the currently available data.

1.0 CHEMICAL INFORMATION SOURCES

Chemical and radionuclide inventory estimates are generally derived from one of two sources of information: (1) sample analysis (Brevick 1996) and sample derived inventory estimates, or (2) component compositions predicted by the Hanford Defined Waste model based upon process knowledge and historical tank transfer information (Agnew et al. 1997a). Due to the timing and nature of the evident releases, only one release can clearly be defined with analytical sampling (see Section 2.1 North West Release) while all other evident releases are defined by location, timing, and process history associated with specific Hanford Defined Waste Streams including OWW2, OWW3, IWW (P2), supernates and B Plant strontium recovery sludge.

2.0 CONTAMINATION SITE SCREENING AND EVALUATION

Recent analyses of gamma-emitting isotopes contaminating the vadose zone of the 241-AX Tank Farm have yielded a preliminary report (DOE 1997a) providing indicators of the magnitude and location of contamination within the tank farm. This preliminary report is based upon geophysical surveys conducted in dry wells located around the four tanks in the tank farm (DOE 1997b, 1997c, 1997d, 1997e). Because the placement, and number, of boreholes are inherent limitations in this type of assay, these analyses can only provide indicators of contamination rather than a basis for a confirmed inventory assessment. The primary limitation is a lack of additional boreholes beyond the perimeter of the edge of the tanks and the maximum depths drilled. The outer edges of the zones of contamination are based on interpretation. A history of gross gamma energy readings in these dry wells provides a longer term view of the initiation and transport of the contamination plumes. These observed contamination sites, in conjunction with a review of facility processes, waste transfers, waste storage records, and occurrence reports, may adequately describe the nature and extent of contamination in the tank farm at a conceptual level.

In review of the borehole logging and histories of releases, six primary release zones are associated with specific tanks and material compositions; these zones are diagrammatically represented in Figure 1. No available information could conclusively point to leakage from any of the four single-shell tanks within the farm, but much evidence was present to indicate that significant releases had occurred at and near the surface of the tank farm through transfer lines and tank ancillary equipment, particularly tank vent headers. Since there is no soil characterization data available, the chemistry and composition of the zones of contamination were used as indicators of migration to the depths indicated by the gamma-emitters measured in each dry well.

A critical parameter in defining the nature and extent of contamination occurring from past spills and leakage in the tank farms is the volume of the area affected. The shapes of the actual plumes in the soils in the 200 Areas are complex and depend on soil parameters such as the local depositional environment, porosity, vertical and horizontal hydraulic conductivities, as well as the characteristics of the spilled or leaked liquids. For the purpose of this study, it is assumed that the shapes of the saturated soil plumes can be approximated by cylinders and the shapes refined through interpretation. The plumes were assumed to have one of two source types. The first source type is a point source, where all leakage or spillage enters the soil from a single discrete point. The second, is a distributed source, in which leakage or spillage is assumed to enter the soil equally from several sources.

2.1 NORTH WEST RELEASE (TANK AX-103)

2.1.1 Borehole Log Review

Review of existing gamma logs for the north west edge of Tank 241-AX-103 suggests surface contamination in an area covered by boreholes 11-03-12 and 11-03-10. This zone of contamination is identified as AX1 and is shown on Figures 2 and 3. This surface contamination may be related to a reported line failure in the AX-103 pump pit. The assumption is that the AX-013 pump pit 03B is the potential source of contamination.

From gamma borehole logs (DOE 1997d) data for two boreholes (11-03-12 and 11-03-10) located on the north west edge of Tank AX-103, indicate primary ^{137}Cs contamination to depths of approximately 6.1 m (20 ft). Minor ^{137}Cs is indicated to depths of approximately 18.3 to 21.3 m (60 to 70 ft). The presence of minor ^{137}Cs contamination to depths of approximately 21.3 m (70 ft) may be due to drilling practices introduced at the time the dry wells were drilled. The man-made radionuclides ^{137}Cs, ^{60}Co, and ^{125}Sb were identified in the zone of contamination. The maximum concentration of ^{137}Cs was approximately 40 pCi/g. No evidence was found to suggest the presence of a continuous plume associated with a tank leak. Examination and comparison of historical and present gamma logs indicate that following infiltration of the contaminants into the subsurface with subsequent migration to depths of approximately 18.3 m (60 ft), no further migration has occurred. The volume of the AX1 contamination is estimated to be approximately 5.34E+05 ℓ (7.0E+02 yd³). The calculation of the volume of the zone for AX1 appears in Appendix A.

The backfill material emplaced around the tanks in the 241-AX Tank Farm extends from the base of the tanks to the surface, a depth of approximately 16.7 m (55 ft). Although the composition of the backfill material is predominantly pebbles, and coarse to medium sands with some silt, it is poorly sorted and only moderately permeable. The physical characteristics of this fill material are estimated to be 35 percent for soil porosity, 6 percent moisture, and 20 percent void space (Routson et al. 1979).

2.1.2 Description of Release

On February 12, 1974, while conducting a hydrostatic test on a line from the diversion box, the line failed in the AX-103 pump pit.

2.1.3 Interpretation of Material Released

Although the quantity of material released was not described, the composition was likely AX-103 supernatant liquor (PSS) diluted with water for hydrostatic testing. A volume estimate based on 30.5 m (100 ft) of 3.8-cm (1.5-in.) schedule 40 carbon steel pipe is approximately 40 ℓ (10.6 gal) of PSS. The reports of Agnew and Brevick provide the bases for the volume estimate (Agnew et al. 1977b and Brevick 1996).

2.2 NORTH CENTRAL RELEASE (TANKS 241-AX-103/241-AX-101)

2.2.1 Borehole Log Review

Three boreholes (11-03-02, 11-01-10, and 11-01-11) located adjacent to the north central edge of tanks AX-103 and AX-101 indicate primary ^{137}Cs contamination to depths of approximately 6.1 to 7.6 m (20 to 25 ft). Minor ^{137}Cs contamination is indicated to depths of approximately 25.6 m (84 ft). The primary zone of contamination is depicted in Figures 4 and 5 and is identified as contamination zone AX4. The man-made radionuclides ^{137}Cs, ^{60}Co, ^{154}Eu, and ^{125}Sb were identified in this zone of contamination. The maximum concentration of ^{137}Cs was approximately 4,000 pCi/g. Examination and comparison of historical gamma logs with present gamma logs indicate infiltration of the contaminants into the subsurface and subsequent migration to depths of approximately 25.6 m (84 ft); no further migration has occurred. The volume of the zone of contamination is estimated to be approximately 3.46E+06 ℓ (4.53E+03 yd^3). The calculation of the volume of the zone for AX4 appears in Appendix A (DOE 1997b and DOE 1997d).

The backfill material emplaced around the tanks from the base to the surface, a depth of approximately 16.7 m (55 ft) consists predominantly of pebbles, and coarse to medium sands with some silt. This material is poorly sorted and considered moderately permeable. The physical properties of the backfill material have been described in Section 2.1.1.

2.2.2 Description of Release

During valve change out on an AX-103 recirculation line in 241-AX-801-B Instrument Building (some confusion exists in the identification of which instrument building), the line pressurized with tank waste and spilled to floor of building. The waste volume was reported to be 20 ℓ (5.3 gal). A 0.5-m (3-ft) deep trench was dug north out of the building to the north of the farm surface 27.4 m (90 ft) over flat ground. A hole was cut in the building and a fire hose was used to wash waste into the trench. The presence of a significant zone of contamination north of Instrument Building 801A suggests that 801A was the source of the spill and not Instrument Building 801B. A second, parallel, trench was also cut and used for residual wash. Both trenches were backfilled with gravel (RHO 1990).

Crib 216-A-39, which is located approximately 30.5 m (100 ft) north of Instrument Building 801A is tied to an existing pipeline which may connect both Instrument Buildings 801A and 801B, as determined from reference drawing H-2-33295. The crib was constructed to receive the 20 ℓ (5.3 gal) of spilled waste from the 801A Instrument Building. The crib is made up of four test wells which were constructed of 5-cm (2-in.) schedule 40 perforated pipe. The test wells were completed in 61-cm (24-in.) borings at depths of approximately 1.8 m (6 ft) and filled with 1.5 m (5 ft) of gravel, plastic sheeting, and backfill. The crib was active for one month, the month of June 1966, and received an unknown quantity of liquid including the 20 ℓ (5.3 gal) of tank waste. The crib was closed in May 1973 and was covered with approximately 6.1 m (20 ft) of fill material.

As identified above, several inconsistencies exist with the cited report. The 241-AX-801-B Instrument Building is in the south center of the farm and services Tanks 241-AX-102 and 241-AX-104. A trench dug north from this building would pass through the other instrument building. Drawing H-2-33295 shows the existence of a Crib 216-A-39 for use in collecting condensates from the 241-AX-801-B Building. However, the details of drawing H-2-33295 indicate that a hand dug trench was provided to allow placement of a 10.1-cm (4-in.) schedule 40 pipe 15 cm (6 in.) below grade running north, then north east (near the northwest quadrant of 241-AX-102) then north to the border of the farm where the line was reduced and welded into an existing 5.1-cm (2-in.) schedule 40 pipe which travels north outside of the farm to two parallel ends 18.3 m (60 ft) and 39.6 m (130 ft) north of the farm boundary, thereby defining Crib 216-A-39. Coating instructions and drain instructions on the drawing are consistent with expectations of future 801-B floor contamination in the way that one might expect from a lesson learned from prior spills at 801A.

One abandoned and capped dry well (11-02-08) and seven poorly documented PVC wells (E25-137 through E25-144) in the south central part of the farm (SW quadrant of 241-AX-102) may be indicative of a spill investigation on the southeast corner of 241-AX-801-B, but no reports are available that suggest that a spill occurred in this region. Further investigation into the site history revealed that the area was part of a short-term research project conducted to determine alternative leak detection technologies. The project was unsuccessful and no further data or history could be located.

2.2.3 Interpretation of Material Released

The spill into the soil in the AX4 zone of the farm was direct tank supernatant liquor from Tank 241-AX-103 (RHO 1990). No chemical fixatives were used in decontamination. The immediate decontamination solution, a large volume of water, percolated fairly rapidly into the soil as the waste liquor was sluiced into the trench. The non-saturated trench saw the highest concentration material first which resulted in the placement of primary contamination at the entrance of the first trench. Reported activity appears below.

Radionuclide/Source	At time of Discharge (Ci)	As of June 30, 1978 (Ci)
Beta	50	36.4
^{137}Cs	25	19.0

This cesium-based calculation places the discharge date approximately 11.95 yr prior to measurement, in the June or July 1966 time frame ($t = -\ln(A1/A0)/\lambda$). The crib service date is noted to be June 1966. The drawing H-2-33295 was first drawn in September 1966. This time period reflects the early operation of Tank 241-AX-103 when neutralized PUREX waste was being received. This composition is consistent with description of the waste as 'low-salt, neutral/basic'. PUREX wastes received into AX-103 by June 1966 include 6.12E+06 ℓ (1.62E+06 gal) IWW and 5.87E+06 ℓ (1.55E+06 gal) OWW for a total of 1.20E+07 ℓ (3.17E+06 gal) with a net of 3.77E+06 ℓ (9.96E+05 gal) in storage at the end of second quarter 1966.

The material to be described for this release would indicate that the beta source calculated in the report was assumed to be ^{90}Sr. Another informal report, *East Tank Farms History* (Kelly 1994), places the event during June 1966. As analyzed below from the material composition, the ^{137}Cs contamination from 20 ℓ (5.3 gal) as reported would be estimated to be 5.6 Ci at December 31, 1999 while the decay from the reported activity would yield 11.33 Ci. In correcting for this estimate, this spill is interpreted and applied as 40 ℓ (10.6 gal). The beta energy, potentially associated with ^{90}Sr, cannot be clearly associated with this waste stream. It is believed that even though the beta sources initially reported include a broad range of short-lived materials, the half-life of strontium was applied in the spill estimate report.

2.3 CENTRAL NORTH WEST RELEASE (TANKS 241-AX-104/241-AX-103)

2.3.1 Borehole Log Review

Four boreholes (11-04-01, 11-04-11, and 11-03-07, 11-04-10) located north west of Tank 241-AX-104 indicate primary ^{137}Cs contamination is present to depths ranging from approximately 3 to 6 m (10 to 20 ft). Minor ^{137}Cs contamination is indicated to depths of approximately 12 m (40 ft). The primary zone of contamination is located on Figures 6 and 7 and is identified as contamination zone AX2. The man-made radionuclides ^{137}Cs, ^{60}Co, and ^{154}Eu were identified in this zone of contamination. The maximum concentration of ^{137}Cs was approximately 100 pCi/g. Examination and comparison of historical gamma logs with present gamma logs indicates that upon following infiltration of the contaminants into the subsurface with subsequent migration to depths of approximately 12 m (40 ft), no further migration has occurred. The volume of the zone of contamination is estimated to be approximately 1.22E+06 ℓ (1.60E+03 yd^3). The calculation of the volume of the zone for AX2 appears in Appendix A (DOE 1997d and DOE 1997e).

The backfill material emplaced around the tanks in the 241-AX Tank Farm extends from the base of the tanks to the surface, a depth of approximately 16.7 m (55 ft). Although this backfill material consists predominantly of pebbles, and coarse to medium sands with some silt, it is poorly sorted and only moderately permeable. The physical properties of the backfill material have been described in Section 2.1.1.

2.3.2 Description of Release

On January 30, 1968, while an attempt was underway to unplug a transfer line from Tank 241-AX-102 with high water pressure, a leak in the ground was observed adjacent to Tank

241-AX-103. The hot dirt was hauled off and plastic was placed over remaining hot dirt and transfer line in the excavation.

Some inconsistencies in information exist on this spill. Transfer lines from 241-AX-102 are not common to 241-AX-103, as they must go through a minimum of one valve pit (241-AX-B). Water supply could come in, but could not be hooked up at the same time as a transfer from 241-AX-102 to 241-AX-103. It is apparent that the author of the release description merely wanted to say that transfer line was plugged by transfer from AX-102 to AX-103 and that remediation was high pressure flush. The WSTRS (Agnew et al. 1997b) does not indicate any transfer from 241-AX-102 to 241-AX-103 during the first quarter of 1968.

Leak detection pit for 104-AX began increasing in activity in late 1976, with counts peaking in December 1978. Sluice pit transfers had occurred prior to 1976, and primary stabilization of the pit took place in September 1978. Liquid level was reduced in August 1977 to 18 cm (7.1 in.), but sluicing and transfers continued through April 1978.

Well 11-04-11, in close proximity to the 241-AX-103/241-AX-104 vent header, demonstrated primary cesium contamination at 7.6 m (25 ft) and again at 18 m (59 ft) when first monitored in January 1975. The contamination plume increased in depth and decreased in concentration until 1982 when readings fell below background. It appears that the initial at-depth contamination may have been associated with the drilling operation. Welty (1991) notes that investigation determined the sources of contamination to be 241-AX-104's 51-cm (20-in.) vapor line at points both above the tank and at the line tied into the 61-cm (24-in.) vessel vent header.

Drywell 11-04-01, when first monitored in January 1975 indicated high subsurface counts at a depth of about 7.3 m (24 ft). This plume decreased and proceeded to a depth of about 11.3 m (37 ft) before decreasing below background in 1982. This activity is adjacent to the 241-AX-103/241-AX-104 vent header in highly permeable soils.

No interpretation is available for the first two contamination zones above; however, the latter contamination zones are ascribed to the 241-AX-103/241-AX-104 vent header leakage and potential transfer line leakage which has been estimated at 3.03E+04 ℓ (8.0E+04 gal) at the declaration as a leaker. Although the releases in the regions of the first two contamination zones described here are important for personnel protection, they are deemed to be much smaller than the aggregate of the latter releases. The source composition, would appear to be defined by the boiling history (Mercier 1990) and air lift circulator (ALC) operation which significantly indicated long-term boiling through early 1970; the primary solutions present in the tank at this time were PUREX IWW (P2) waste with trace B-Plant solutions. The material appears to have been aerosolized after which it collected in the vent header and then leaked to the soil.

2.3.3 Interpretation of Material Released

The spill was a subsurface line spill of 241-AX-102 tank liquor and solids. Time period would indicate that material lost was neutralized PUREX wastes (high level P2 and OWW2) present in the tank at the end of 1967. A 6.96E+05 ℓ (1.84E+05 gal) water heel was present mid-year 1966, with receipt of 2.41E+06 ℓ (6.36E+05 gal) OWW waste through 1966, receipt of an additional 3.29E+05 ℓ (8.7E+04 gal) OWW and shipment of essentially all contents removed by end of third quarter 1967, and refilled with OWW waste in fourth quarter to 2.25E+06 ℓ (5.94E+05 gal).

Next receipts in early 1967 were OWW (Anderson 1990). These reports are not inconsistent with WSTRS (Agnew et al. 1997b) which indicates OWW (P) static in the tank having been received as supernate following sludge deposition in Tank 241-AX-101.

The inventory of material released is unknown. The source is probably 241-AX-102 supernate from late 1967 to January 1968 with some sludge entrainment of OWW2 waste. The locus of release to soil column is not defined, but likely to be near the south center of 241-AX-103 dome edge. An estimate of material release based upon 61 m (200 ft) of 3.8-cm (1.5-in.) schedule 40 carbon steel piping is 80 ℓ (21.1 gal) of OWW2 waste.

2.4 CENTRAL RELEASE (TANK 241-AX-102/241-AX-101)

2.4.1 Borehole Log Review

Four boreholes (11-02-11, 11-02-12, 11-02-22, and 11-01-05) located on the north west edge of Tank 241-AX-102 indicate primary ^{137}Cs contamination depths of approximately 3 to 4.6 m (10 to 15 ft). Minor ^{137}Cs contamination is indicated to depths of approximately 12 m (40 ft). This zone of contamination is identified as AX5 and is shown on Figures 8 and 9. Cesium-137, ^{60}Co, ^{154}Eu, and ^{125}Sb were the man-made radionuclides identified in this zone contamination. The maximum concentration of ^{137}Cs was approximately 417.8 pCi/g. Examination and comparison of historical gamma logs with present gamma logs indicate that following infiltration of the contaminants into the subsurface with subsequent migration to depths of approximately 12 m (40 ft), no further migration occurred. The volume of the zone of contamination is estimated to be approximately 1.10E+06 ℓ (1.44E+03 yd^3). The calculation of the volume of the zone for AX5 is included in Appendix A (DOE 1997b and DOE 1997c).

The backfill material emplaced around the tanks in the 241-AX Tank Farm extends from the base of the tanks to the surface, a depth of approximately 16.8 m (55 ft). This material consists of predominantly of pebbles, and coarse to medium sands with some silt. This backfill is poorly sorted and considered moderately permeable. The physical properties of the backfill material have been described in Section 2.1.1.

2.4.2 Description of Release

Wells 11-02-11 and 11-02-12 demonstrated primary contamination at depths of approximately 17.1 m (56 ft) and 12.2 m (40 ft), respectively, upon first monitoring in May and June 1975 (Welty 1991). Little migration was seen with activity dropping off to background levels by 1986 and 1984, respectively. Current logging indicates no significant contamination at-depth but significant contamination near surface, almost entirely within the top 4.6 m (15 ft) of soil.

The contamination source has been previously interpreted to be vent header leak. In late 1975 an asphalt sealant was injected into the soil to contain the activity and seal the dresser coupling leak.

Well 11-01-05 activity began increasing in June 1976 at a depth of approximately 21 m (70 ft) and remained at that depth before falling below background in November 1984. This was considered to be the continued migration of vapor header leakage from 241-AX-101/241-AX-

102. Current well logging continues to display primary contamination within the top 1.5 m (5 ft) of soil.

2.4.3 Interpretation of Material Released

Quantity of the release associated with wells 11-02-11 and 11-02-12 is unknown. The composition of the released material is likely 241-AX-102 supernatant liquor released prior to 1976. Given the history of boiling (Mercier 1990), application of air lift circulators (ALC), and probability of association with vapor header, the time frame for release is most likely prior to 1969. The material was probably PUREX OWW3 which had been aerosolized and carried into ventilation system after which it leaked into the soil. It is expected that this is the same release that was seen at well 11-01-05, discussed below.

This release was observed to have occurred in the region of the vent header associated with 241-AX-102 (Welty 1991).

Although the quantity for the released material associated with well 11-01-05 is unknown, the composition is likely 241-AX-102 supernatant liquor released prior to 1976. Given the history of boiling (Mercier 1990), application of ALC, and probability of association with the vapor header, the time frame for the release is most likely prior to 1969. The material was probably PUREX OWW3 which had been aerosolized and carried into ventilation system after which it leaked into the soil. An estimate had been previously established as 1.14E+04 ℓ (3.0E+03 gal) in defining the tank as a leaker. The contamination is reasonably well associated with that described above.

2.5 CENTRAL AND SOUTH WEST (TANK AX-104)

Releases in this sector are ascribed to both identifiable and unidentifiable sources. The largest of the sources is associated with possible transfers and decontamination activities at the sluice pits.

2.5.1 Borehole Log Review

Three boreholes (11-04-07, 11-04-08, and 11-04-19) located on the south west edge of Tank 241-AX-104 indicated primary ^{137}Cs contamination depths of approximately 1.5 m (5 ft). Minor ^{137}Cs contamination is indicated to depths of approximately 21 m (70 ft). This zone of contamination is identified as AX3 and is shown on Figures 10 and 11. The only man-made radionuclide detected in the zone of contamination was ^{137}Cs with a maximum concentration of approximately 34 pCi/g. Examination and comparison of historical gamma logs with present gamma logs indicate that following infiltration of the contaminants into the subsurface with subsequent migration to depths of approximately 21 m (70 ft), no further migration has occurred. The volume of the zone of contamination is estimated to be approximately 8.02E+05 ℓ (1.05E+03 yd^3). The calculation of the volume of the zone for AX3 is included in Appendix A (DOE 1997e).

The backfill material emplaced around the tanks in the 241-AX Tank Farm extends from the base of the tanks to the surface, a depth of approximately 16.8 m (55 ft). Although the backfill material consists predominantly of pebbles, and coarse to medium sands with some silt, it is poorly sorted and only moderately permeable. The physical properties of the backfill material have been described in Section 2.1.1.

Some inconsistencies exist with borehole locations. Borehole 11-04-07, identified as located near the 241-AX-B Valve Pit, is incorrectly located and should be near 11-04-19 which would place it 30.5 m (100 ft) closer to the tank.

2.5.2 Description of Material Released

In November 1977, drywell 11-04-08 showed increasing activity at 19.5-m (64-ft) level; it had begun exceeding background in August 1976. By 1984, the counts had dropped to background. Current gamma logging indicates near surface contamination of depths of about 16.5 m (54 ft) (tank bottom) in the region of valve pit 241-AX-A. As a comparison, well 11-04-07 indicates only surface contamination close to the valve pits.

The leak detection pit for 241-AX-104 began increasing in activity in late 1976 with peaking in December 1978. Sluice pit transfers had occurred prior to 1976, and primary stabilization of the pit took place in September 1978. Liquid level was reduced in August 1977 to 7.1 in., but sluicing and transfers were occurring through April 1978.

Well 11-04-19 indicates potential contamination in the southwest quadrant to an approximate depth of 21.3 m (70 ft). This well is close to the 241-AX-04B sluice pit and transfer lines. The history of transfer line leaks in the farm lends credence to the belief that contamination in this zone is due to leaking transfer lines.

2.5.3 Interpretation of Material Released

No interpretation is available for the contamination zone described above; however, transfer line leakages are probable sources of this contamination. The source composition would appear to be greatly defined by the boiling history (Mercier 1990), and ALC operation which significantly indicates long-term boiling through early 1970, and the primary solutions present in the tank which were PUREX IWW(P2) waste with trace B Plant solutions.

2.6 SOUTH EAST RELEASE (TANK 241-AX-102)

2.6.1 Borehole Log Review

Five boreholes (11-02-01, 11-02-02, 11-02-03, 1-02-04, and 11-02-05) located on the north east edge of Tank 241-AX-102 indicate primary ^{137}Cs contamination occurring at the surface and at depths of 1.5 to 4.6 m (5 to 15 ft). A general trend downward of primary ^{137}Cs contamination continues to depths of approximately 22.9 m (75 ft). This apparent plume of contamination is evident in the borehole logs (11-02-01, 11-02-02, and 11-02-03) and decreases in activity at depth. This zone of contamination is identified as AX6 and is shown on Figures 12 and 13. The man-made radionuclides ^{137}Cs and ^{60}Co were identified in the zone of contamination with ^{137}Cs having a maximum concentration of approximately 15.8 pCi/g. Examination and comparison of historical gamma logs with present gamma logs indicate that following infiltration of the contaminants into the subsurface with subsequent migration to depths of approximately 22.9 m

(75 ft), no further migration has occurred. The volume of the zone of contamination is estimated to be approximately 3.36E+06 ℓ (4.4E+03 yd^3). The calculation of the volume of the zone for AX6 is included in Appendix A (DOE 1997c).

The backfill material emplaced around the tanks in the 241-AX Tank Farm extends from the base of the tanks to the surface, a depth of approximately 16.8 m (55 ft). This material consists predominantly of pebbles, and coarse to medium sands with some silt. This backfill is poorly sorted and considered moderately permeable. The physical properties of the backfill material have been described in Section 2.1.1.

2.6.2 Description of Material Released

On December 3, 1976, during a jumper removal in the AX-102-02A pump pit a dark solution ran from an open nozzle to the pit floor. High dose readings led an operator to flush the released material off the floor. The high temperature of the pit and solution resulted in spray and vapor being released out of pit in a plume for about 22.9 m (75 ft), in a southerly direction. Decontamination efforts were not described (Kelly 1994).

2.6.3 Interpretation of Material Released

The spill into the soil was an aerosol of tank supernatant liquor (primarily water) and solids from, presumably, 241-AX-102. B-Plant strontium recovery activities for this tank were underway and nearly complete during this period. The volume of the spill was undefined but not likely to be less than 1 ℓ (0.26 gal) nor greater than 100 ℓ (26.4 gal). It is reasonable to believe that the aerosolized portion did not exceed 50 percent of solution spilled in pit. An estimate of 20 ℓ (5.3 gal) contaminated liquid with 10 percent sludge is considered reasonable. Decontamination efforts likely included water washdown of large surface areas over the tank dome. This would have driven the contamination plume to the dome upper surface and over the edge of dome.

2.7 GENERAL FARM CONTAMINATION

Numerous reports exist of accidental surface contamination, usually associated with sludge measurement systems, sluicing operations, and tank waste transfers. Additionally, the gamma borehole logging (DOE 1997a) indicates general contamination spread throughout the near-surface region of the tank farm. It is believed that the majority of this general contamination is due to transport from the described releases at or near the surface of the tank farm. These minor releases have been assigned zones of contamination AX7, AX8, AX9, AX10, AX11, AX12, and AX13. The locations of these zones of contamination are shown on Figure 1. Limited documentation is available to determine the compositions and inventory of these minor zones of contamination.

The zone of contamination designated as AX7 is shown on Figures 14 and 15. AX7 is located on the west central side of Tank 241-AX-103. The zone of contamination extends to an approximate depth of 3.7 m (12 ft) with the only man-made radionuclide detected being ^{137}Cs. The maximum concentration of ^{137}Cs was 7.5 pCi/g at 0.46 m (1.5 ft). The volume of the zone of contamination is estimated to be approximately 2.17E+05 ℓ (2.84E+02 yd^3). The calculation of the volume of the zone for AX7 is included in Appendix A.

The zone of contamination designated as AX8 is shown on Figures 16 and 17. AX8 is located on the northwest edge of Tank AX-104 and may be co-mingled with the AX2 zone of contamination. This zone of contamination extends to an approximate depth of 12.2 m (40 ft). The man-made radionuclides ^{137}Cs, ^{60}Co, and ^{154}Eu were detected in the zone of contamination. The maximum ^{137}Cs concentration was approximately 1,456 pCi/g at 1.1 m (3.5 ft). The volume of the zone of contamination is estimated to be approximately 6.79E+05 ℓ (8.88E+02 yd^3). The calculation of the volume of the zone for AX8 is included in Appendix A.

The zone of contamination designated as AX9 is shown on Figures 18 and 19. AX9 is located on the northeast edge of Tank 241-AX-101. This zone of contamination extends to an approximate depth of 6.1 m (20 ft). The man-made radionuclide detected was identified as ^{137}Cs. The maximum concentration was approximately 8 pCi/g at 0.6 and 5.5 m (2 and 18 ft). The volume of the zone of contamination is estimated to be approximately 2.57E+05 ℓ (3.36E+02 yd^3). The calculation of the volume of the zone for AX9 is included in Appendix A.

The zone of contamination designated as AX10 is shown on Figures 20 and 21. AX10 is located on the eastern edge of Tank 241-AX-101. The zone of contamination extends to an approximate depth of 3 m (10 ft). The man-made radionuclide ^{137}Cs was identified in this zone of contamination. The maximum concentration of ^{137}Cs was approximately 6 pCi/g. The volume of the zone of contamination is estimated to be approximately 1.22E+05 ℓ (1.59E+02 yd^3). The calculation of the volume of the zone for AX10 is included in Appendix A.

The zone of contamination designated as AX11 is shown on Figures 22 and 23. AX11 is located on the southeastern edge of Tank 241-AX-101. The zone of contamination extends to an approximate depth of 7.6 m (25 ft). The man-made radionuclide ^{137}Cs was identified in this zone of contamination. The maximum concentration of ^{137}Cs was approximately 51.5 pCi/g. The estimated volume of contamination is approximately 2.11E+05 ℓ (2.75E+02 yd^3). The calculation of the volume of the zone for AX11 is included in Appendix A.

The zone of contamination designated as AX12 is shown on Figures 24 and 25. AX12 is located on the south west edge of Tank 241-AX-102. The zone of contamination extends to an approximate depth of 6.1 m (20 ft). The man-made radionuclide identified in the zone of contamination is ^{137}Cs with an approximate concentration of 13 pCi/g. The volume of contamination is estimated to be approximately 2.2E+05 ℓ (2.88E+02 yd^3). The calculation of the volume of the zone for AX12 is included in Appendix A.

The zone of contamination designated as AX13 is shown on Figures 26 and 27. AX13 is located on the south east edge of Tank 241-AX-104. The zone of contamination extends to an approximate depth of 6.1 m (20 ft). The man-made radionuclide identified in this zone of contamination is ^{137}Cs with a maximum concentration of approximately 9.8 pCi/g. The volume of contamination is estimated to be approximately 2.43E+05 ℓ (3.18E+02 yd^3). The calculation of the volume of the zone for AX13 is included in Appendix A.

2.8 EX-FARM CONTAMINATION

At present, no compelling evidence exists that contamination near the tank farm has resulted in plume migration into the 241-AX Tank Farm. As described above, some areas of existing contamination near the surface and adjacent to the tanks has likely been due to transfer line leaks. The volumes and inventory of these leaks in ancillary equipment have been aggregated into the leakage declaration volumes AX-102 and AX-104. The nearest potential zone of contamination is one associated with the 216-A-39 Crib which operated for approximately one month. There was no soil characterization data available for this site.

3.0 CONTAMINANT STREAM COMPOSITIONS

As described above, a summary of contaminant streams is tabulated in Table 1 with compositions described in Tables 2 and 3 Chemical Contaminants and Radiological Contaminants, respectively. Contaminant stream compositions are based upon reports by Agnew and Brevick as described in Section 1.0 (Agnew 1997a and Brevick 1996).

No laboratory data on these streams is available which describes useful information on the waste contaminants. Among these characteristics is that of the valence of chromium as +6. From a process perspective, a release into the soil may reduce the valence to +3, and the PUREX stream sources were neutralized prior to shipment to this farm. From this standpoint, the Cr^{+6} fraction should be less than 5 percent of total chromium in the stream.

4.0 RELEASE INVENTORY BEST ESTIMATE

An estimate of release inventory has been prepared based on the composition of identified waste streams deemed released in the six major contamination zones of the AX-241 Tank Farm. These have been tabulated, grouping the zones into six areas, by chemical and radiological contaminants in Tables 4 and 5, respectively. The extent of contamination identified in the vadose zone at 241-AX Tank Farm was based on the results of geophysical well logging studies. The gross gamma-ray logs produced during these studies were evaluated for the radionuclide migration from post spills in the vadose zone. The primary radionuclides monitored were ^{137}Cs, ^{60}Co, ^{154}Eu, and ^{125}Sb. Table 6 is a summary of the estimated volumes of contamination for each zone identified. The relationship between ^{137}Cs and the other more highly mobile radionuclides and chemical contaminates has not yet been established. Consequently, there is no direct way to assess the potential extent of migration from the releases around the 241-AX Tank Farm. Several reports were reviewed which suggest that distribution of mobile contaminates under a number of conditions could be extensive. In order to estimate the potential extent of contamination resulting migration of the more mobile constituents, the initial volume estimates were doubled, as seen in Table 6.

As tabulated, the majority of identified contaminants of concern to site closure activities are those of beta and gamma radiation, due to cesium and strontium contamination in the north central region. The central southwest region is second and is associated with the 241-AX-103/241-AX-104 vent header. The third highest area of contamination is in the central east portion of the farm associated with the 241-AX-101/241-AX-102 vent header. Table 7 is a summary of the concentration for each zone and the man-made radionuclides identified.

As described by process history and by historic and current borehole logging of gamma contamination in the farm, there is no conclusive evidence of leakage from the tank structures. However, extensive evidence exists of losses from the vent headers, valve pits, risers, and possibly transfer lines. The maximum depth of migration for the zones of contamination described above is approximately 30.5 m (100 ft). The maximum concentration of man-made radionuclides measured in the tanks farm soils is approximately 4,000 pCi/g. Examination and comparison of historical and present gamma logs indicate that following initial infiltration of the contaminants with subsequent migration to the indicated depths, no evidence of further migration is indicated.

An evaluation was performed on the radiological release inventory presented in Table 5 to determine which transuranics were released and their total estimated concentrations. The primary transuranics presented in the releases are ^{237}Pu, ^{237}Np, ^{240}Pu, ^{241}Am, ^{242}mAm, ^{243}Am, and ^{243}Cm. The associated inventories are given in Table 8 with the zones of identified contamination. A further analysis was performed to determine if these inventories could exceed 100 nCi/g concentrations. Three potential zones of contamination were identified: AX2, AX4, and AX6. The associated mobility of these transuranics is low with the exception of ^{237}Np. The identified concentrations of transuranics are expected to be found in the upper 3 m (10 ft) of backfill within the three zones of contamination.

5.0 REFERENCES

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Figure 1. General Site and Plumes

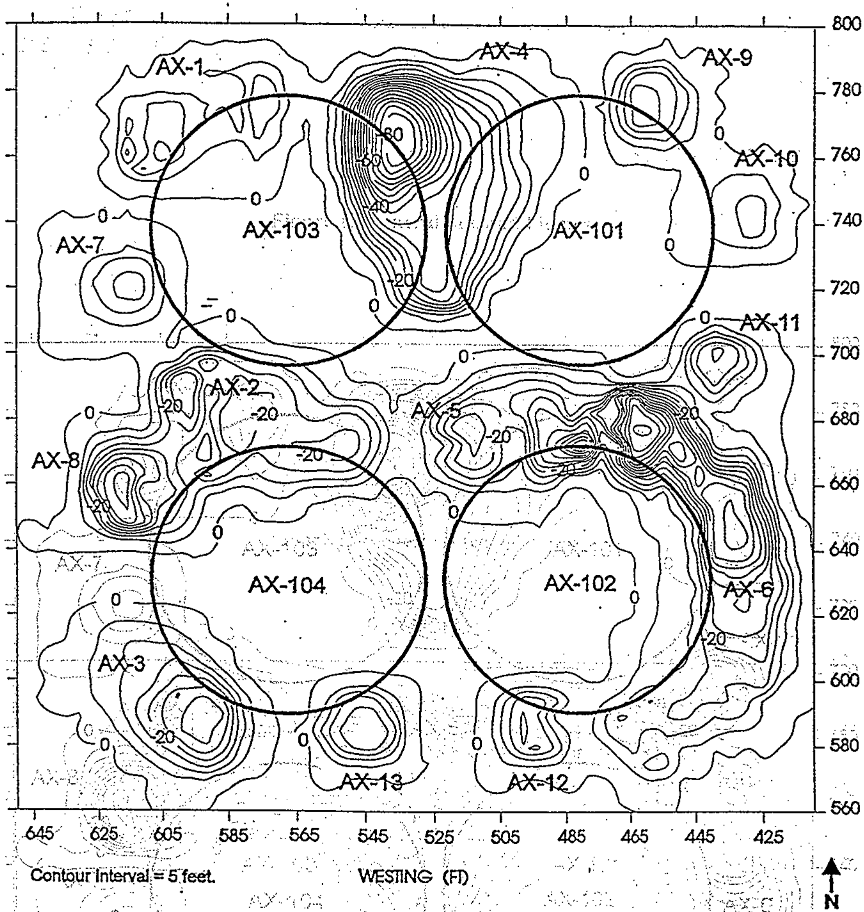


Figure 2. AX1 - Contaminated Area

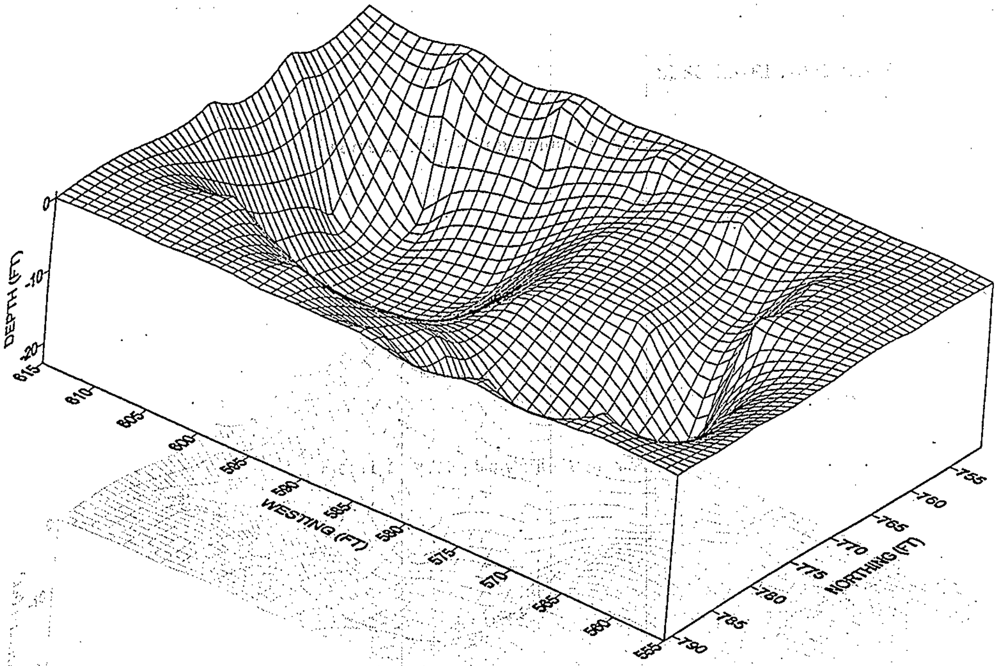


Figure 3. AX1 - Contour Map

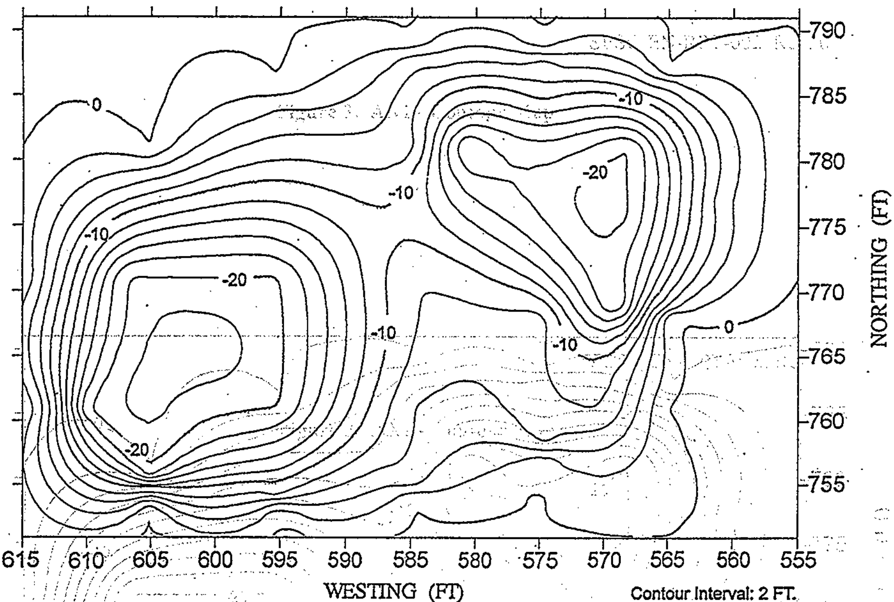


Figure 4. AX4 - Contaminated Area

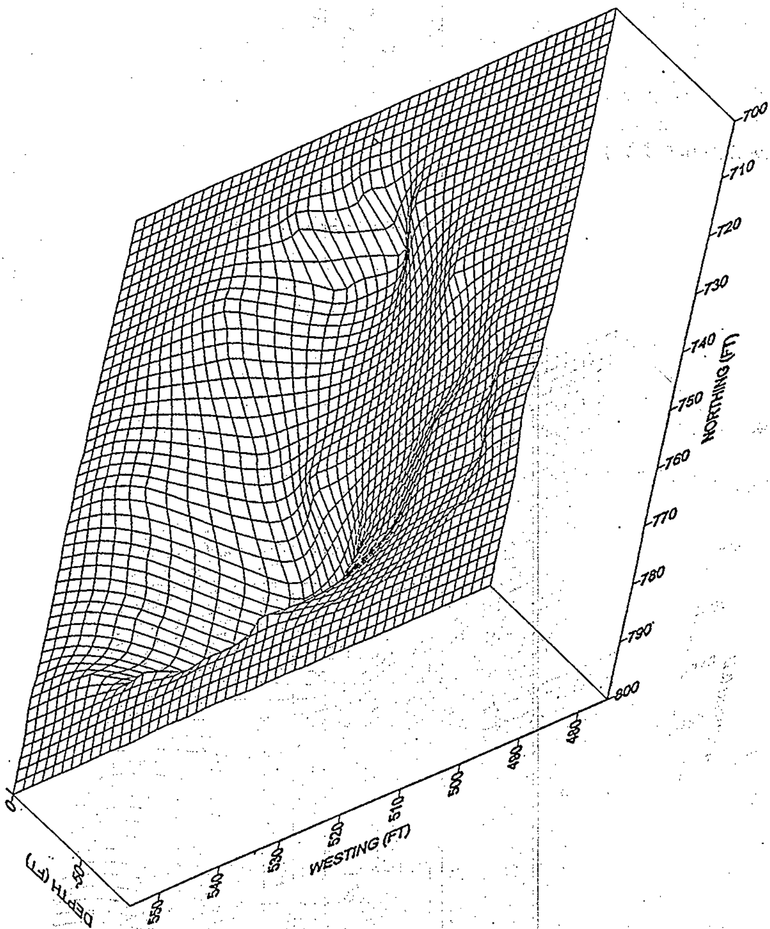


Figure 5. AX4 - Contour Map

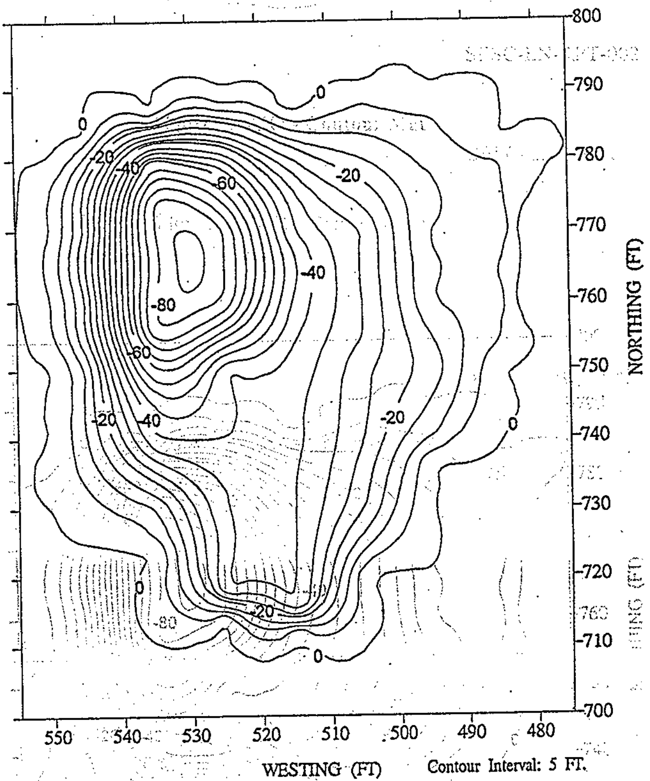


Figure 6. AX2 - Contaminated Area

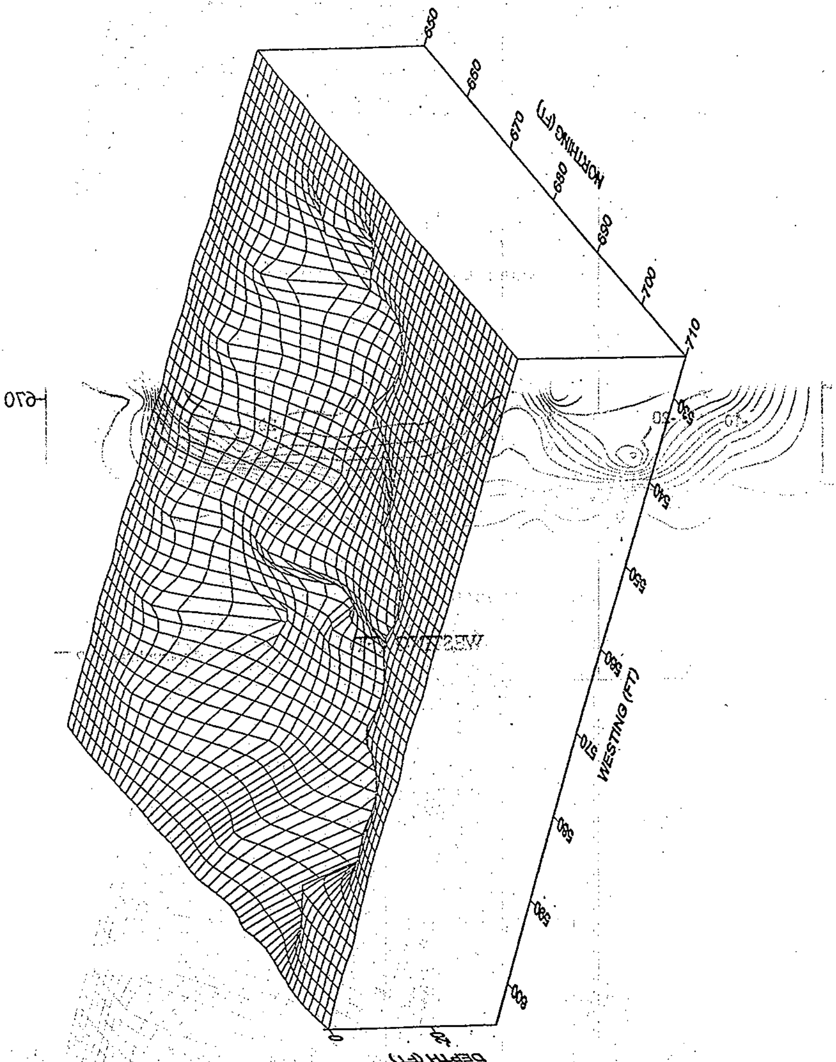


Figure 7. AX2 - Contour Map

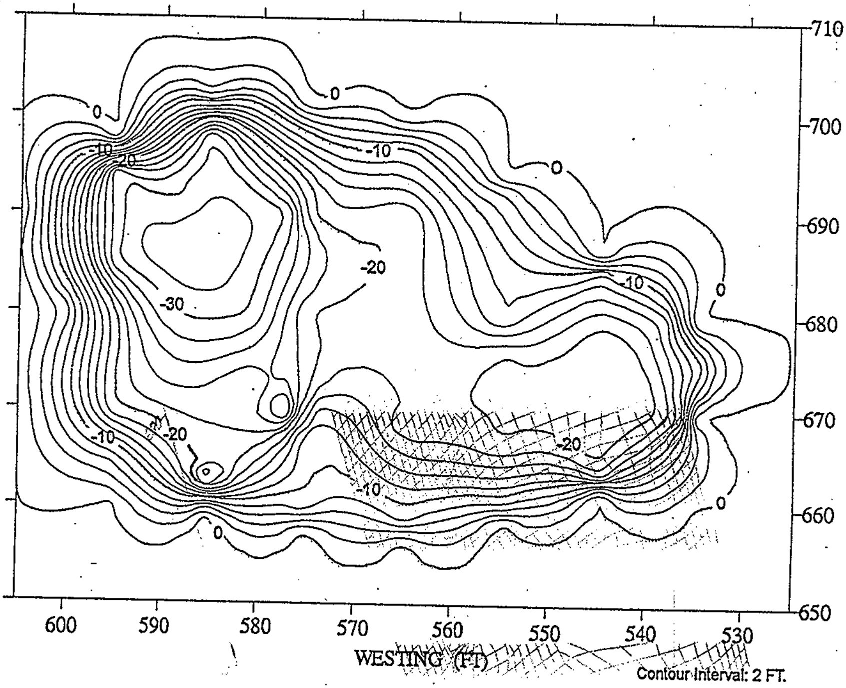


Figure 8. AX5 - Contaminated Area

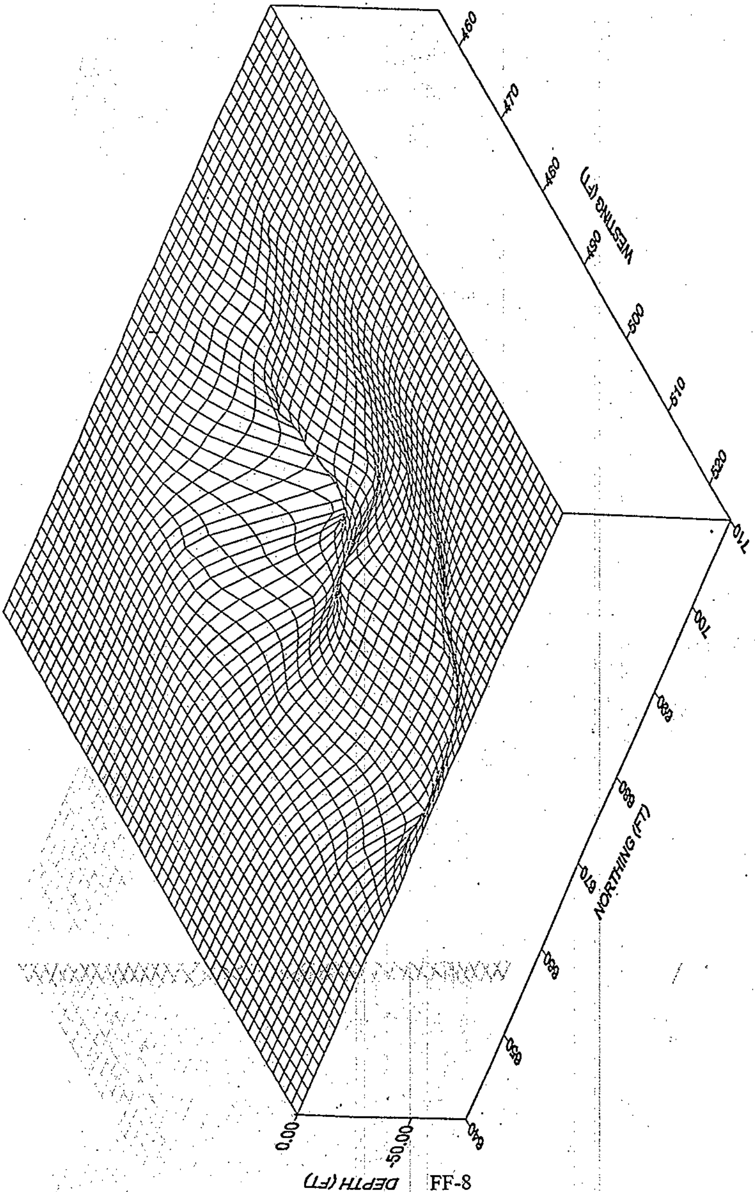


Figure 9. AX5 - Contour Map

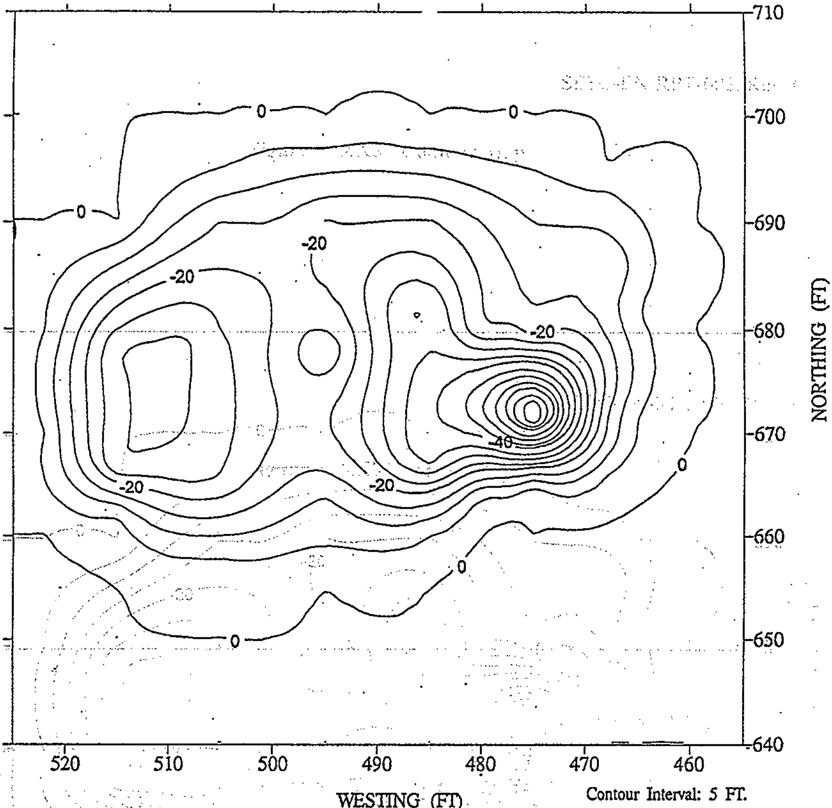


Figure 10. AX3 - Contaminated Area

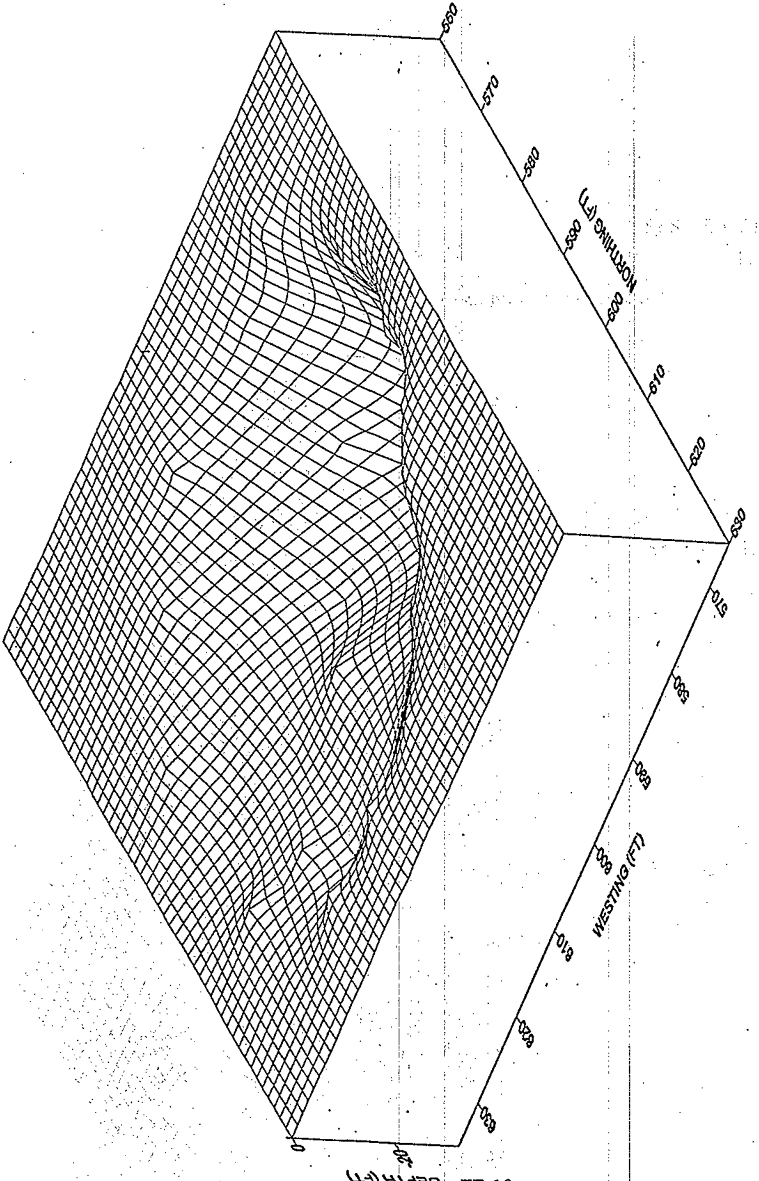


Figure 11. AX3 - Contour Map

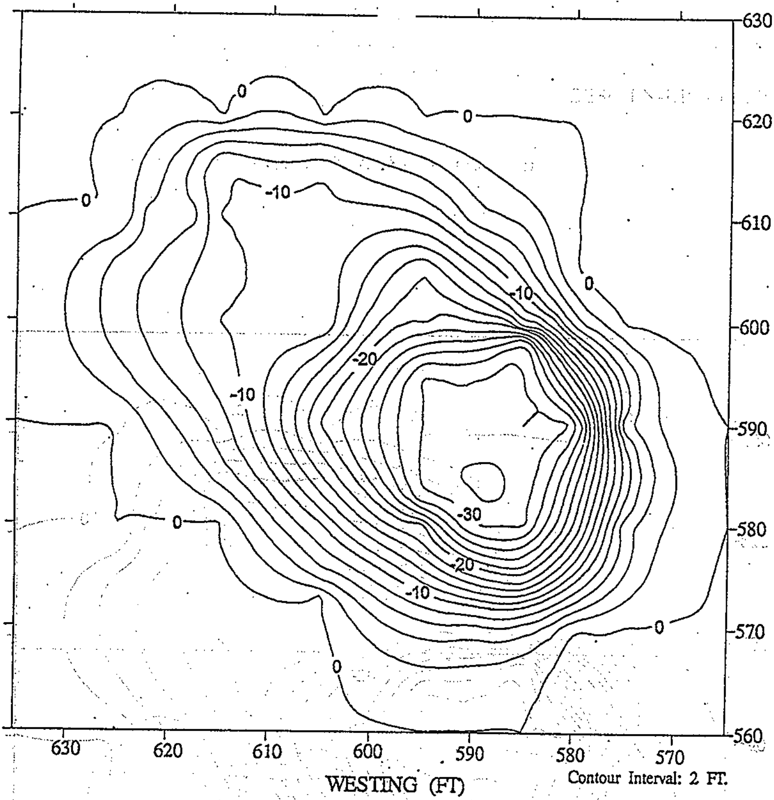


Figure 12. AX6 - Contaminated Area

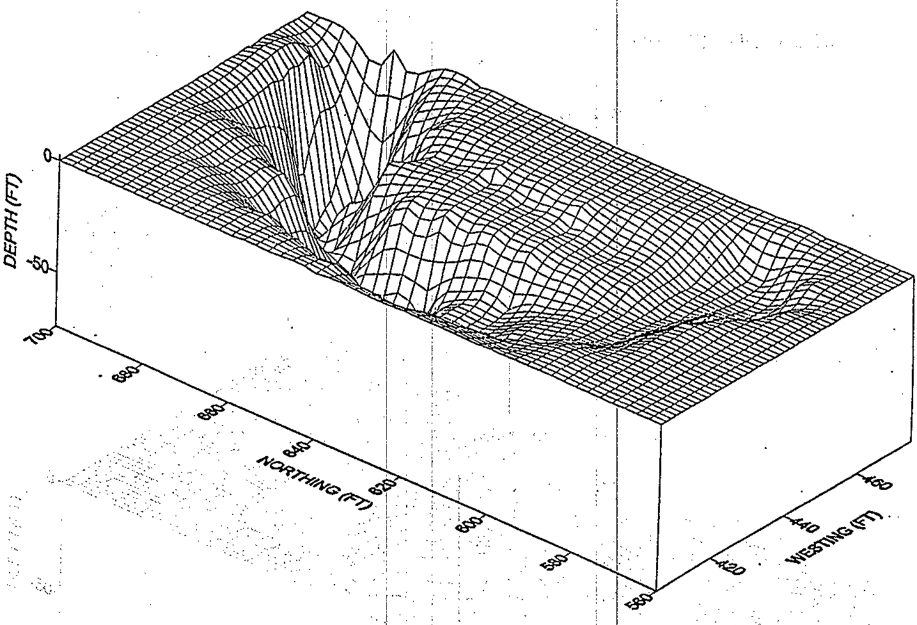
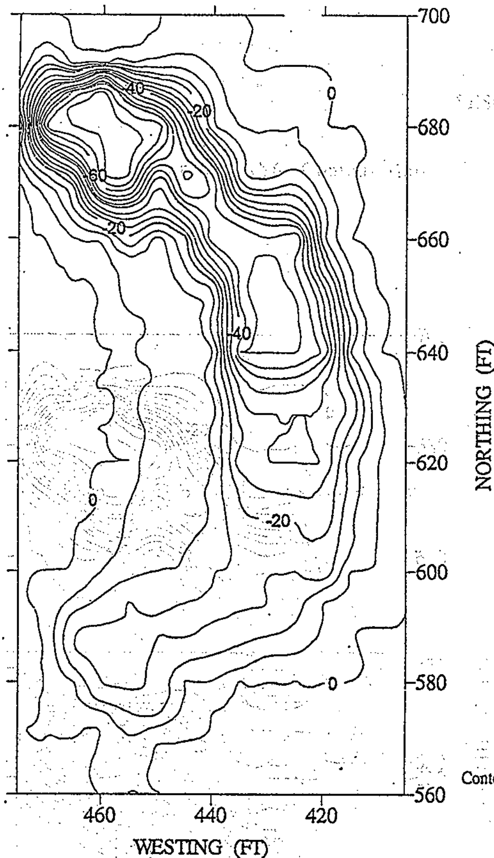


Figure 13. AX6 - Contour Map



Contour Interval: 5 FT.

Figure 14. AX7 - Contaminated Area

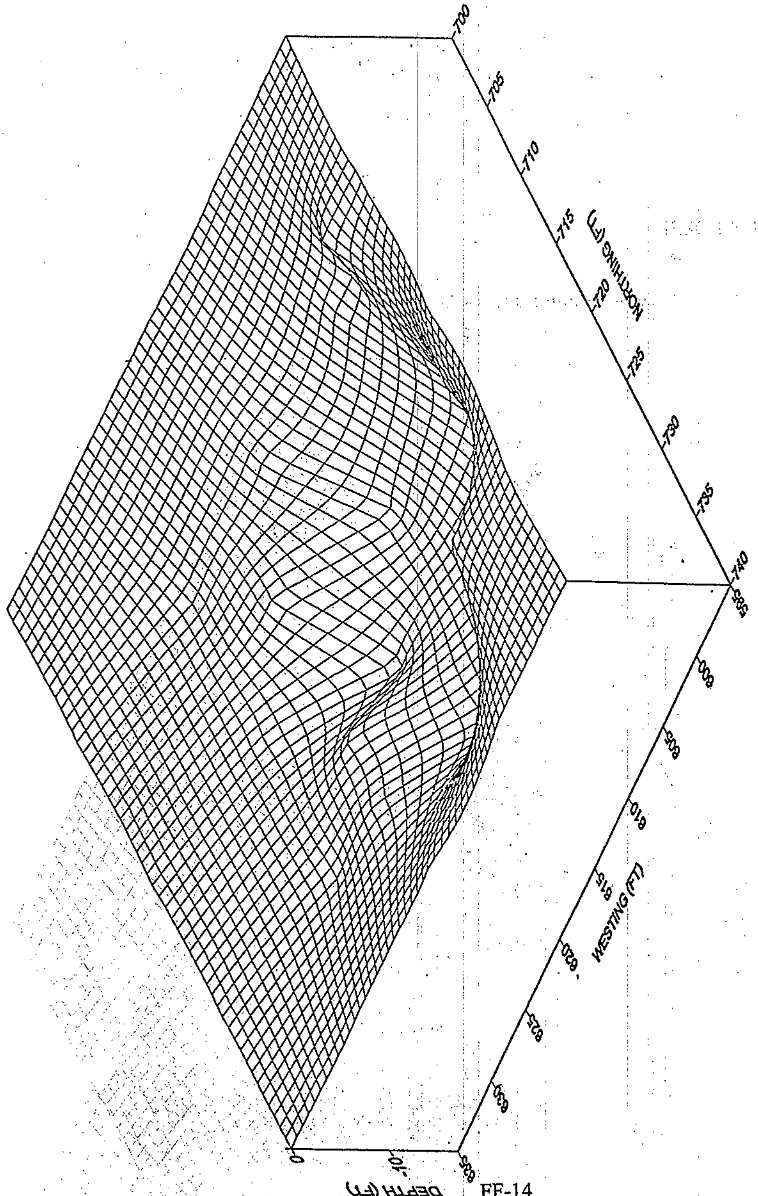


Figure 15. AX7 - Contour Map

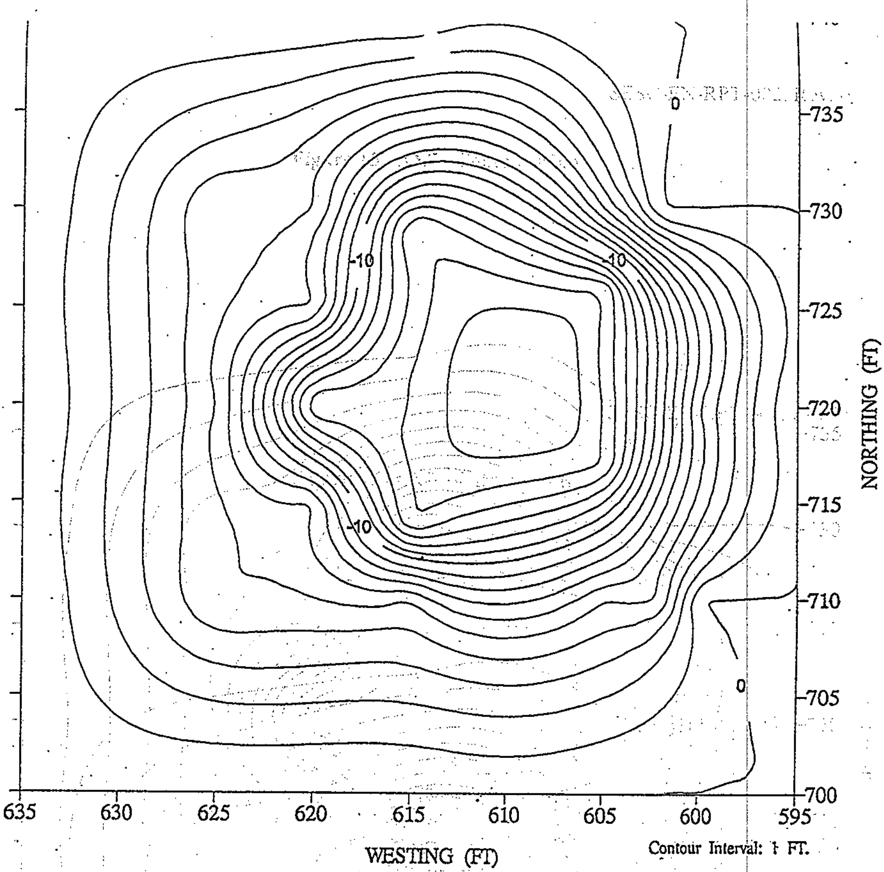


Figure 16. AX8 - Contaminated Area

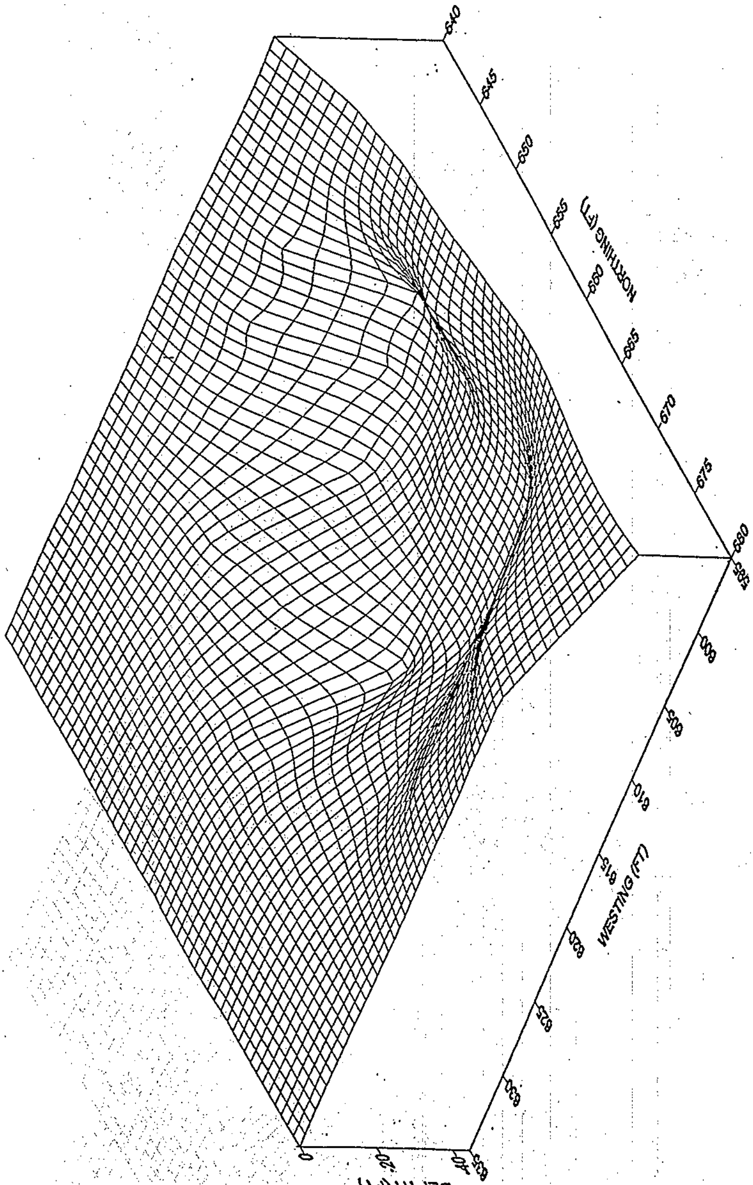


Figure 17. AX8 - Contour Map

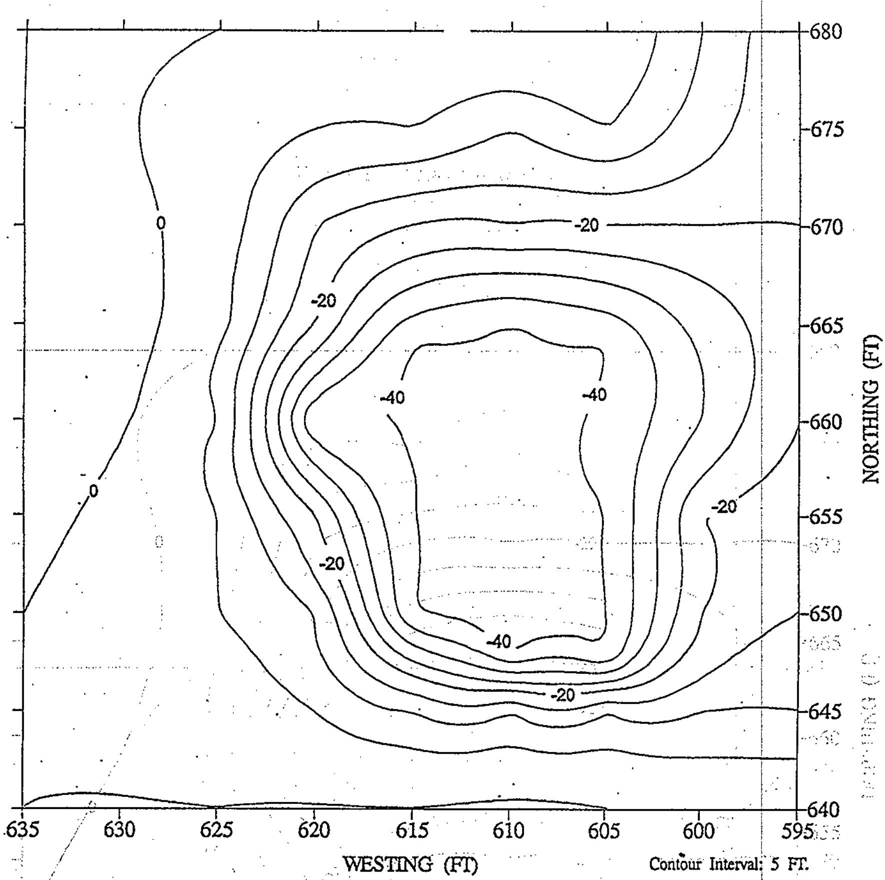


Figure 18. AX9 - Contaminated Area

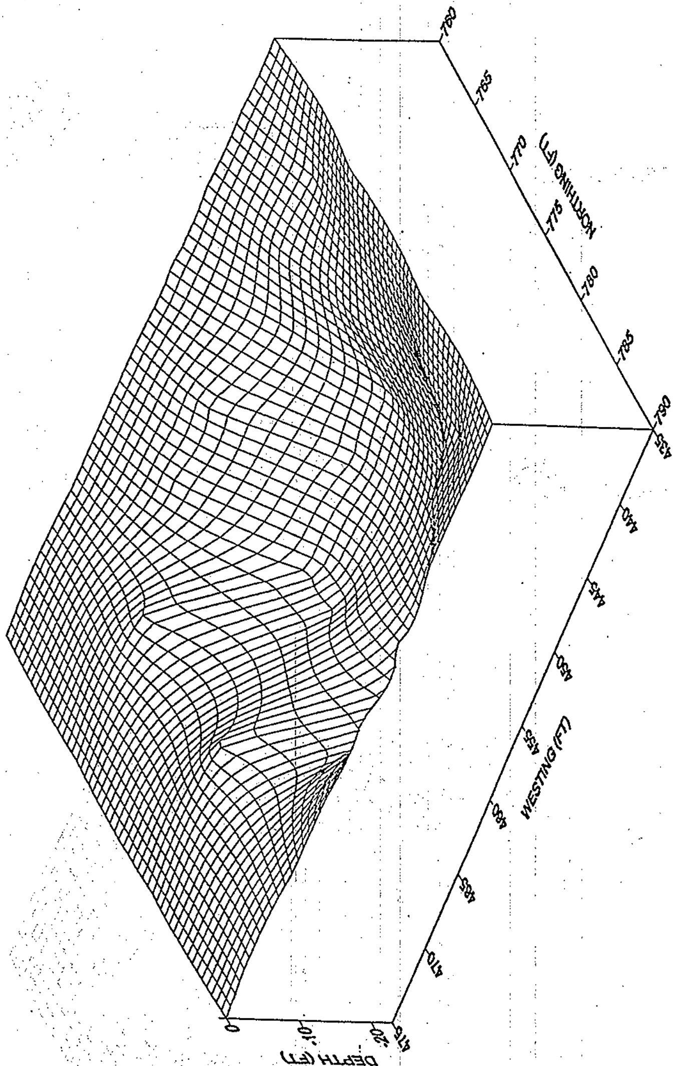


Figure 19. AX9 - Contour Map

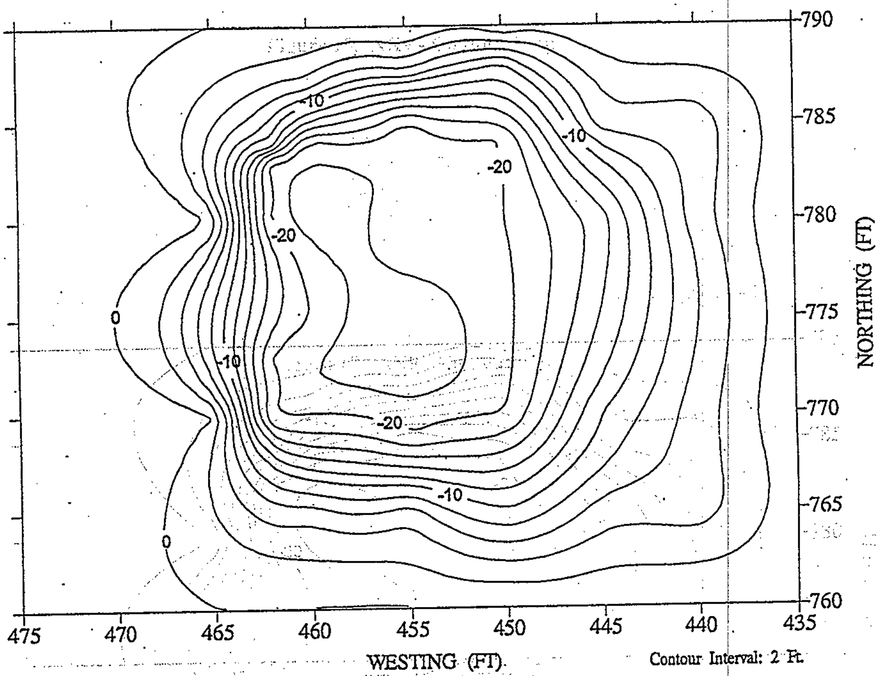


Figure 20. AX10 - Contaminated Area

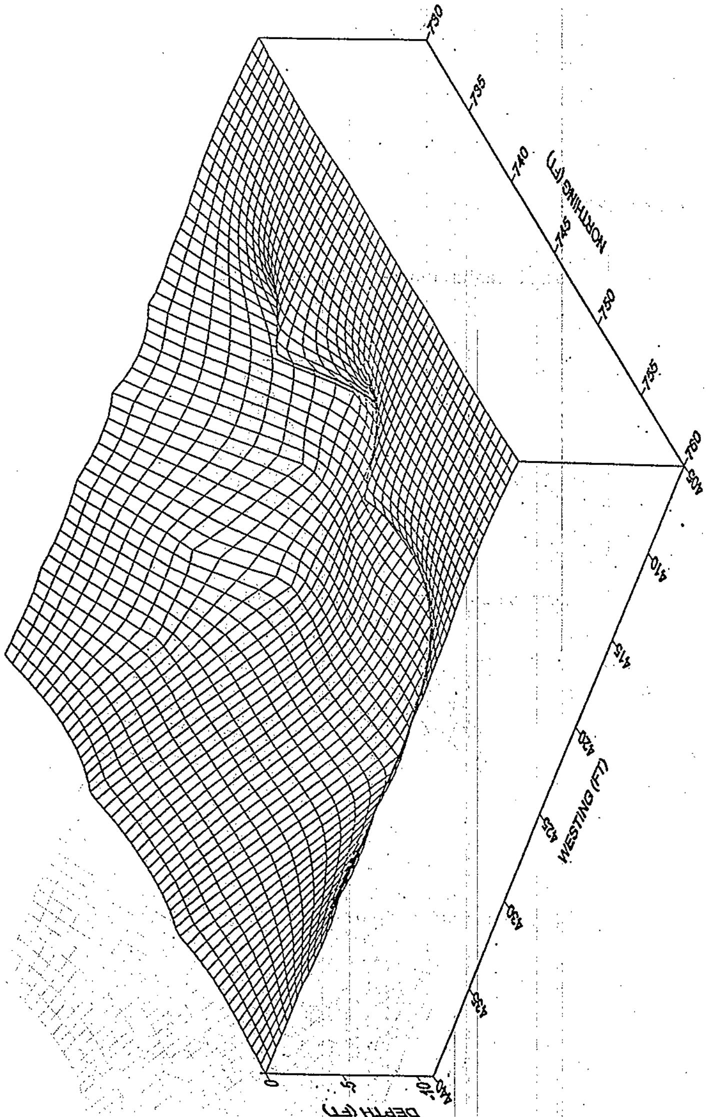


Figure 21. AX10 - Contour Map

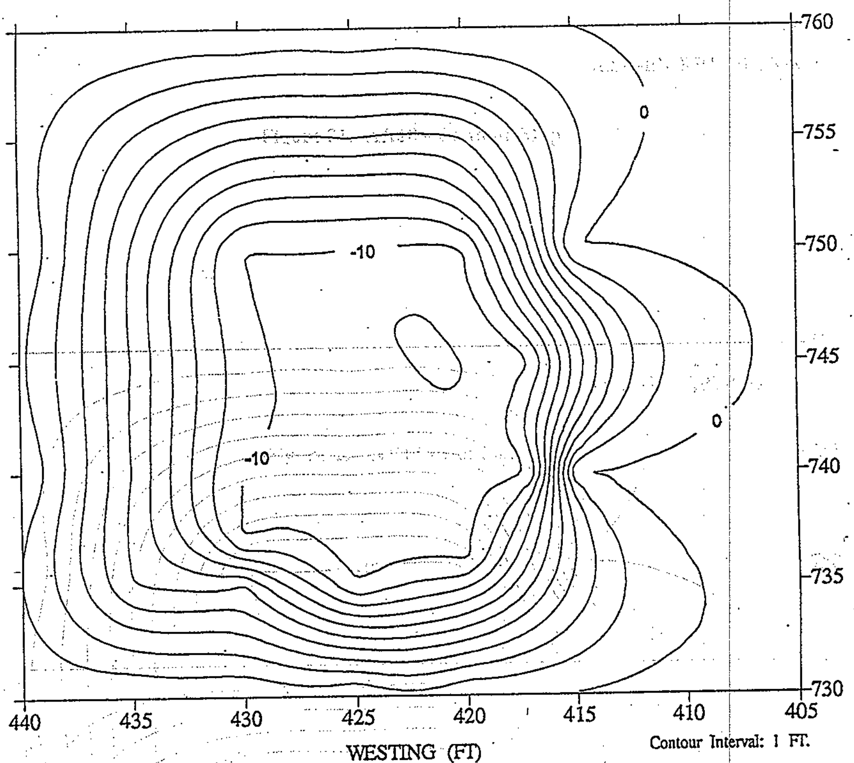


Figure 22. AX11 - Contaminated Area

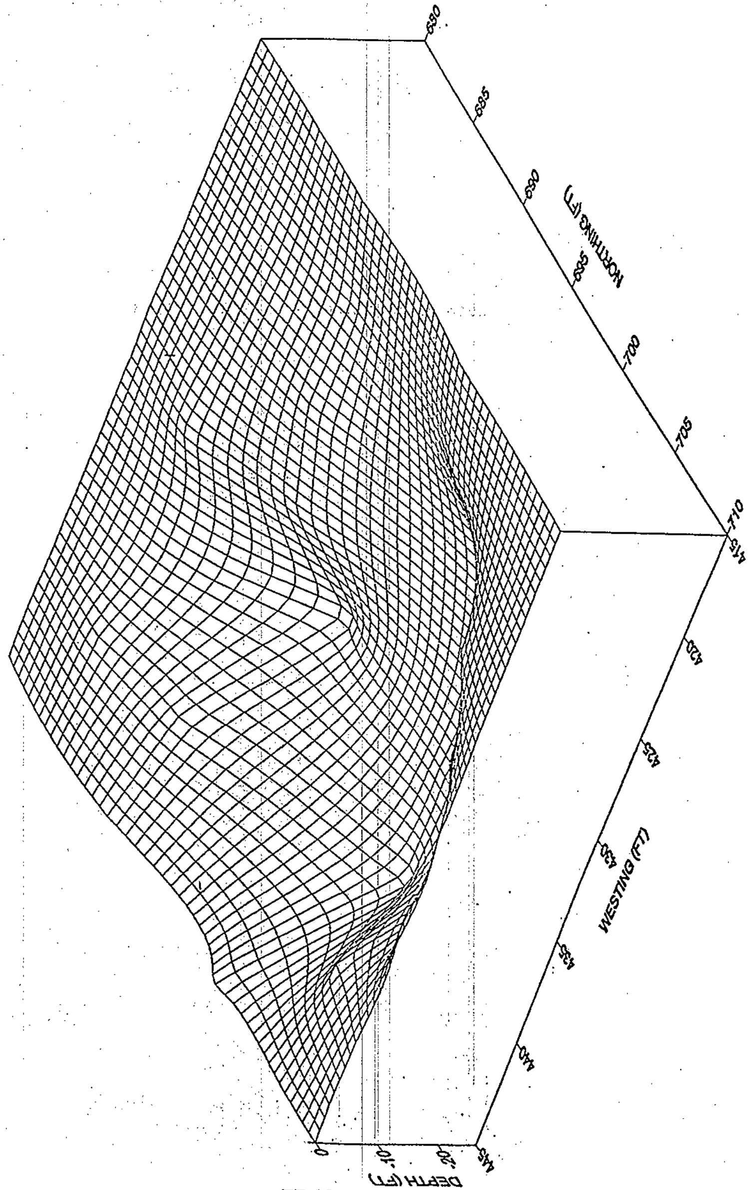


Figure 23. AX11 - Contour Map

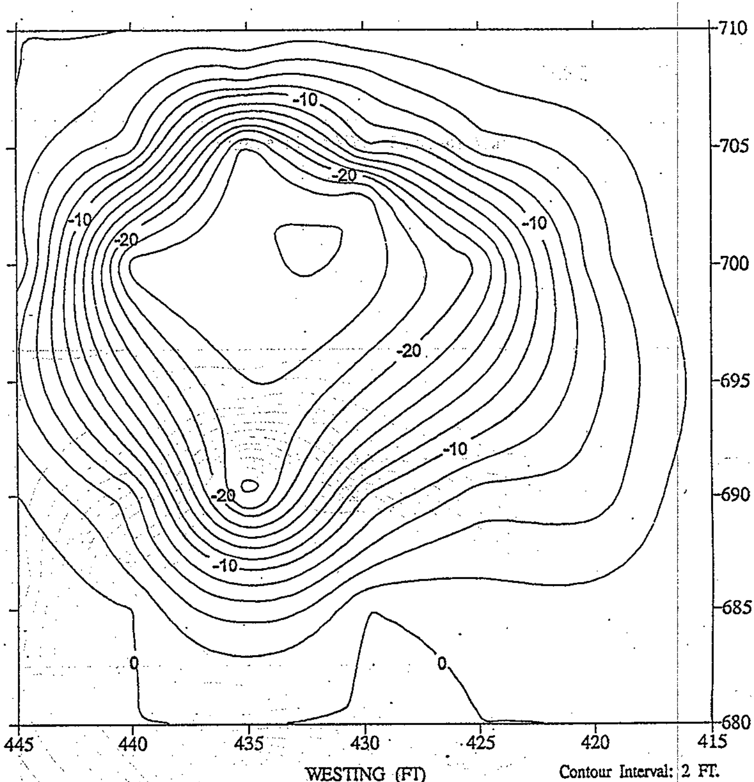


Figure 24. AX12 - Contaminated Area

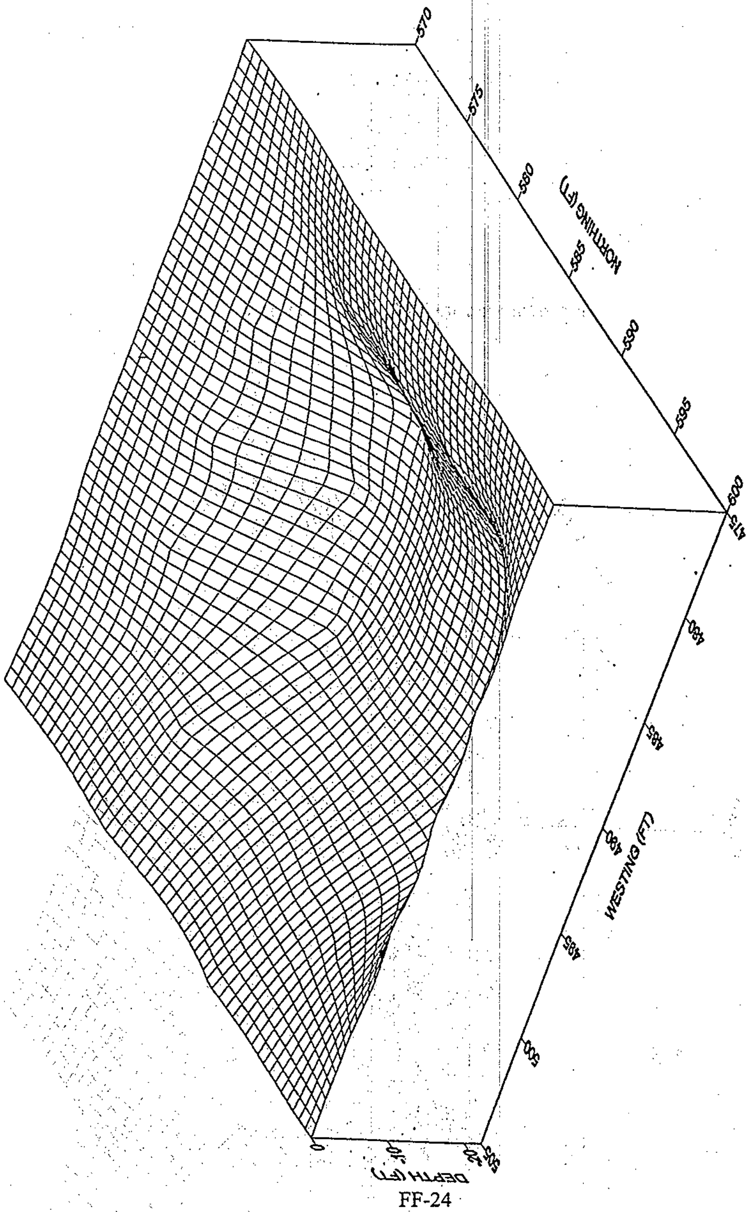


Figure 25. AX12 - Contour Map

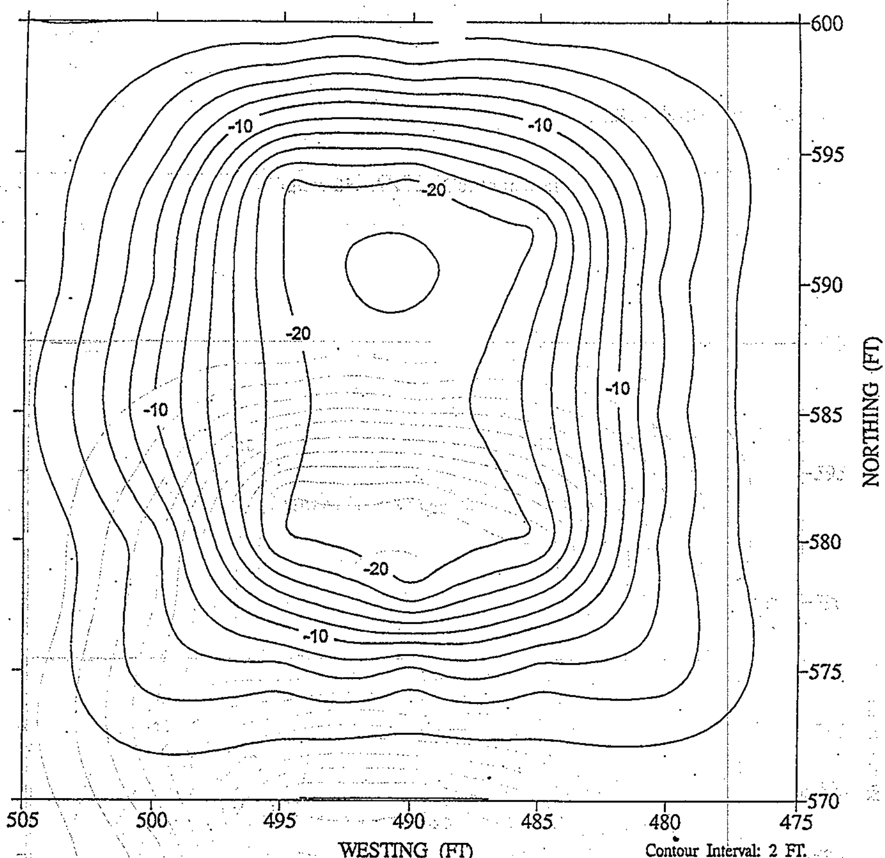


Figure 26. AX13 - Contaminated Area

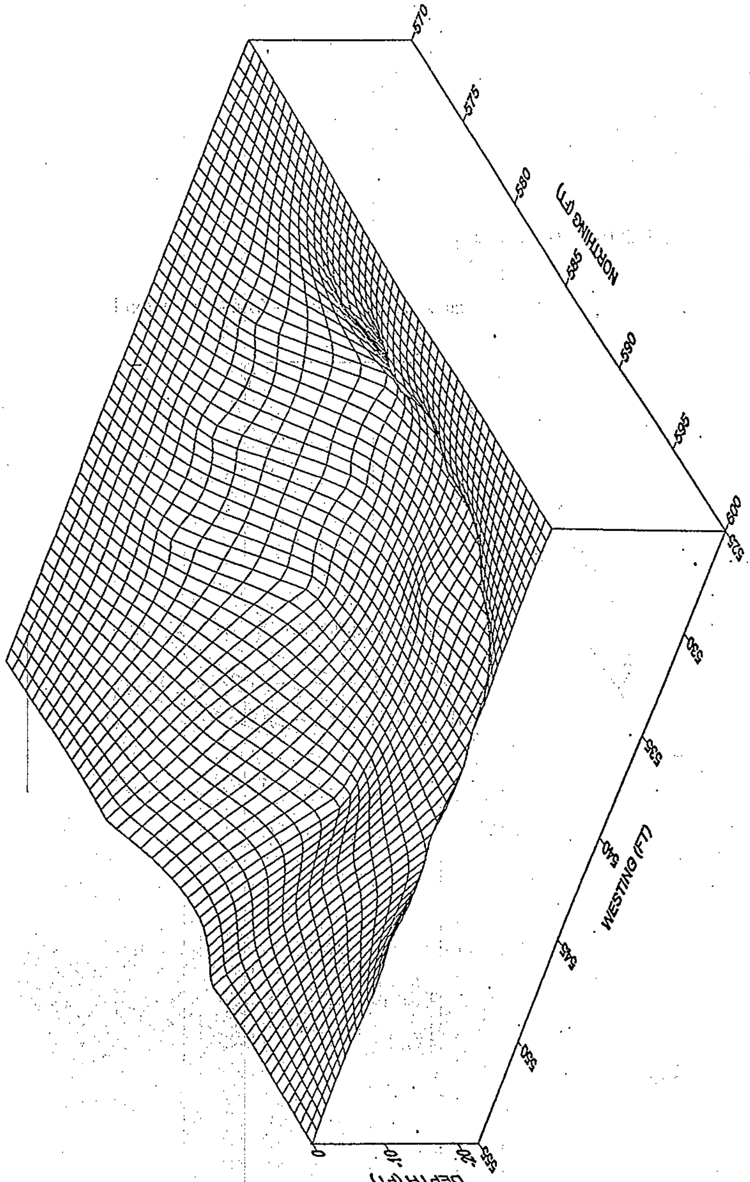


Figure 27. AX13 - Contours Map

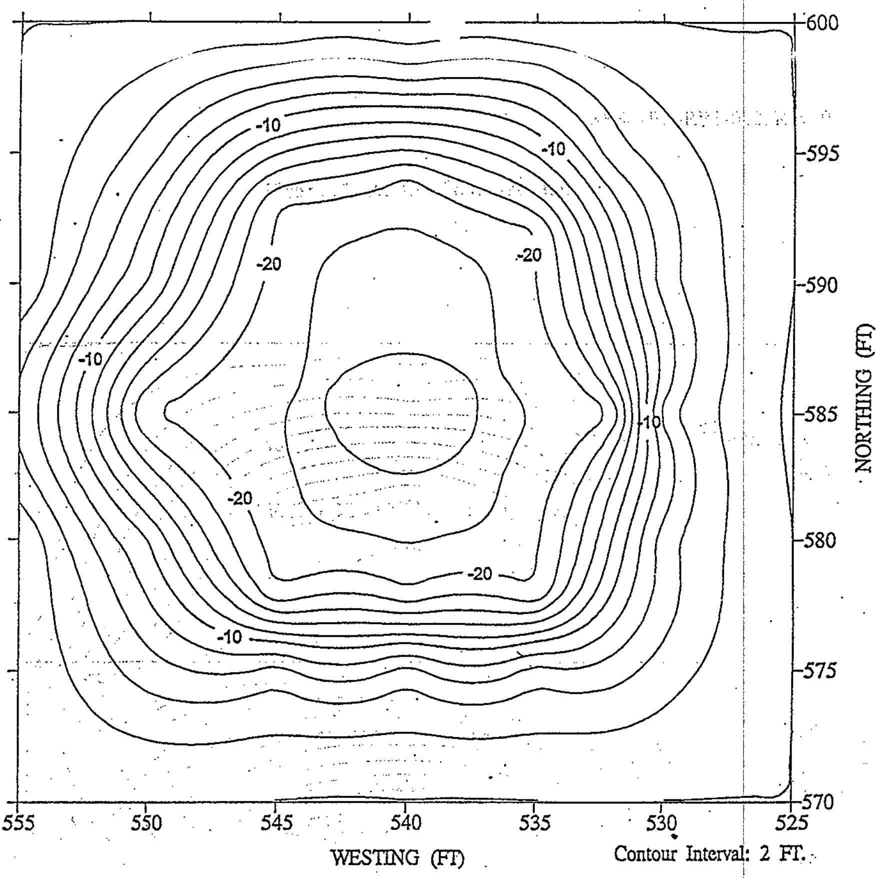


Table 1. Summary of Contamination Releases

Release Order	AX-Farm Location	Quantity	Description
1	Northwest	40L	PSS
2	Northcentral	40L	48.9% OWW2 51.1% IWW
3	Central Northwest	80L	OWW2
4 & 5	Central and Centraleast	11.360L	OWW3
6	Central and Southwest	30.280L	IWW
7	Southeast	20L	12/76 B Plant Sludge Recovery (10%)/Sluice water

Table 2. Contaminant Stream Compositions (page 1 of 2)

241-AX Farm Release Estimates			Concentrations - mol /L				
Region	NW	NC	NC	CNW	C&CE	C&SW	SE
Assoc. Tank	103-AX	103-AX	103-AX	102-AX	102-AX	104-AX	102-AX
Volume (m^3)	0.04	0.02	0.02	0.08	11.36	30.28	0.002
Date	2/13/74	7/1/66	7/1/66	1/21/68	7/1/68	7/1/69	12/4/76
Material	PSS	OWW2	IWW(P2)	OWW2	OWW3	IWW(P2)	B SL/H20
Density	1.157	1.04179	1.0459412	1.04179	1.058684	1.0459412	1.24409
Ag				0		0	
Al	0.022			0		0	2.324
As				0		0	
Ba				0		0	
Bi				0		0	
Ca		9.00e-03	9.00e-03	9.00e-03	9.00e-03	9.00e-03	2.14e-01
Cd				0		0	
Cl		0.00692	0.02614008	0.00692	0.021392	0.0261401	
Cr		0.00802	0.00806046	0.00802	0.008018	0.0080605	
Cu				0		0	
F				0		0	
Fe		0.002	0.00200005	0.002	0.002	0.0020001	1.000298
Hg				0		0	
K		0.01353	0.00568263	0.01353	0.005535	0.0056826	
La				0		0	
Mg				0		0	
Mn		0.009		0.009	0.000884	0	
Na	5.111	1.12565	1.28540407	1.12565	1.579112	1.2854041	2.40634
Ni		0.0018	0.0018	0.0018	0.0018	0.0018	0.040277
Pb				0		0	
Se				0		0	
Si	2.78e-04		0.03402903	0		0.034029	1.20317
Sr	0.0000023	0	0.00002	0	0	0.0000172	0.0000208
TOC		0.27986		0.27986	0.22239	0	
Total U	0	0.0040394	0.0015748	0.0040394	0.0040104	0.0015748	0.001065
Zr				0		0	
Zn				0		0	
Zr				0		0	
EDTA				0		0	
NH_3				0		0	
Cr^{+6}				0		0	
TIC as CO_3	0.4	0.39095	0.00900371	0.39095	0.295646	0.0090037	0.214419
CN				0		0	

Table 2. Contaminant Stream Compositions (page 2 of 2)

241-AX Farm Release Estimates			Concentrations - mol /L				
Region	NW	NC	NC	CNW	C&CE	C&SW	SE
Assoc. Tank	103-AX	103-AX	103-AX	102-AX	102-AX	104-AX	102-AX
Volume (m^3)	0.04	0.02	0.02	0.08	11.36	30.28	0.002
Date	2/13/74	7/1/66	7/1/66	1/21/68	7/1/68	7/1/69	12/4/76
Material	PSS	OWW2	IWW(P2)	OWW2	OWW3	IWW(P2)	B SL/H20
NO_3	0.14	0.37839	0.1337853	0.37839	0.944986	0.1337853	
NO_2	1.36	0.01002	0.59358138	0.01002	0.010023	0.5935814	
OH	0.77	0.06559	0.19274894	0.06559	0.088134	0.1927489	1.080852
P as PO_4	0.013			0		0	
S as SO_4	0.19	0.00401	0.15998807	0.00401	0.004009	0.1599881	
H_2O	52.149518	53.1716427	53.185209	53.171643	51.980008	53.18521	

Table 3. Contaminant Stream Radiological Compositions (page 1 of 2)

241-AX Farm Release Estimates			Concentrations - Ci /L				
	NW	NC	NC	CNW	C&CE	C&SW	SE
	PSS	OWW2	IWW(P2)	OWW2	OWW3	IWW(P2)	B SL/H20
Decay	10/15/74	1/2/94	1/2/94	1/2/94	1/2/94	1/2/94	1/2/94
^{3}H			0.0001581	0		0.0001581	0.0000649
^{14}C			2.95e-05	0		0.0000295	0.00002
^{60}Co			4.06e-05	0		0.0000406	0.0000481
^{63}Ni			0.0003663	0		0.0003663	0.0003679
^{79}Se			2e-06	0		0.000002	0.0000024
^{90}Sr	0.0046		0.03400003	0		0.034	0.0411512
^{90}Y	0.0046	0	0.03400003	0	0	0.034	0.0411512
^{93}Zr			1e-05	0		0.00001	0.0000121
^{99}Tc			0.00020894	0		0.0002089	0.000133
^{126}Sn			3e-06	0		0.000003	0.0000036
^{129}I			4.04e-07	0		0.0000004	0.0000003
^{134}Cs	0.0358		9.68e-06	0		0.0000097	0.0000023
^{135}Cs				0		0	
^{137}Cs	2.16		0.77029728	0		0.7702973	0.0320419
^{137}mBa	2.04336	0	0.7287	0	0	0.7287012	0.0303116
^{151}Sm			0.00700001	0		0.007	0.0084723
^{152}Eu			4.84e-06	0		0.0000048	0.0000065
^{154}Eu			0.0005	0		0.0005	0.0006052
^{155}Eu			0.00036024	0		0.0003602	0.0003163
^{226}Ra			6.02e-09	0		6.020e-09	7.504e-11
^{227}Ac			3.60e-10	0		3.600e-10	4.357e-10
^{228}Ra			2.55e-15	0		2.550e-15	2.728e-15
^{229}Th			3.98e-13	0		3.980e-13	2.560e-13
^{231}Pa			2e-09	0		2.000e-09	2.421e-09
^{232}Th			7.48e-15	0		7.481e-15	8.445e-15
^{232}U		6.40e-08	1.04e-11	6.400e-08	1.59e-06	1.040e-11	3.164e-11
^{233}U		2.50e-07	2.45e-13	0.0000002	6.09e-06	2.452e-13	4.183e-13
^{234}U		3.30e-07	1.28e-07	0.0000003	4.64e-07	0.0000001	0.0000001
^{235}U		1.40e-08	5.35e-09	1.400e-08	1.62e-08	5.346e-09	4.305e-09
^{236}U		8.90e-09	3.50e-09	8.900e-09	3.25e-08	3.497e-09	8.628e-09
^{237}Np			4.46e-07	0		0.0000004	0.0000004
^{238}Pu			3.37e-07	0		0.0000003	0.0000015
^{238}U		3.20e-07	1.25e-07	0.0000003	3.17e-07	0.0000001	8.424e-08
^{239}Pu			8.73e-06	0		0.0000087	0.0000101
^{240}Pu			1.67e-06	0		0.0000017	0.0000036
^{241}Am			0.00003	0		0.00003	0.0000363
^{242}Cm			1.34e-07	0		0.0000001	0.0000006

Table 3. Contaminant Stream Radiological Compositions (page 2 of 2)

241-AX Farm Release Estimates			Concentrations - Ci /L				
	NW	NC	NC	CNW	C&CE	C&SW	SE
	PSS	OWW2	IWW(P2)	OWW2	OWW3	IWW(P2)	B SL/H20
Decay	10/15/74	1/2/94	1/2/94	1/2/94	1/2/94	1/2/94	1/2/94
^{242m}Am				0		0	
^{243}Am			9.20e-10	0		9.203e-10	0.0000649
^{243}Cm			1.03e-08	0		1.027e-08	4.061e-09
^{244}Cm			1e-07	0		0.0000001	0.0000001

Table 4. 241-AX Farm Chemical Release Inventory Estimate (page 1 of 2)

241-AX Farm Release Estimates					Inventory kg		
Region	NW	NC	CNW	C&CE	C&SW	SE	Total
Assoc. Tank	103-AX	103-AX	102-AX	102-AX	104-AX	102-AX	
Volume (m^3)	0.0400335	0.04	0.08	11.35599	30.28264	0.002	
Date	02/12/74	06/30/66	01/20/68	06/30/68	06/30/69	12/03/76	
Material	PSS	OWW2IWW(P2)	OWW2	OWW3	IWW(P2)	B SL/H20	
Ag	NR[1]	NR	NR	NR	NR	NR	NR
Al	2.38e-02	NR	NR	NR	NR	1.25e-01	1.49e-01
As	NR	NR	NR	NR	NR	NR	NR
Ba	NR	NR	NR	NR	NR	NR	NR
Bi	NR	NR	NR	NR	NR	NR	NR
Ca	NR	1.44e-02	2.89e-02	4.10e+00	1.09e+01	1.72e-02	1.51e+01
Cd	NR	NR	NR	NR	NR	NR	NR
Cl	NR	2.37e-02	1.96e-02	8.61e+00	2.81e+01	NR	3.67e+01
Cr	NR	1.67e-02	3.34e-02	4.73e+00	1.27e+01	NR	1.75e+01
Cu	NR	NR	NR	NR	NR	NR	NR
F	NR	NR	NR	NR	NR	NR	NR
Fe	NR	4.47e-03	8.94e-03	1.27e+00	3.38e+00	1.12e-01	4.78e+00
Hg	NR	NR	NR	NR	NR	NR	NR
K	NR	1.49e-02	4.24e-02	2.46e+00	6.73e+00	NR	9.24e+00
La	NR	NR	NR	NR	NR	NR	NR
Mg	NR	NR	NR	NR	NR	NR	NR
Mn	NR	9.67e-03	3.96e-02	5.52e-01	NR	NR	6.01e-01
Na	4.70e+00	1.11e+00	2.07e+00	4.12e+02	8.95e+02	1.11e-01	1.32e+03
Ni	NR	4.23e-03	8.46e-03	1.20e+00	3.20e+00	4.73e-03	4.42e+00
Pb	NR	NR	NR	NR	NR	NR	NR
Se	NR	NR	NR	NR	NR	NR	NR
Si	3.13e-04	1.95e-02	NR	NR	2.89e+01	6.76e-02	2.90e+01
Sr	8.17e-06	3.08e-05	NR	NR	4.57e-02	3.65e-06	4.57e-02
TOC	NR	6.57e-02	2.69e-01	3.03e+01	NR	NR	3.07e+01
Total U	NR	2.65e-02	7.70e-02	1.08e+01	1.14e+01	5.07e-04	2.23e+01
Zr	NR	NR	NR	NR	NR	NR	NR
Zn	NR	NR	NR	NR	NR	NR	NR
Zr	NR	NR	NR	NR	NR	NR	NR
EDTA	NR	NR	NR	NR	NR	NR	NR
NH_3	NR	NR	NR	NR	NR	NR	NR

NR [=] Not Reported

Table 4. 241-AX Farm Chemical Release Inventory Estimate (page 2 of 2)

241-AX Farm Release Estimates					Inventory kg		
Region	NW	NC	CNW	C&CE	C&SW	SE	Total
Assoc. Tank	103-AX	103-AX	102-AX	102-AX	104-AX	102-AX	
Volume (m^3)	0.0400335	0.04	0.08	11.35599	30.28264	0.002	
Date	02/12/74	06/30/66	01/20/68	06/30/68	06/30/69	12/03/76	
Material	PSS	OWW2IW W(P2)	OWW2	OWW3	IWW(P2)	B SL/H20	
Cr^{+6}	NR	NR	NR	NR	NR	NR	NR
TIC as CO_3	9.61e-01	4.70e-01	1.88e+00	2.01e+02	1.64e+01	2.57e-02	2.21e+02
CN	NR	NR	NR	NR	NR	NR	NR
NO_3	3.48e-01	6.28e-01	1.88e+00	6.65e+02	2.51e+02	NR	9.19e+02
NO_2	2.50e+00	5.67e-01	3.69e-02	5.24e+00	8.27e+02	NR	8.35e+02
OH	5.24e-01	8.88e-02	8.93e-02	1.70e+01	9.93e+01	3.68e-02	1.17e+02
P as PO_4	4.94e-02	NR	NR	NR	NR	NR	4.94e-02
S as SO_4	7.31e-01	3.22e-01	3.08e-02	4.37e+00	4.65e+02	NR	4.71e+02
H_2O	3.76e+01	3.83e+01	7.67e+01	1.06e+04	2.90e+04	NR	3.98e+04

Table 5. 241-AX Release Radiological Inventory (page 1 of 2)

241-AX Farm Release Estimates				Inventory (Ci)			
	NW	NC	CSW	C&CE	CNW	SE	Total
	PSS	OWW2 IWW(P2)	OWW2	OWW3	IWW(P2)	B SL/H20	
Decay	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99	12/31/99
^{3}H	NR	2.31e-03	NR	NR	3.42e+00	9.28e-05	3.42e+00
^{14}C	NR	4.30e-04	NR	NR	6.38e-01	2.86e-05	6.38e-01
^{60}Co	NR	5.93e-04	NR	NR	8.79e-01	6.88e-05	8.79e-01
^{63}Ni	NR	5.35e-03	NR	NR	7.93e+00	5.26e-04	7.93e+00
^{79}Se	NR	2.92e-05	NR	NR	4.33e-02	3.46e-06	4.33e-02
^{90}Sr	4.48e-02	4.97e-01	NR	NR	7.36e+02	5.88e-02	7.36e+02
^{90}Y	4.48e-02	4.97e-01	NR	NR	7.36e+02	5.88e-02	7.36e+02
^{93}Zr	NR	1.46e-04	NR	NR	2.16e-01	1.73e-05	2.17e-01
^{99}Tc	NR	3.05e-03	NR	NR	4.52e+00	1.90e-04	4.52e+00
^{126}Sn	NR	4.38e-05	NR	NR	6.49e-02	5.19e-06	6.50e-02
^{129}I	NR	5.90e-06	NR	NR	8.75e-03	3.70e-07	8.75e-03
^{134}Cs	3.49e-01	1.41e-04	NR	NR	2.09e-01	3.31e-06	5.58e-01
^{135}Cs	NR	NR	NR	NR	NR	NR	NR
^{137}Cs	2.10e+01	1.12e+01	NR	NR	1.67e+04	4.58e-02	1.67e+04
^{137}mBa	1.99e+01	1.06e+01	NR	NR	1.58e+04	4.33e-02	1.58e+04
^{151}Sm	NR	1.02e-01	NR	NR	1.51e+02	1.21e-02	1.52e+02
^{152}Eu	NR	7.06e-05	NR	NR	1.05e-01	9.33e-06	1.05e-01
^{154}Eu	NR	7.30e-03	NR	NR	1.08e+01	8.65e-04	1.08e+01
^{155}Eu	NR	5.26e-03	NR	NR	7.79e+00	4.52e-04	7.80e+00
^{226}Ra	NR	8.79e-08	NR	NR	1.30e-04	1.07e-10	1.30e-04
^{227}Ac	NR	5.26e-09	NR	NR	7.79e-06	6.23e-10	7.80e-06
^{228}Ra	NR	3.72e-14	NR	NR	5.52e-11	3.90e-15	5.52e-11
^{229}Th	NR	5.81e-12	NR	NR	8.61e-09	3.66e-13	8.62e-09
^{231}Pa	NR	2.92e-08	NR	NR	4.33e-05	3.46e-09	4.33e-05
^{232}Th	NR	1.09e-13	NR	NR	1.62e-10	1.21e-14	1.62e-10
^{232}U	NR	8.95e-07	3.66e-06	1.29e-02	2.25e-07	4.52e-11	1.29e-02
^{233}U	NR	3.49e-06	1.43e-05	4.94e-02	5.31e-09	5.98e-13	4.94e-02
^{234}U	NR	6.48e-06	1.89e-05	3.76e-03	2.77e-03	1.60e-07	6.56e-03
^{235}U	NR	2.74e-07	8.01e-07	1.31e-04	1.16e-04	6.15e-09	2.48e-04
^{236}U	NR	1.75e-07	5.09e-07	2.64e-04	7.57e-05	1.23e-08	3.40e-04
^{237}Np	NR	6.52e-06	NR	NR	9.66e-03	6.11e-07	9.67e-03
^{238}Pu	NR	4.92e-06	NR	NR	7.29e-03	2.13e-06	7.30e-03
^{238}U	NR	6.29e-06	1.83e-05	2.57e-03	2.70e-03	1.20e-07	5.30e-03
^{239}Pu	NR	1.27e-04	NR	NR	1.89e-01	1.44e-05	1.89e-01
^{240}Pu	NR	2.43e-05	NR	NR	3.60e-02	5.18e-06	3.61e-02
^{241}Am	NR	4.38e-04	NR	NR	6.49e-01	5.19e-05	6.50e-01
^{242}Cm	NR	1.95e-06	NR	NR	2.89e-03	8.05e-07	2.89e-03

Table 5. 241-AX Release Radiological Inventory (page 2 of 2)

^{242m}Am	NR	NR	NR	NR	NR	NR	NR
^{243}Am	NR	1.34e-08	NR	NR	1.99e-05	9.28e-05	1.13e-04
^{243}Cm	NR	1.50e-07	NR	NR	2.22e-04	5.80e-09	2.22e-04
^{244}Cm	NR	1.46e-06	NR	NR	2.16e-03	1.73e-07	2.17e-03

Table 6. Estimated Volume of Contamination in 241-AX Tank Farm

Zone of Contamination	Estimated Volume		Estimated Volume (X2)	
	(liter)	(yd^3)	(liter)	(yd^3)
AX1	5.34E+05	6.99E+02	1.07E+06	1.40E+03
AX2	1.22E+06	1.60E+03	2.44E+06	3.19E+03
AX3	8.02E+05	1.05E+03	1.60E+06	2.10E+03
AX4	3.46E+06	4.53E+03	6.92E+06	9.05E+03
AX5	1.10E+06	1.44E+03	2.20E+06	2.88E+03
AX6	3.36E+06	4.40E+03	6.73E+06	8.80E+03
AX7	2.17E+05	2.84E+02	4.35E+05	5.68E+02
AX8	6.79E+05	8.88E+02	1.36E+06	1.78E+03
AX9	2.57E+05	3.36E+02	5.14E+05	6.72E+02
AX10	1.22E+05	1.59E+02	2.43E+05	3.18E+02
AX11	2.11E+05	2.75E+02	4.21E+05	5.51E+02
AX12	2.20E+05	2.88E+02	4.40E+05	5.76E+02
AX13	2.43E+05	3.18E+02	4.86E+05	6.36E+02
Estimated Total	1.24E+07	1.63E+04	2.49E+07	3.25E+04

Table 7. Radionuclide Concentrations of Zones of Contamination

Zone of Contamination	Concentration (pCi/g)	Man-Made Radionuclides Detected	Location of Peak Concentrations
AX1	40	^{137}Cs, ^{60}Co, ^{125}Sb	0 to 15 ft
AX2	100	^{137}Cs, ^{60}Co, ^{125}Sb	0 to 10 ft
AX3	34	^{137}Cs	0 to 5 ft
AX4	4,000	^{137}Cs, ^{60}Co, ^{154}Eu, ^{125}Sb	0 to 25 ft
AX5	417	^{137}Cs, ^{60}Co, ^{154}Eu, ^{125}Sb	0 to 15 ft
AX6	16	^{137}Cs, ^{60}Co	0 to 10 ft
AX7	8	^{137}Cs	0 to 5 ft
AX8	1,456	^{137}Cs, ^{60}Co, ^{154}Eu	0 to 10 ft
AX9	8	^{137}Cs	0 to 5 ft
AX10	6	^{137}Cs	0 to 5 ft
AX11	52	^{137}Cs	0 to 5 ft
AX12	13	^{137}Cs	0 to 5 ft
AX13	10	^{137}Cs	0 to 5 ft

Table 8. 241-AX Tank Farm Release Radiological Inventory

Transuranics	Zones of Contamination					
	AX1 (Ci)	AX2 (Ci)	AX3 (Ci)	AX4 (Ci)	AX5 (Ci)	AX6 (Ci)
^{237}Np	NR	9.66E+-03	NR	6.52E-06	NR	6.11E-04
^{238}Pu	NR	7.29E-03	NR	4.92E-06	NR	2.13E-06
^{240}Pu	NR	3.60E-02	NR	2.43E-05	NR	5.18E-06
^{241}Am	NR	6.49E-01	NR	4.38E-04	NR	5.19E-05
^{243}mAM	NR	NR	NR	NR	NR	NR
^{243}Am	NR	1.99E-05	NR	1.34E-08	NR	9.28E-05
^{243}Cm	NR	2.22E-04	NR	1.50E-07	NR	5.80E-09
Estimated Total TRU (Ci)	NR	7.02E-01	NR	4.74E-04	NR	7.62E-04

NR - not recorded

ATTACHMENT 1

VOLUME COMPUTATIONS

VOLUME COMPUTATIONS

UPPER SURFACE

Grid File: C:/AXTF/AX1/AX1.GRD
Rows: 0 to 32766
Cols: 0 to 32766
Grid size as read: 50 cols by 50 rows
Delta X: 1.22449
Delta Y: 0.816327
X-Range: 555 to 615
Y-Range: 751 to 791
Z-Range: -22.7541 to 0.875335

LOWER SURFACE

Level Surface defined by Z = 0

VOLUMES

Approximated Volume by
Trapezoidal Rule: -18861.3
Simpson's Rule: -18873.5
Simpson's 3/8 Rule: -18868.8

CUT & FILL VOLUMES

Positive Volume [Cuts]: 85.4335
Negative Volume [Fills]: 18946.7
Cuts minus Fills: -18861.3

AREAS

Positive Planar Area
(Upper above Lower): 310.934
Negative Planar Area
(Lower above Upper): 2089.07
Blanked Planar Area: 0
Total Planar Area: 2400

Positive Surface Area
(Upper above Lower): 316.375
Negative Surface Area
(Lower above Upper): 3646.51

VOLUME COMPUTATIONS

UPPER SURFACE

Grid File: C:/AXTF/AX2/AX2.GRD
Rows: 0 to 32766
Cols: 0 to 32766
Grid size as read: 50 cols by 50 rows
Delta X: 1.63265
Delta Y: 1.22449
X-Range: 525 to 605
Y-Range: 650 to 710
Z-Range: -33.1141 to 0.973262

LOWER SURFACE

Level Surface defined by Z = 0

VOLUMES

Approximated Volume by
Trapezoidal Rule: -43100
Simpson's Rule: -43118.2
Simpson's 3/8 Rule: -43132.8

CUT & FILL VOLUMES

Positive Volume [Cuts]: 536.881
Negative Volume [Fills]: 43636.9
Cuts minus Fills: -43100

AREAS

Positive Planar Area
(Upper above Lower): 1503.38
Negative Planar Area
(Lower above Upper): 3296.62
Blanked Planar Area: 0
Total Planar Area: 4800

Positive Surface Area
(Upper above Lower): 1528.96
Negative Surface Area
(Lower above Upper): 6209.35

VOLUME COMPUTATIONS

UPPER SURFACE
Grid File: C:/AXTF/AX3/AX3.GRD
Rows: 0 to 32766
Cols: 0 to 32766
Grid size as read: 50 cols by 50 rows
Delta X: 1.42857
Delta Y: 1.42857
X-Range: 565 to 635
Y-Range: 560 to 630
Z-Range: -32.2984 to 1.15128

LOWER SURFACE
Level Surface defined by Z = 0

VOLUMES
Approximated Volume by
Trapezoidal Rule: -28312.9
Simpson's Rule: -28314.7
Simpson's 3/8 Rule: -28313.7

CUT & FILL VOLUMES
Positive Volume [Cuts]: 443.22
Negative Volume [Fills]: 28756.1
Cuts minus Fills: -28312.9

AREAS
Positive Planar Area
(Upper above Lower): 1708.16
Negative Planar Area
(Lower above Upper): 3191.84
Blanked Planar Area: 0
Total Planar Area: 4900

Positive Surface Area
(Upper above Lower): 1721.8
Negative Surface Area
(Lower above Upper): 4975.51

VOLUME COMPUTATIONS

UPPER SURFACE
Grid File: C:/AXTF/AX3/AX3.GRD
Rows: 0 to 32766
Cols: 0 to 32766
Grid size as read: 50 cols by 50 rows
Delta X: 1.42857
Delta Y: 1.42857
X-Range: 565 to 635
Y-Range: 560 to 630
Z-Range: -32.2984 to 1.15128

LOWER SURFACE
Level Surface defined by Z = 0

VOLUMES
Approximated Volume by
Trapezoidal Rule: -28312.9
Simpson's Rule: -28314.7
Simpson's 3/8 Rule: -28313.7

CUT & FILL VOLUMES
Positive Volume [Cuts]: 443.22
Negative Volume [Fills]: 28756.1
Cuts minus Fills: -28312.9

AREAS
Positive Planar Area
(Upper above Lower): 1708.16
Negative Planar Area
(Lower above Upper): 3191.84
Blanked Planar Area: 0
Total Planar Area: 4900

Positive Surface Area
(Upper above Lower): 1721.8
Negative Surface Area
(Lower above Upper): 4975.51

VOLUME COMPUTATIONS

UPPER SURFACE

Grid File: C:/AXTF/AX5/AX5.GRD
Rows: 0 to 32766
Cols: 0 to 32766
Grid size as read: 50 cols by 50 rows
Delta X: 1.42857
Delta Y: 1.42857
X-Range: 455 to 525
Y-Range: 640 to 710
Z-Range: -73.9561 to 1.29546

LOWER SURFACE

Level Surface defined by Z = 0

VOLUMES

Approximated Volume by
Trapezoidal Rule: -38899.4
Simpson's Rule: -38908.9
Simpson's 3/8 Rule: -38911.5

CUT & FILL VOLUMES

Positive Volume [Cuts]: 569.429
Negative Volume [Fills]: 39468.8
Cuts minus Fills: -38899.4

AREAS

Positive Planar Area
(Upper above Lower): 1803.95
Negative Planar Area
(Lower above Upper): 3096.05
Blanked Planar Area: 0
Total Planar Area: 4900

Positive Surface Area
(Upper above Lower): 1824.66
Negative Surface Area
(Lower above Upper): 6862.53

VOLUME COMPUTATIONS

UPPER SURFACE

Grid File: C:/AXTF/AX6/AX6.GRD
Rows: 0 to 32766
Cols: 0 to 32766
Grid size as read: 50 cols by 50 rows
Delta X: 1.42857
Delta Y: 2.85714
X-Range: 405 to 475
Y-Range: 560 to 700
Z-Range: -74.4226 to 2.52762

LOWER SURFACE

Level Surface defined by Z = 0

VOLUMES

Approximated Volume by
Trapezoidal Rule: -118778
Simpson's Rule: -118809
Simpson's 3/8 Rule: -118766

CUT & FILL VOLUMES

Positive Volume [Cuts]: 454.758
Negative Volume [Fills]: 119232
Cuts minus Fills: -118778

AREAS

Positive Planar Area
(Upper above Lower): 2410.89
Negative Planar Area
(Lower above Upper): 7389.11
Blanked Planar Area: 0
Total Planar Area: 9800

Positive Surface Area
(Upper above Lower): 2457
Negative Surface Area
(Lower above Upper): 17193.2

VOLUME COMPUTATIONS

UPPER SURFACE
Grid File: C:/AXTF/AX7/AX7.GRD
Rows: 0 to 32766
Cols: 0 to 32766
Grid size as read: 50 cols by 50 rows
Delta X: 0.816327
Delta Y: 0.816327
X-Range: 595 to 635
Y-Range: 700 to 740
Z-Range: -16.9266 to 0.576796

LOWER SURFACE
Level Surface defined by Z = 0

VOLUMES
Approximated Volume by
Trapezoidal Rule: -7671.59
Simpson's Rule: -7674.16
Simpson's 3/8 Rule: -7674.28

CUT & FILL VOLUMES
Positive Volume [Cuts]: 22.8273
Negative Volume [Fills]: 7694.42
Cuts minus Fills: -7671.59

AREAS
Positive Planar Area
(Upper above Lower): 93.8422
Negative Planar Area
(Lower above Upper): 1506.16
Blanked Planar Area: 0
Total Planar Area: 1600

Positive Surface Area
(Upper above Lower): 95.2003
Negative Surface Area
(Lower above Upper): 2045.91

VOLUME COMPUTATIONS

UPPER SURFACE
Grid File: C:/AXTF/AX8/AX8.GRD
Rows: 0 to 32766
Cols: 0 to 32766
Grid size as read: 50 cols by 50 rows
Delta X: 0.816327
Delta Y: 0.816327
X-Range: 595 to 635
Y-Range: 640 to 680
Z-Range: -44.5405 to 0.83372

LOWER SURFACE
Level Surface defined by Z = 0

VOLUMES
Approximated Volume by
Trapezoidal Rule: -23969.5
Simpson's Rule: -23973.5
Simpson's 3/8 Rule: -23974.2

CUT & FILL VOLUMES
Positive Volume [Cuts]: 56.5943
Negative Volume [Fills]: 24027.2
Cuts minus Fills: -23970.6

AREAS
Positive Planar Area
(Upper above Lower): 169.985
Negative Planar Area
(Lower above Upper): 1430.02
Blanked Planar Area: 0
Total Planar Area: 1600

Positive Surface Area
(Upper above Lower): 174.438
Negative Surface Area
(Lower above Upper): 3572.94

VOLUME COMPUTATIONS

UPPER SURFACE

Grid File: C:/AXTF/AX9/AX9.GRD
Rows: 0 to 32766
Cols: 0 to 32766
Grid size as read: 50 cols by 50 rows
Delta X: 0.816327
Delta Y: 0.612245
X-Range: 435 to 475
Y-Range: 760 to 790
Z-Range: -23.0326 to 0.960121

LOWER SURFACE

Level Surface defined by Z = 0

VOLUMES

Approximated Volume by
Trapezoidal Rule: -9073.25
Simpson's Rule: -9076.56
Simpson's 3/8 Rule: -9075.96

CUT & FILL VOLUMES

Positive Volume [Cuts]: 92.4404
Negative Volume [Fills]: 9165.69
Cuts minus Fills: -9073.25

AREAS

Positive Planar Area
(Upper above Lower): 215.168
Negative Planar Area
(Lower above Upper): 984.832
Blanked Planar Area: 0
Total Planar Area: 1200

Positive Surface Area
(Upper above Lower): 221.345
Negative Surface Area
(Lower above Upper): 1991.49

VOLUME COMPUTATIONS

UPPER SURFACE

Grid File: C:/AXTF/AX10/AX10.GRD
Rows: 0 to 32766
Cols: 0 to 32766
Grid size as read: 50 cols by 50 rows
Delta X: 0.714286
Delta Y: 0.612245
X-Range: 405 to 440
Y-Range: 730 to 760
Z-Range: -11.0765 to 0.319953

LOWER SURFACE

Level Surface defined by Z = 0

VOLUMES

Approximated Volume by
Trapezoidal Rule: -4293.29
Simpson's Rule: -4295.77
Simpson's 3/8 Rule: -4295.31

CUT & FILL VOLUMES

Positive Volume [Cuts]: 21.8042
Negative Volume [Fills]: 4315.1
Cuts minus Fills: -4293.29

AREAS

Positive Planar Area
(Upper above Lower): 170.661
Negative Planar Area
(Lower above Upper): 879.339
Blanked Planar Area: 0
Total Planar Area: 1050

Positive Surface Area
(Upper above Lower): 171.396
Negative Surface Area
(Lower above Upper): 1224

VOLUME COMPUTATIONS

UPPER SURFACE

Grid File: C:/AXTF/AX11/AX11.GRD
Rows: 0 to 32766
Cols: 0 to 32766
Grid size as read: 50 cols by 50 rows
Delta X: 0.612245
Delta Y: 0.612245
X-Range: 415 to 445
Y-Range: 680 to 710
Z-Range: -26.2546 to 1.16173

LOWER SURFACE

Level Surface defined by Z = 0

VOLUMES

Approximated Volume by
Trapezoidal Rule: -7431.52
Simpson's Rule: -7434.56
Simpson's 3/8 Rule: -7434.28

CUT & FILL VOLUMES

Positive Volume [Cuts]: 19.247
Negative Volume [Fills]: 7450.77
Cuts minus Fills: -7431.52

AREAS

Positive Planar Area
(Upper above Lower): 56.746
Negative Planar Area
(Lower above Upper): 843.254
Blanked Planar Area: 0
Total Planar Area: 900

Positive Surface Area
(Upper above Lower): 59.4689
Negative Surface Area
(Lower above Upper): 1846.64

VOLUME COMPUTATIONS

UPPER SURFACE

Grid File: C:/AXTF/AX12/AX12.GRD
Rows: 0 to 32766
Cols: 0 to 32766
Grid size as read: 50 cols by 50 rows
Delta X: 0.612245
Delta Y: 0.612245
X-Range: 475 to 505
Y-Range: 570 to 600
Z-Range: -22.313 to 0.0773491

LOWER SURFACE

Level Surface defined by Z = 0

VOLUMES

Approximated Volume by
Trapezoidal Rule: -7771.15
Simpson's Rule: -7774.54
Simpson's 3/8 Rule: -7774.34

CUT & FILL VOLUMES

Positive Volume [Cuts]: 0.0185393
Negative Volume [Fills]: 7771.17
Cuts minus Fills: -7771.15

AREAS

Positive Planar Area
(Upper above Lower): 0.823584
Negative Planar Area
(Lower above Upper): 899.176
Blanked Planar Area: 0
Total Planar Area: 900

Positive Surface Area
(Upper above Lower): 0.919
Negative Surface Area
(Lower above Upper): 1774.04

VOLUME COMPUTATIONS

UPPER SURFACE

Grid File: C:/AXTF/AX13/AX13.GRD
Rows: 0 to 32766
Cols: 0 to 32766
Grid size as read: 50 cols by 50 rows
Delta X: 0.612245
Delta Y: 0.612245
X-Range: 525 to 555
Y-Range: 570 to 600
Z-Range: -22.7918 to 0.290993

LOWER SURFACE

Level Surface defined by Z = 0

VOLUMES

Approximated Volume by
Trapezoidal Rule: -8578.61
Simpson's Rule: -8582.41
Simpson's 3/8 Rule: -8582.03

CUT & FILL VOLUMES

Positive Volume [Cuts]: 0.42165
Negative Volume [Fills]: 8579.03
Cuts minus Fills: -8578.61

AREAS

Positive Planar Area
(Upper above Lower): 6.75232
Negative Planar Area
(Lower above Upper): 893.248
Blanked Planar Area: 0
Total Planar Area: 900

Positive Surface Area
(Upper above Lower): 7.56796
Negative Surface Area
(Lower above Upper): 1877.02

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Project Title/Work Order		EDT No. 622810
HTI - AX TANK FARM WASTE INVENTORY STUDY FOR THE HANFORD TANKS INITIATIVE PROJECT HNF-SD-HTI-TI-001, REV. 0		ECN No.

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