

Table 4-1. Tank Leak Inventory Estimates for A, AX, and C Tank Farms.  
(3 sheets)

Tank	A-104	A-105	C-105	UPR-200-E-81	UPR-200-E-82	UPR-200-E-86
Leak Vol.	2.0 kgal	1 kgal	1 kgal	36 Kgal	2,600 gal	17,400 gal
Analyte	kg	kg	kg	kg	kg	kg
Ra-226	4.67E-07	9.27E-07	1.19E-06	2.01E-07	3.10E-06	1.32E-06
Ra-228	4.24E-07	5.50E-08	1.34E-06	2.11E-04	3.48E-06	1.67E-06
Ac-227	2.71E-06	5.40E-06	7.22E-06	4.93E-05	1.88E-05	2.38E-05
Pa-231	1.51E-05	3.00E-05	4.00E-05	2.74E-04	1.04E-04	1.32E-04
Th-229	9.60E-08	3.02E-08	6.09E-07	9.51E-05	1.58E-06	7.74E-07
Th-232	8.50E-07	1.18E-07	2.87E-06	4.51E-04	7.46E-06	7.14E-06
U-232	4.77E-04	6.88E-06	9.18E-05	8.82E-03	2.39E-04	4.19E-03
U-233	1.84E-03	2.66E-05	3.59E-04	3.43E-02	9.33E-04	1.62E-02
U-234	1.48E-03	1.90E-03	2.33E-03	4.62E-02	6.06E-03	1.29E-02
U-235	6.07E-05	7.95E-05	9.90E-05	1.89E-03	2.57E-04	5.35E-04
U-236	4.05E-05	4.67E-05	4.55E-05	1.38E-03	1.18E-04	3.55E-04
U-238	1.42E-03	1.87E-03	2.36E-03	4.36E-02	6.13E-03	1.24E-02
Np-237	2.22E-03	6.50E-03	7.70E-03	7.63E-04	2.00E-02	1.94E-02
Pu-238	1.40E-02	4.18E-03	2.80E-03	2.88E-02	7.28E-03	1.24E-01
Pu-239	5.94E-01	1.31E-01	1.77E-01	1.20E+00	4.61E-01	5.24E+00
Pu-240	9.77E-02	2.35E-02	2.68E-02	2.14E-01	6.97E-02	8.60E-01
Pu-241	1.01E+00	3.00E-01	2.08E-01	2.30E+00	5.41E-01	8.93E+00
Pu-242	4.96E-06	1.64E-06	7.69E-07	6.49E-06	2.00E-06	4.37E-05
Am-241	2.26E-01	4.49E-01	5.75E-01	8.70E-02	1.50E+00	1.98E+00
Am-243	4.99E-06	1.11E-05	5.81E-06	9.18E-07	1.51E-05	4.36E-05
Cm-242	4.08E-04	1.56E-03	6.06E-04	3.70E-05	1.58E-03	3.56E-03
Cm-243	2.31E-05	1.12E-04	1.61E-05	1.02E-06	4.19E-05	2.00E-04
Cm-244	7.50E-04	1.18E-03	5.00E-04	3.49E-05	1.30E-03	6.61E-03

All radionuclides decayed to 1/1/1994

#### 4.2.3 C and A-AX WMA Transfer Line Leak Data Integration and Interpretation

Numerous transfer line leaks have occurred in the C and A-AX WMAs. Among the tanks, spectral gamma data suggest that the most contaminating leaks occurred between tanks C-104 and C-105, between tanks C-108 and C-109, between A-101 and A-102, between AX-103 and AX-104, and between tanks AX-101 and AX-103. The data that characterize these events (primarily spectral gamma data) was summarized in Chapter 3. In addition, three transfer line leaks near three diversion boxes (241-CR-151, 241-C-151 and 241-C-152) have been reported as unplanned releases in the C WMA. Of these, the two near diversion boxes 241-C-152 (UPR-200-82) and 241-C-151 (UPR-200-86) are the most significant sources of contamination (see Section 4.3). Other unplanned releases were also reported, but their descriptions suggest a minimal vadose zone contamination outcome.

While there are individual differences in the occurrence, extent and waste type discharged to the vadose zone, the conceptual model for the various transfer line discharges of tank waste to the vadose zone and subsequent contaminant migration in the vadose zone is basically similar. Typically, waste leaks from transfer lines for some time before the leak is discovered, either through nearby drywell gamma data or observed collection of water at the near surface. At that point the transfer line was repaired or abandoned.

Contaminants proceed to migrate according to their reactivity with soils and natural infiltration rates. At the C, A and AX Tank Farms, the common gamma-emitting contaminants are Cs-137, Co-60, Eu-154 and Eu-152. Of these, the most reactive and therefore slowest moving contaminant is Cs-137. When drywell spectra gamma data are available the leak location is assumed to be near a drywell exhibiting a sharp high concentration Cs-137 peak at depths consistent with transfer line depths. Cobalt-60 tends to be the least reactive and fastest moving gamma-emitting radionuclide in the C and A-AX WMAs. Spectral gamma data suggest that contaminant migration generally has been limited to an area whose size is on the order of a tank diameter (75 ft [23 m]) or two. However, at C Tank Farm the extent of Co-60 migration may be greater because Co-60 is measured in numerous tanks as much as 250 ft (76 m) away from the two primary transfer line leaks between tanks C-104 and C-105 and between tanks C-108 and C-109. On the other hand when all the Co-60 spectral gamma data are considered in the C Tank Farm, logical patterns linking this Co-60 contamination to these two transfer line locations are not readily discernable. It is plausible that additional leak sources are involved that cannot be clearly identified by the available data (e.g., a tank C-103 leak).

Radionuclide migration may also have been accelerated because of additional artificial water discharge through the vadose zone area contaminated by transfer line leaks. This has rarely occurred at the C and A-AX WMAs or has rarely been identified. One possible occurrence was between tanks A-101 and A-102 on the south side where one or more transfer line leaks are indicated by drywells 10-01-28, 10-01-39, 10-01-16, and 10-01-04. The spectral gamma data show a progression of increased vertical migration of Co-60 in the vadose zone away from the apparent source, and gross gamma data interpretation at drywell 10-01-04 show a clear and rapid vertical migration of Co-60 from the late 1970s and through the 1980s. Just to the north of this area a raw water line break occurred in 1978, which was sufficient to cause soil cave in between tanks A-102 and A-105. At the same time increased activity in nearby laterals was also observed. It is therefore postulated that enhanced migration of transfer line leak waste occurred.

#### **4.3 TANK LEAK AND TRANSFER LINE INVENTORY ESTIMATES**

The approach used in developing quantitative leak inventory estimates is the same as that used in previous tank leak inventory estimates (Jones et al 2000a, Jones et al 2001b). The best estimates of actual leak volumes were combined with waste composition estimates at the suspected time of the waste loss events. The uncertainty of the inventory estimated depends mainly on the volume estimates and time of the leak. At least for the major constituents of the tank wastes, reasonable composition estimates are available as long as there has not been major commingling of waste types.

### 4.3.1 C Tank Farm

Except for tank C-105, there is essentially no evidence to support listing any of the C Farm tanks as known or suspected leakers. An inventory is provided in Table 4-1 for a nominal 1-kgal leak volume from tank C-105. If results for future investigations indicate a different leak volume the reported results can be scaled appropriately.

Outside the C Tank Farm, the most significant contamination comes from two transfer line leaks of PUREX high activity waste at the western edge of the C WMA, identified in the Waste Information Data Base System (WIDS) as UPR-200-E-82, and UPR-200-E-86. Report UPR-200-E-82 describes the loss of Cs-137 Recovery Process feed solution being pumped from tank C-105 to the B Plant. The leak occurred near the 241-C-152 Diversion Box and involved the loss of approximately 2,600 gallons of liquids (Tanaka 1971). The inventory estimate was developed assuming a PUREX high-level waste supernatant template. These results are listed in Table 4-1. Report UPR-200-E-86 describes a waste loss event associated with a pipeline break near the southwest corner of the C Tank Farm. Fluids were being pumped from the 244-AR Vault to the C Tank Farm. Approximately 17,400 gal of fluid that contained approximately 25,000 Ci of Cs-137 were lost to the soil (Maxfield 1979). The inventory estimate was developed using the "AR waste type" template (Agnew 1997). These results are listed in Table 4-1. The large estimated Tc-99 inventory from these events is a primary contributor in the C WMA to long-term risk estimates.

Two other transfer line leaks involved the loss of PUREX cladding waste. First, report UPR-200-E-81 describes a 1969 waste loss event that occurred near the 241-CR-151 Diversion Box and involved the loss of 136,000 L (36 Kgal) of PUREX cladding waste (Williams 2001, Maxfield 1979). The PUREX cladding waste was a reasonably low activity waste stream produced from the caustic dissolution of the aluminum fuel rod cladding. The origin of the radioactive contamination in this waste stream was congruent dissolution of the uranium fuel during the de-cladding operation. Inventory estimates for the waste loss event use the PUREX cladding waste composition used in the Hanford defined waste (HDW) Model for PUREX cladding waste (CWP2) (Agnew 1997). These inventory estimates are given in Table 4-1. Second, there is also a small overland piping leak (50 gal) involving the loss of PUREX cladding waste between tanks C-105 and C-108, documented in UPR-200-E-16. A negligible inventory is associated with this leak.

The final contamination source in the C WMA is generalized near-surface contamination across the C Tank Farm where Cs-137 contaminates the vadose zone between the surface and 15 ft (5 m) bgs to levels of about 10 pCi/g. About a dozen of the drywells in the farm have Cs-137 gamma activity that peaks at or above 100 pCi/g in the upper 15 feet of the vadose zone, with the most contaminated zones occurring between tanks C-104 and C-105 and between tanks C-108 and C-109. Inventory estimates of near surface contamination can be made for a generalized level of contamination and for transfer line 'hot spots'.

An inventory estimate based on the generalized level of Cs-137 (10 pCi/g) contamination is insignificant when compared to other Cs-137 inventory estimates in this tank farm. For example, if one assumes a surface area of 400 ft by 400 ft down to a depth of 15 ft with a soil density of 1.7 g/ml and a Cs-137 contamination level of 10 pCi/g, the estimated inventory of Cs-137 is

1.1 Ci. Assuming a PUREX high activity waste or B Plant isotope recovery source, other constituents can be scaled from the Cs-137 estimate. For example, a Tc-99 inventory estimate can be made assuming the Cs-137 is 1,000 to 10,000 times more abundant than Tc-99 in the discharged waste. Even if this Cs-137 inventory estimate increased by 2 or 3 orders of magnitude, both Cs-137 and other constituent inventories would still be insignificant compared to that from other losses in the C WMA.

A similar calculation can be done for smaller contamination zones affected by transfer line leaks with somewhat high Cs-137 concentrations distributed over a depth interval of a few feet. For example, at the transfer line leak between tanks C-104 and C-105, the maximum Cs-137 concentration approaches 1,000 pCi/g for a 1 ft depth interval. Assuming contamination in the area between four tanks (roughly a 25 ft (8 m) square down to about 20 ft (7m) bgs, a Cs-137 inventory of < 0.1 Ci Cs-137 is calculated. Based on these calculations it is clear that near-surface contamination inventories from small transfer line leaks are also insignificant compared to the high activity waste loss events from tank C-105, UPR-200-E-82 and UPR-200-E-86.

#### 4.3.2 A-AX Waste Management Area

Inventory estimates are provided for a nominal 1-kgal leak for tank A-105 and a 2 kgal leak for tank A-104. The results reported in Table 4-1 were scaled from previously reported estimates (Simpson et al 2001). If results for future investigations indicate a different leak volume the reported results can be scaled appropriately.

As in C Tank Farm, low concentration near surface contamination is frequently observed in A and AX Tank Farms as well as occasional 'hot spot' higher contamination zones created by small transfer line leaks and other tank farm activities (e.g., between tanks A-101 and A-102, an apparent pump pit leak created a higher-level contamination zone). Simple calculations similar to those described for C tank indicate that currently existing vadose contamination is small (< 3 Ci of Cs-137 from these sources) and not significant as a potential source for future groundwater contamination. Additional inventory estimates are available for near-surface leaks in the AX Tank Farm (Hendrickson et al 1997).

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## **5.0 RECOMMENDATIONS FOR FURTHER CHARACTERIZATION OF THE C AND A-AX WMAS**

Chapters 1 through 3 present information pertinent to the occurrence of contaminants in the vadose zone underlying the C and A-AX WMAs. Chapter 4 presents qualitative hypotheses of events leading to the observed vadose zone and aquifer contamination. From these observations and process knowledge, the primary locations of interest for additional aquifer contamination have been identified. For most of these areas, contamination extensive enough to warrant remediation is not expected. However, further characterization is recommended primarily because of the following three data gaps.

- The volumes of most leaks are not well documented because no clear means of measuring leaks was available.
- Analyses of leaked waste fluid chemistry are rare and incomplete.
- The spectral gamma data do not provide information about the nature and extent of non-gamma-producing contaminants. In particular, the distribution and inventory of technetium-99 is of interest.

### **5.1 DESCRIPTION OF CHARACTERIZATION ALTERNATIVES**

The primary goal of additional characterization is to determine the nature and extent of tank waste contaminants near known or suspected leaks. This is to be done primarily through sampling soil in the regions of interest and analyzing the samples for expected contaminants of concern; soil water pH, electrical conductivity, moisture content, and, if feasible, hydrologic properties. Of particular interest are known mobile constituents, technetium-99 and nitrate. Other contaminants, particularly Cs-137 and Co-60, are of interest because they provide some indication of contaminant migration and distribution. Neither radionuclide is expected to contaminate groundwater to unacceptable levels in the future (see Field Investigative Reports for S-SX and B-BX-BY Waste Management Areas [Knepp 2002 and 2003]).

Table 5-1 lists the most highly contaminated vadose zone areas in the C and A-AX WMAs and the critical factors that influence future characterization decisions. These factors are primary indicators of the nature and extent of contamination underlying these WMAs in the vadose zone and are listed for separate, potentially significant contamination zones associated with the tanks listed in the top row of the table. The primary critical factors are leak volumes and contaminant inventory and distribution. Leak volume estimates are based on several sources where available, including historic liquid level measurements, waste transfer records, and gamma-emitting radionuclide distributions in the vadose zone. Contaminant distribution is indicated by the location and concentration of gamma-emitting radionuclides in drywells.

Table 5-1. Critical Factors Evaluations/Recommendations

Critical Factors	Vadose Zone Contamination Areas										
	Tank Leaks			Near Surface Leaks (Transfer Lines or Surface Spills)							
	C-105	A-104	A-105	C-104 / C-105, C-108/ C-109	A-101/ A-102	AX Tank Farm drywell 11-01-10	drywell 11-02-12	UPR-200-E-81	UPR-200-E-82	UPR-200-E-86	
Discharge Volume Estimate (gal)	1000	2000	1000	Unknown	Unknown	Unknown	Unknown	36000	2,640	17400	
Drywell/Lateral Coverage	Fair	Fair	Fair	Good	Good	Good	Good	None	None	None	
Leak Boundary Controls	Fair	Good	Good	Good	Good	Good	Good	None	None	None	
Gamma-Emitting Radionuclide Contamination Depth (ft below ground surface [bgs])	Tank bottom (50) to ?	Lateral Depth (60) to ?	50 to 70	25 to 70	25 to 70	3 to 30	10 to 30	Unknown	Unknown	Unknown	
Relative Vadose Zone Contamination Level Among C, A and AX Sites	Medium	Low	Medium	Medium	Medium	Low	Low	Low	High	High	
Maximum Cs-137 concentration in spectral gamma data (pCi/g)	~10,000,000	Unknown	Unknown	~1,000	~100	40,000	4,000	Unknown	Unknown	Unknown	
Estimated Cs-137 Inventory (Ci)	6,330	2,370	9,600	<0.1	<1	<3	<1	377	16,500	20,800	
Estimated Tc-99 Inventory (Ci)	1.9	0.7	2.7	<0.001	<0.1	<0.001	<0.001	0.1	5.0	6.2	
Recommended Approach											
Spectral Gamma Logging		X	X								
Borehole	Evaluate feasibility to deepen drywell 30-05-07; if feasible, drill to 250 ft bgs								Drill borehole near leak location to Plio-Pleistocene		

- (a) Estimate of volume discharged to the vadose zone
- (b) Estimates in this report
- (c) Maxfield (1979)
- (d) Tanaka (1971)
- e) Logging recommended for laterals under these tanks

Estimates of key radionuclide inventories are based on process records of waste types present in the tank or transfer lines at the time of the leak, waste chemistry flow sheet records, the Hanford Defined Waste (HDW) Model (Agnew, 1997) and historic chemical analyses of supernatant, when available. The technetium-99 values shown in Table 5-1 were generated from a combination of these sources. Quantitative estimates of the critical factors are provided in Table 5-1 where available and appropriate. Other factors are qualitative and quantities are defined relatively. Finally, leak volume and contaminant information are evaluated for reliability and consistency.

The second part of Table 5-1 lists the primary additional characterization options that were chosen to improve the estimate of the nature and extent of contamination in the vadose zone underlying single shell tank farms. These were selected from a variety of characterization methods including the following:

- Direct push or cone penetrometer characterization allows limited downhole measurements (gamma and moisture measurements) and soil sampling. The primary limitation of the technique is that the feasible penetration depth is shallow under tank farm conditions, typically 30 to 40 ft (9 to 12 m), preventing exploration of contaminated soils beneath the tank bottom. Thus, this technique is potentially useful only if the contamination of interest exists above the tank bottom.
- Borehole drilling and sampling provide the greatest potential for collecting soil samples and indirect measurements. These techniques can be used anywhere in the soil column unoccupied by tanks and infrastructure. For the technique to be useful, sufficient evidence of contamination must be available to properly place the borehole in a location that intercepts the more highly concentrated portion of the contamination zone.
- Kriging is a mathematical technique for extrapolating or interpolating concentration data in a given region based on discrete data points within that region. This technique is useful only if data points of sufficient number and density are available. Given the present database, insufficient concentration data are available for the contaminated vadose zone areas in the C and A-AX WMAs.
- Additional spectral gamma logging provides updates to spectral gamma data collected previously. This technique can be used anywhere drywells or laterals underlying tanks in the WMA exist. Drywells exist in all three tank farms and laterals are present in the A Tank Farm.

## **5.2 RECOMMENDATIONS FOR ADDITIONAL CHARACTERIZATION IN THE C AND A-AX WMAS**

Proposed characterization options are indicated in Table 5.1. Characterization is recommended for the contamination zones near the bottom of tank C-105, at the unplanned release location just southeast of the 241-C-152 and in the laterals underlying tanks A-104 and A-105. Collectively, this combination of characterization targets comprises all primary vadose zone contamination sites in the C and A-AX WMAs.

Further characterization is not recommended for the areas between tanks C-104 and C-106, between tanks C-108 and C-109, near diversion boxes on the west side of C Tank Farm, between tanks A-101 and A-102, and between tanks AX-101, AX-103 and AX-104. The primary reason is that conservative calculations of mobile radionuclide inventory in these areas indicate that inventory estimates of environmentally mobile constituents are too low to present a potentially significant long-term risk to the environment. Further characterization is also not recommended for various tanks listed as leakers in Hanlon (1999). These include tanks C-101, C-110, C-201 through C-204, A-103, AX-102 and AX-104. The vadose zone contamination resulting from these leaks is either fictitious or of insufficient contamination levels to be of concern.

### 5.2.1 Characterization of the Tank C-105 Leak

Two high concentration zones of cesium-137 (up to  $10^7$  pCi/g) are present in drywell 30-05-07 adjacent to the southwest side of the tank, concentration values that exceed gamma concentrations in all other contaminated areas in the C, A and AX WMAs by at least three orders of magnitude. This distribution strongly indicates the occurrence of a leak near the bottom of the tank. Tank C-105 has not been reported previously as a leaking tank but liquid level drops were recorded in the 1960s. The high cesium-137 concentration zones have been attributed to a leaking transfer line between tanks C-104 and C-105 but the probable waste chemistry and cesium-137 distribution patterns in the area do not support this hypothesis. This potential leak is of interest from a risk perspective because process records suggest that the waste is either high activity PUREX waste or cesium recovery waste, both of which are characterized by high technetium-99 concentrations.

Currently, neither the waste leak volume nor the real distribution of contaminants in the vadose zone is very well understood. Consequently, it is recommended that sampling and analysis of contaminated soils be completed if possible. Gaining access to the contaminated zone does present difficulties. The high contamination zone is only expressed in the one drywell very close to the tank sidewall and it is likely that some contamination exists underneath the tank.

Two approaches to sampling this zone are considered. The first is to drill a slant borehole underneath tank C-105. However, the area is congested with other drywells and piping systems. In addition, it is difficult to drill a slant hole at an angle that comes close to the bottom of the tank (e.g., within 10 ft [3 m]). Thus, there is a real possibility that the contamination zone would be missed. The second and recommended approach is to examine the feasibility of deepening the drywell in which high Cs-137 concentrations have been observed (30-05-07) and collecting soil samples down to the Plio-Pleistocene about 250 ft (76 m) bgs. If this approach is feasible then it should be implemented. The data to be collected are a complete set of chemical and radiological soil sample analyses with depth. The distribution and concentration of technetium-99 with depth are of particular interest. This database will increase substantially our understanding of the nature and extent of non-gamma-emitting constituents in this zone because no information exists presently.

### **5.2.2 Characterization of Waste Transfer Line Leaks in the C WMA**

Historical records and previous field characterization efforts indicate that the largest contamination events in the C WMA were two unplanned releases of high activity derivatives of PUREX waste in waste transfer lines at the western edge of the C WMA, UPR-200-E-82 in 1969 and UPR-200-E-86 in 1971. Both transfer line leaks are estimated to have released collectively about 11 curies of Tc-99, the primary constituent of concern for future groundwater contamination. The contamination zone created by UPR-200-E-82 is the preferred alternative site even though a smaller volume, but more concentrated leak occurred here. The historical documentation of the leak is more complete at this site and locating the contamination zone should be more straightforward.

The primary characterization goal is to determine the extent of vertical migration of this and other mobile constituents (e.g., nitrate) over a thirty-year period and to provide a well-defined source location for estimates of future migration towards the unconfined aquifer. The recommended characterization approach is to complete a borehole down to the Plio-Pleistocene about 250 ft (76 m) bgs and collect a complete set of chemical and radiological soil sample analyses with depth. The combination of these data with the tank C-105 borehole data should also provide a useful indication of the effects of tank structures on infiltration rates.

### **5.2.3 Collection of Spectral Gamma Data from Lateral Underlying Tanks A-104 and A-105**

Loss of tank integrity for tanks A-104 and A-105 were demonstrated in 1965 by the occurrence of gross gamma measurements in several laterals that underlie these two tanks. In this report it has been concluded that a relatively small loss of tank waste to the vadose zone has occurred in each tank, a conclusion that, in the case of tank A-105, is considerably smaller than the volume estimates provided in Hanlon (2002). The basis for the smaller volume estimate in this report is the lack of measured Cs-137 contamination in the drywells surrounding tank A-105. Given the estimated waste loading at the time of the leak, a large volume release should have distributed measurable Cs-137 over an area large enough to intersect the drywell locations.

The most direct means of measuring Cs-137 in the vadose zone is to relog the laterals underlying the tanks to collect spectral gamma data. The gamma emitting radionuclides that created the initial measured radiation were short-lived fission products (e.g., Ru-106). The data to be collected in the relogging effort will determine the concentrations of specific gamma-emitting radionuclides still present in the vadose zone near the laterals. By now, the primary gamma-emitting radionuclide should be Cs-137. If minimal concentrations of Cs-137 are found in laterals measurements about 10 ft (3 m) from the leak location, then the released tank waste volume will be constrained to a minimal value.

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**APPENDIX A**  
**HISTORICAL BACKGROUND OF C, A AND AX TANK FARMS OPERATIONS AND  
CONTAMINATION EVENTS**

### A.1.0 INTRODUCTION

This appendix includes narrative description from *Historical Vadose Zone Contamination from A, AX, and C Tank Farm Operations* (Williams 2001). Williams (2001) is a primary document supporting this report that describes tank farms operations history and provides the evolution of tank farm infrastructure. The narrative from Williams (2001) describing tank farm history and tables of liquid discharge events are provided in this appendix. Drawings of the tank farm infrastructure layout that existed with each of the major processing activities (e.g., bismuth phosphate processes and PUREX waste storage) are provided in the referenced document.

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**HISTORICAL VADOSE ZONE CONTAMINATION  
FROM A, AX, AND C TANK FARM OPERATIONS**

**AUGUST 2001**

**Prepared by Fluor Federal Services  
for  
CH2M HILL Hanford Group, Inc.**

**HISTORICAL VADOSE ZONE CONTAMINATION  
FROM A, AX, AND C TANK FARM OPERATIONS**

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**ABBREVIATIONS/ACRONYMS**

<b>B</b>	<b>High-level waste generated by B Plant from 1967 to 1978</b>
<b>BL</b>	<b>Intermediate-level waste generated by B Plant from 1967 to 1978.</b>
<b>CWP</b>	<b>PUREX coating waste</b>
<b>DCRT</b>	<b>Double-contained receiver tank</b>
<b>DST</b>	<b>Double-shell tank</b>
<b>FP</b>	<b>Waste generated by B Plant from 1963 to 1967</b>
<b>HS</b>	<b>Waste generated by Strontium Semiworks from 1961 to 1967</b>
<b>ITS</b>	<b>In-tank solidification</b>
<b>LERF</b>	<b>Liquid Effluent Retention Facility</b>
<b>MW</b>	<b>Metal waste</b>
<b>OWW</b>	<b>Organic Wash Waste</b>
<b>PAW</b>	<b>PUREX acid waste (same as P, CAW, HAW, or IWW)</b>
<b>PSN</b>	<b>PUREX supernatant waste</b>
<b>PUREX</b>	<b>Plutonium-Uranium Extraction (Plant)</b>
<b>SNAP</b>	<b>Space Nuclear Applications Program</b>
<b>SST</b>	<b>Single-shell tank</b>
<b>TBP</b>	<b>Tri-butyl phosphate</b>
<b>UNH</b>	<b>Uranyl nitrate hexahydrate</b>
<b>UPR</b>	<b>Unplanned release</b>
<b>WESF</b>	<b>Waste Encapsulation and Storage Facility</b>
<b>WIDS</b>	<b>Waste information data system</b>
<b>1C</b>	<b>Bismuth Phosphate first-cycle waste</b>
<b>2C</b>	<b>Bismuth Phosphate second-cycle waste</b>
<b>224</b>	<b>Plutonium concentrator waste</b>
<b>5-6</b>	<b>B Plant cell drainage waste</b>

## GLOSSARY

**Crib:** An underground liquid waste disposal site filled with soil and/or crushed gravel utilizing the ion exchange properties to remove radioactive contamination. Typically, cribs were operated until contamination was observed in the groundwater beneath the crib.

**Double-Contained Receiver Tank (DCRT):** A reinforced concrete structure containing a receiver tank for radioactive liquid waste, a pump pit, and a filter pit.

**French Drain:** A buried horizontal pipe filled with rock, open-ended or perforated, for disposal of liquid waste by seepage into the ground.

**Interim Isolation:** The process of establishing at least one physical barrier to any credible source of liquid addition to a single-shell tank or other facility, such as a diversion box, and separating the tank atmosphere from the outside air by a filtered ventilation system.

**Interim Stabilization:** The process of pumping all supernatant waste and as much drainable interstitial liquid as possible from a single-shell tank, typically using a saltwell pump, to minimize the volume of liquid available to leak into the ground.

**Reverse Well:** A buried vertical pipe with the lower end open or perforated to allow seepage of liquid waste into the ground. Also called *dry well*.

**Specific Retention Trench:** An unlined excavation used for the disposal of a designated volume of low-level or intermediate-level radioactive waste. Liquid is retained in the trench soil and does not migrate to the groundwater.

**Supernate:** The supernatant liquid in a tank when all suspended solids have settled.

**Tank Bump:** A sudden release of a steam bubble from stratified waste in a tank, caused by radiolytic heating of the waste.

**Vadose Zone:** The portion of the soil below the surface but above the groundwater.

**WIDS:** The waste information data system (WIDS) comprises the official summary of the history and status of the Hanford waste sites. A general summary report is maintained for each site.

## HISTORICAL VADOSE ZONE CONTAMINATION FROM A, AX, AND C TANK FARM OPERATIONS

### 1.0 INTRODUCTION

This document is a collection of historical information regarding radioactive contamination of the soil surface and vadose zone in the vicinity of the 241-A, 241-AX, and 241-C Tank Farms. Specifically, the information is compiled for the tank farms, all known liquid waste disposal sites (cribs), and all known unplanned releases (UPRs) in the vicinity. The area of interest is shown in Figure 1 (all figures are in Appendix D). Releases are included from initial construction in 1944 to the present. Tables showing disposal sites and UPRs are contained in Appendix A.

Four UPRs have been remediated and are not included in this report:

- On October 15, 1974, contaminated soil was discovered in 241-A Farm (UPR-200-E-47). The contaminated soil was removed and the area released for normal service.
- On November 22, 1974, the 241-A-106 pump pit contaminated the 241-A Farm parking lot (UPR-200-E-48). The area was cleaned and returned to normal service the same day.
- On May 23, 1979, contaminated mud was found in swallow nests at the 244-AR vault, and contaminated tumbleweeds and mud were found outside the containment bag in the 216-A-40 retention basin (UPR-200-E-59). The nests and tumbleweeds were removed, and the basin was decontaminated. The basin was backfilled and the surface stabilized in 1994.
- The soil around the 244-CR vault became contaminated from the numerous piping modifications (UPR-200-E-99). The site was decontaminated in 1981 and released from radiological controls.

Nonradioactive releases (such as fuel spills and septic tanks) and buried radioactive solid waste are excluded from this report. Water discharges to the soil, from precipitation, water line leaks, or decontamination activities, are addressed in Gaddis (1999).

A timeline of events is shown in Appendix B. Crib discharge histories are in Appendix C.

The primary focus of this report is on tank farm operations, which includes spills, tank leaks, and crib discharges. Crib discharges are the largest contributor of vadose zone contamination. Crib disposal outlets are typically located 3 to 10 meters below grade, while most spills occur above ground level and contaminate only the surface. Many spill sites were quickly cleaned up and decontaminated. Additionally, the sitewide volume of waste discharged to cribs is more than 100 times the volume of waste leaked from the tanks (Consort 1994).

The groundwater beneath the A/AX/C Tank Farm complex is approximately 80 meters under ground with a very small ( $2E-04$ ) hydraulic gradient. The flatness makes it difficult to ascertain

the flow direction. Generally, groundwater under A/AX Farms moves to the east, and groundwater under C Farm moves to the southwest, at about 1 meter per day. The groundwater level beneath 200-East Area has been decreasing gradually since B pond was decommissioned in 1995 (Hartman 2001).

The topography of C Farm and of A and AX Farms is such that precipitation can run onto the farm and develop into standing water. Provisions for controlling run-on contamination are described in Gaddis (1999).

## 2.0 SUMMARY AND CONCLUSIONS

A number of significant discharges of radioactive contamination to the surface soil and vadose zone occurred throughout the operating history of the Hanford Site. The most significant discharges to the area of interest around the A/AX/C Farm complex are summarized as follows:

- Cribs 216-A-8 and 216-A-24 received a total of 1.97E+09 L of single-shell tank (SST) condensate.
- Crib 216-A-9 received 9.81E+08 L of PUREX acid fractionator condensate.
- Cribs 216-A-1, 216-A-18, 216-A-19, and 216-A-20 received a total of 2.65E+06 L of PUREX cold startup waste.
- The largest spill was UPR-200-E-81 (1.36E+05 L). The largest tank leaks were from 241-C-101 (9.10E+04 L) and 241-AX-104 (3.0E+04 L).

Other cribs in the 200-East Area are outside the scope of this report but are mentioned here for comparison. Cribs 216-A-6, 216-A-30, and 216-A-37-2 received 7.7E+09 L of PUREX plant steam condensate. Cribs 216-A-5, 216-A-10, and 216-A-45 received 5E+09 L of PUREX process condensate. Crib 216-A-37-1 received 3.8E+08 L of 242-A evaporator condensate. The BC cribs and trenches received 1.10E+08 L of scavenged tributyl phosphate (TBP) waste.

This report supports previous work on discharges to the cribs associated with the B/BX/BY and T/TX/TY Tank Farm complexes (Williams 1999; Williams 2000). Unlike the B/BX/BY and T/TX/TY Tank Farms, the A/AX/C Tank Farm complex is not completely deactivated. Interim stabilization operations will continue for several more years, and the possibility exists that future contamination events could occur.

## 3.0 FACILITIES HISTORICAL BACKGROUND

The 241-C Tank Farm contains 12 first-generation, reinforced concrete tanks with carbon steel liners covering the sides and bottoms. The tanks are 23 m (75 ft) in diameter and 4.9 m (16 ft) deep, with a capacity of 2 million liters (530,000 gallons). The tanks are arranged in four rows of three tanks. The tanks in each row are piped together so that when the first tank fills, it overflows (cascades) into the second tank, and the second into the third. Four diversion boxes were originally provided in C Farm; another three diversion boxes, the 244-CR process vault, the 271-CR control house, 271-CRL laboratory, and the 241-C-801 cesium loadout facility were built later. The farm also contains four smaller "200-series" tanks that are 6.1 m (20 ft) in

diameter and hold 0.2 million liters (55,000 gallons). These four tanks are piped to diversion box 241-C-252.

The 241-A Tank Farm contains six third-generation tanks similar to C Farm tanks but are 9.1 m (30 ft) deep with a 3.8 million liter (1 million gallon) capacity. The tanks are filled individually and do not cascade. Tanks were connected to each other by overflow lines (which had a water-filled seal loop to isolate individual tanks) and a common vapor header, also with water-filled seal loops. A Farm contains two diversion boxes and no 200-series tanks. A Farm also contains the 241-A-431 vent building, the 241-A-271 control building, and the 241-A-701 compressor building. The 241-A-401 condenser building, the 241-A-417 catch tank, the 241-A-702 filter building, and the 241-A-350 drainage lift station were constructed later. Since A Farm was designed to store boiling waste, it was equipped with leak detection caissons and laterals (see Section 4.0) (Anderson 1990).

The 241-AX Tank Farm contains four, fifth-generation tanks. These tanks are identical to the tanks in A Farm, but with a grid of drain slots beneath the steel liner bottom. The grids collect potential tank leakage, which is diverted to a leak detection well. The grids also provide an escape route for free water formed as it is released from the concrete grout during initial heating of the tank. AX Farm contains the 241-AX-152 diverter station and the 2707-AX change house, but no 200-series tanks. AX Farm has no leak detection caissons (Anderson 1990).

Other facilities located in and around the A/AX/C Farm complex are:

- 244-AR vault
- 241-AX-151 diverter station
- 204-AR unloading station
- 244-A lift station

The A/AX/C complex operations can be separated into six operational phases:

- Construction and bismuth phosphate operations, 1944-1952
- Uranium recovery operations, 1952-1957
- PUREX operations 1956-1972, 1983-1988
- Waste fractionation operations 1961-1978
- Tank farm interim stabilization and isolation began in 1975

Sanitary water was provided to the 271-CR control building in C Farm. Sanitary water was provided to the 241-A-271 control building in A Farm. Later, sanitary water was provided to the 2707-AX change house in AX Farm, the 244-AR vault, and the 242-A evaporator.

### 3.1 CONSTRUCTION AND BISMUTH PHOSPHATE OPERATIONS (1944-1952)

The Hanford Site was constructed as part of the Manhattan Project to produce plutonium by chemical separation from irradiated fuel slugs using the bismuth phosphate process. Preliminary design (1943) called for four separations plants (B, C, T, and U) and their associated tank farms, but later development reduced that number to three. C Plant construction was cancelled, but by that time, 241-C Tank Farm had already been built. Figure 2 shows facilities constructed during that time.

The bismuth phosphate process produced five waste streams:

- Metal waste (MW) was the byproduct from the plutonium separation phase of the bismuth phosphate process. MW contained unfissioned uranium and approximately 90% of the fission products of the irradiated fuel.
- First-cycle waste (1C) was the byproduct from the first plutonium decontamination cycle of the bismuth phosphate process. This waste contained about 10% of the fission products of the irradiated fuel. This waste also contained coating-removal waste.
- Second-cycle waste (2C) was the byproduct from the second and last plutonium decontamination cycle of the bismuth phosphate process. This waste contained less than 0.1% of the fission products of the irradiated fuel. C Farm did not store 2C.
- The 224 waste was low-level liquid waste from the 224-B plutonium concentrator building. This waste stream was the primary contributor to plutonium contamination of the soil. This waste was discharged to the 216-B-5 reverse well, which is outside the scope of this report but is described in Williams (1995).
- The 5-6 waste was low-level liquid waste from floor drains in individual process cells in B Plant. Drainage from the cells was stored in the 5-6 tank before being discharged to the 216-B-5 reverse well.

During World War II, MW, 1C, and 2C were stored in tanks at B Farm, which is outside the scope of this report but is described in Williams (1999). In December 1946, underground lines were constructed from the 241-B-154 diversion box near B Plant to the 241-C-151 and 241-C-152 diversion boxes in C Farm (see Figure 3). MW from B Plant was stored in the 241-C-101/2/3 and 241-C-104/5/6 cascades, and 1C from B Plant was stored in the 241-C-107/8/9 and 241-C-110/1/2 cascades (Anderson 1990).

Ground disposal of aqueous industrial waste, relying on the ion exchange properties of the soil to decontaminate the water as it percolates to the aquifer, was a commonly accepted method in the 1940s. The ability of Hanford topsoil and substrate to adsorb radioactive material was tested at the Clinton Site in Tennessee (now the Oak Ridge National Laboratory) and at the University of California at Berkeley in 1944. Tests determined that ground disposal of 5-6 and 224 was acceptable, but ground disposal of 1C and 2C was not. Methods to treat 1C and 2C to facilitate ground disposal were investigated at the time, but were unsuccessful (Parker 1944; Patterson 1945; Leader 1945).

In September 1946, the Army Corps of Engineers Manhattan District selected General Electric Company to replace DuPont as the Hanford prime contractor. Pursuant to the McMahon Atomic Energy Act of 1946, control of the Hanford Site passed from the Army to the civilian Atomic Energy Commission (AEC) on January 1, 1947. The AEC opted to maintain Hanford as a permanent facility rather than dismantle it, as happened to many other wartime munitions plants. Wartime production had filled all available tank storage space, so plans were made to increase

high-level waste storage capacity and to recover some tank space. These plans included disposing of the relatively low-level 2C waste into the ground, and concentrating the intermediate-level 1C waste in an evaporator. Plans were also made to recover the unfissioned uranium in the MW (by 1947, most of the world's known supply of uranium was in the Hanford Site waste tanks) (Gerber 1991).

From 1947 to 1949, many new facilities were constructed at Hanford. The Hot Semi-Works complex, facilities for the planned uranium recovery mission (see Section 3.2), and other facilities beyond the scope of this report (BX, BY and TX Tank Farms, Z Plant, H Reactor, DR Reactor) were all built during this period (Gerber 1991). Figure 3 shows facilities constructed for post-war bismuth phosphate and uranium recovery operations.

The 242-B and 242-T evaporators were built in 1951 to reduce the volume of stored 1C. C Farm 1C was retrieved from January to March 1952 and evaporated in 242-B. A dedicated underground line (V121) was built for retrieval, and the waste was pumped from 241-C-152 to 241-B-154 to 241-B-152, which connected to evaporator feed tank 241-B-106. B Plant was shut down in 1952 (Anderson 1990; Williams 1999). The operations in 242-B are described in Williams (1999).

Conflicting information exists regarding the piping used for 1C retrieval. Line V121 is shown on drawing H-2-2021, but this drawing has no "as-built" note. The piping encasement from the 241-CR-151 diversion box to the 200-series tanks is shown in the same location as V121 on drawing H-2-41126, which gives an "as-built" date of October 14, 1952. Anderson (1990) says that 1C retrieval was finished on August 15, 1952, and MW retrieval in the 200-series tanks began no earlier than October 1953. This leaves over a year to remove V121 and build the encasement, however drawing H-2-41126 indicates it may have been only two months. Installation of a dedicated line for 1C retrieval was done for T, TX, and U Farms. Most likely, V121 was installed and used, then removed when the encasement was built in September 1952. It is possible that the "as-built" dates on some drawings may be wrong.

No UPRs occurred in C Farm during this time.

### 3.2 URANIUM RECOVERY OPERATIONS (1952-1957)

U Plant was originally constructed during World War II as a bismuth phosphate plant, but was not needed for that purpose, and the facility was used as a simulator. It was modified in 1951 for uranium recovery operations using the TBP process. For this reason, U Plant was frequently referred to as the "TBP Plant." Beginning in October 1952, MW was sluiced from tanks in C Farm, treated in the 244-CR process vault, and transferred to U Plant via the cross-site transfer line. MW in the 200-series tanks was sluiced out in early 1954. MW from B, T and U Farms was also sent to U Plant for uranium recovery. Newly generated MW from T Plant was also sent to U Plant for uranium recovery, until T Plant shutdown in 1956. Uranium recovered by this method was in the form of uranyl nitrate hexahydrate (UNH), which was sent to the 224-U building for conversion to UO<sub>2</sub>. 224-U was known as the "UO<sub>2</sub> Plant" (Rodenhizer 1987; Anderson 1990).

The uranium recovery facilities in C Farm include the 271-CR control house, the 244-CR vault, the 241-CR-151, -152, and -153 diversion boxes, and modifications to the underground piping system. Other facilities which are outside the scope of this report, but relevant, include the cross-site transfer line, the 241-ER-151 diversion box near B Plant, the BY cribs, and the BC cribs. Figure 3 shows facilities constructed for uranium recovery.

Uranium recovery operations produced two waste streams: TBP waste and low-level waste. TBP waste, concentrate from the waste concentrator, was returned to the tank farms, including C Farm (all tanks). The design called for the same volume of TBP waste to be produced as the volume of MW processed, but inefficiencies in the process resulted in approximately twice as much TBP waste produced as the MW processed. A total of 215 million liters of TBP waste was produced. Low-level waste included condensate from the feed concentrator, waste concentrator, and HNO<sub>3</sub> fractionator. This waste was sent to various cribs that are outside the scope of this report. Cooling water and cell drainage from the TBP Plant were discharged to U pond, also outside the scope of this report (Waite 1991; DiLorenzo 1994; GE 1951).

Despite additional tank farm construction and ongoing volume reduction efforts, tank space was not sufficient to support both the uranium recovery mission and plutonium production. To reduce the volume of stored waste, TBP waste was concentrated in the 242-T and 242-B evaporators beginning in July 1953 (very little C Farm waste was evaporated – some from 241-C-112 in the third quarter of 1953). Additionally, a ferrocyanide scavenging process was developed to remove the principal long-lived fission products, <sup>137</sup>Cs and <sup>90</sup>Sr, from the TBP waste to enable disposal of the waste supernate to the cribs. Beginning in September 1954, TBP waste was scavenged in U Plant, instead of being evaporated. The scavenged waste from U Plant was transferred to BY Farm only (see Williams 1999) (Anderson 1990).

The 244-CR vault was modified in 1955 to scavenge TBP waste that was stored in C Farm, and the 241-C-601 chemical makeup building was constructed. Nickel ferrocyanide was added to the TBP waste, which caused the <sup>137</sup>Cs to precipitate and join the <sup>90</sup>Sr in sludge settling at the bottom of the vault tank. The scavenged waste supernate could then be discharged to cribs. New piping was installed to facilitate TBP retrieval from the 241-C-107/8/9 and 241-C-110/1/2 cascades. TBP could be jetted out of these tanks to the 241-C-104 pump pit and transferred to the 244-CR vault via the existing encasements. Beginning November 1955, TBP waste was retrieved from the C Farm tanks and sent to 244-CR, using the encasements and pump pits. The 244-CR vault received TBP waste from only two tanks outside C Farm: 241-BX-108 and 241-BX-109.

Scavenged TBP waste was transferred from 244-CR via the 241-CR-151, 241-C-151, and 241-C-252 diversion boxes to 241-C-109 and 241-C-112 to settle, and from there to the BC cribs and trenches. Cribbing of scavenged TBP waste began in November 1954. Approximately 155 million liters (41 million gallons) of scavenged TBP waste was discharged into the ground. Of this, approximately 44 million liters (12 million gallons) resulted from in-farm scavenging in the 244-CR vault. The BC cribs and trenches are outside the scope of this report, and are over 2 kilometers from the nearest tank farm. The 241-C-601 building was torn down in August 1973 (Anderson 1990; Waite 1991).

The 241-CR steam cleaning pit was dug in 1954, northwest of 241-C-103. No further information is available about this facility (Baldrige 1959).

Two UPRs occurred in C Farm during this period. Installation of a transfer pump in the 244-CR vault on November 26, 1952, resulted in the spill of liquid waste to the ground (UPR-200-E-107). Airborne contamination spread from 241-C-107 to C Farm and the south bank of the parking lot on April 20, 1957 (UPR-200-E-118).

### 3.3 PUREX OPERATIONS 1956-1972 (1983-1988)

The PUREX process was the third and final plutonium separation process used at the Hanford Site, and the PUREX plant ultimately processed approximately 72% of the irradiated fuel produced at Hanford. The process recovered both plutonium (in the form of plutonium nitrate) and uranium (in the form of UNH) in a continuous solvent extraction process, and also recovered nitric acid and the TBP organic solvent for reuse. This innovation minimized waste generation and resulted in PUREX waste being more highly concentrated than other Hanford waste streams. The PUREX plant, the 241-A Tank Farm, and various and waste transfer lines and cribs were constructed for PUREX operations (Courtney and Clark 1954; Gerber 1993; Anderson 1990). Figure 4 shows the PUREX facilities constructed in the area of interest.

The use of TBP instead of the more flammable methyl isobutyl ketone (hexone) that had been used in the REDOX plant was also a safety improvement. Plutonium nitrate product generated by the PUREX plant was trucked to the Plutonium Finishing Plant (PFP), and UNH byproduct was trucked to the UO<sub>2</sub> Plant (Gerber 1993).

The PUREX plant produced various low-level waste streams and three high-level waste streams: PUREX coating waste (CWP), PUREX acid waste (PAW), and organic wash waste (OWW), also called "carbonate." PAW, which contained 99% of the fission products, was also known as P, HAW, CAW, and IWW. These waste streams are described in subsections below (Courtney and Clark 1954; Anderson 1990).

PUREX cold startup waste was discharged to 216-A-1 in November 1955 via an overground line from proportional sampler pit 3. When the specific retention capacity was reached, cold startup waste was then discharged to 216-A-18 in November 1955, 216-A-19 in November/December 1955, and 216-A-20, all via an overground line from proportional sampler pit 2 and the 216-A-34 ditch. It is believed that this was the only use of the 216-A-34 ditch (Heid 1956; Baldrige 1959; WIDS). The Hanford Engineer Works monthly report for December 1955 (GE 1956) states that AEC approval to crib the cold startup waste was obtained during that month. Analytical data for these discharges is presented in the following table:

PUREX Cold Startup Waste Disposal		
Crib No.	Waste Volume (L)	U (kg)
216-A-1	1.00E+05	152
216-A-18	8.02E+04	19
216-A-19	4.88E+05	2460
216-A-20	9.61E+05	N/A

### 3.3.1 PUREX High-Level Waste Streams

Self-boiling PAW and OWW from PUREX were stored in A Farm. The first waste discharges to 241-A-101 and 241-A-102 were not sufficiently concentrated to boil, so OWW was temporarily segregated and sent to 241-C-110. Subsequent waste discharges to A Farm did boil (see Section 3.3.2) (Anderson 1990).

Non-boiling CWP was sent to now-empty tanks in C Farm. Lines V050 from diversion box 241-A-152 to the 241-CR-151 diversion box, and V051 from 241-A-152 to the 244-CR vault, were built for this purpose. As the Uranium Recovery project provided space in B/BX/BY Farms (see Williams 1999), CWP was transferred there from C Farm beginning in 1957. In 1962, tank 241-C-102 was designated as the CWP receiver tank, and all CWP from PUREX went there. From 241-C-102, CWP was pumped to B/BX/BY Farms via the 241-CR-152, 241-CR-151, 241-C-151 and 241-B-154 diversion boxes (Anderson 1990).

New pump discharge line 8107 was built from 241-C-102 to 241-CR-152 in 1966 for CWP transfer to B/BX/BY. When the Waste Fractionization Program got underway in B Plant in 1968 (see Section 3.4), OWW was sent to 241-C-102 along with CWP. Line V843 was built in January 1969 and allowed CWP/OWW to be discharged from 241-CR-151 directly to 241-C-102, bypassing the 241-CR-152 diversion box (this simplified the routing to B/BX/BY). Line V844 was built at the same time, tying into 8107 and allowing 241-C-102 to discharge to 241-CR-151 instead of 241-CR-152. Additionally, line V051 from 241-A-152 to the 244-CR vault was rerouted to 241-CR-151 (Anderson 1990; H-2-33087, Rev 0, 3).

Several months later, in October 1969, CWP leaked from line V051 (UPR-200-E-81). Lines V050 and V051 from diversion box 241-A-152 were modified in November 1969 to bypass the 241-CR-151 diversion box and discharge CWP/OWW directly into 241-C-104 instead of 241-C-102. This waste was transferred from 241-C-104 to B/BX/BY Farms from 1969 to 1973, and from 241-C-104 to 200-West Area from 1973 to 1976 (Anderson 1990; H-2-33087, Rev 5).

There is a discrepancy between drawings H-2-33087 and H-2-44502, sh 7, regarding the piping from the 241-CR-151 and 152 diversion boxes to 241-C-102 and 104. Drawing H-2-44502 shows line 8107 discharging to tank 241-C-102 via a riser along with abandoned line V843, and line V844 connected to V843 and discharging to tank 241-C-104 via a riser. Drawing H-2-33087 shows line V843 discharging to 241-C-102 via a riser, and lines 8107 and V844 connected to the pump discharge line from 241-C-102. It is believed that drawing H-2-44502, sh 7, is wrong.

The overground transfer line from 241-C-105 to 241-C-108 broke sometime between January 1956 and July 1959 and spilled 190 L (50 gallons) of CWP to the ground (UPR-200-E-16). On November 1, 1960, during work in the 244-CR vault, wind spread contaminated particles eastward (UPR-200-E-27).

### 3.3.2 Tank Farm Ventilation System

PAW was sent to A Farm beginning in January 1956. The more efficient PUREX process was expected to produce highly concentrated waste that was expected to boil. This boiling was regarded as an efficient method of volume reduction. The A Farm tanks were designed to

accommodate self-boiling waste, based on experience gained in storage of Redox self-boiling waste in SX Farm. Four airlift circulators were installed in each tank, powered by two air compressors in the 241-A-701 building, and a vapor exhaust system exhausting through the 241-A-431 building (Anderson 1990).

The original tank farm ventilation system consisted of an underground vent header connected to all six A Farm tanks, the TK-401 deentrainment vessel, and direct buried contact condenser E-411 (E-412 was an installed spare condenser). TK-401 drained to 241-A-106, which was initially used only to collect condensate, not to store waste. Condensate/cooling water from the contact condensers drained to the 241-A-08 valve pit, and from there to the 216-A-8 crib. The condensers were vented to the 241-A-431 vent building, where the vapors were routed through another deentrainer to the 241-A-11 stack. Drainage from this stack went to the 216-A-16 and 216-A-17 French drains near the 241-A-431 building. Drainage from the deentrainer went to 216-A-23A and 216-A-23B French drains. A bypass line containing a water-filled seal pot connected the vent header (upstream of TK-401) directly to the 241-A-11 stack. If a tank bump occurred, headspace vapors would blow out the vapor header seal loop and the bypass seal pot and go directly to the stack (O'Neill 1956).

In May 1958, crib 216-A-8 reached its radionuclide capacity and the condensate/cooling water waste stream was diverted to crib 216-A-24 (WIDS).

There is a discrepancy in the description of the waste going to crib 216-A-8. Lundgren (1970) states that from November 1955 to December 1957, tank farm condenser cooling water went to 216-A-34 and condensate went to crib 216-A-8. In December 1957, the two streams both went to 216-A-8, and 216-A-34 was retired from service. This continued until May 1958, when crib 216-A-8 was retired from service and the condensate was rerouted to 216-A-24, and the cooling water rerouted to 216-A-25. However, the condensate and cooling water were commingled in the contact condensers and could not have been separated. Additionally, crib discharge records show little change in discharge volume to 216-A-8 around December 1957 (Bernard 1958 and Baldrige 1958). It is believed that the combined cooling water/condensate waste stream was discharged to 216-A-8 from PUREX startup until May 1958, and that 216-A-34 was used only for disposal of cold startup waste, as described above. This discrepancy is repeated in Maxfield (1979) and WIDS.

Dissatisfaction with the performance of the contact condensers led to their replacement in October 1959 by surface condensers in the 241-A-401 building (project CA-719). The new condensers still vented to the 241-A-431 building. Cooling water went to the newly built 216-A-25 Gable Mountain pond. Condensate drained to the 241-A-417 catch tank, and overflowed to the 216-A-24 crib. This modification reduced the condensate discharge volume to crib 216-A-24 by 95%. Cooling water was supplied by the raw water system. If raw water was unavailable, backup cooling was supplied by a closed-loop system with forced draft cooling towers and makeup water from a well (Wood 1957; GE 1960).

Crib 216-A-24 reached its radionuclide capacity in July 1966, and the condensate was diverted back to crib 216-A-8 until April 1976, when it was diverted to double-shell tanks (DSTs) instead of ground disposal. From 1973 to 1976, the 241-A-417 catch tank condensate was filtered by an

ion exchange column prior to discharge to 216-A-8. A small amount (600 L) of condensate was discharged to the crib in 1978 (McMurray 1967; Mirabella 1977; Anderson and Poremba 1979; Stickney and Lipke 1998; WIDS). The crib discharge history for 216-A-8 is shown in Table C-1, and the crib discharge history for 216-A-24 is shown in Table C-2 (see Appendix C).

The 241-AX Tank Farm and the 241-AX-151 and 241-AX-152 diverter stations were built in 1965. The AX Farm vapor header was tied into the 241-A Farm vapor header, upstream of the 241-A-401 condenser building (Doud et al 1962). Later, AY and AZ Farms tied into this system.

The 241-A-702 filter building was added in March 1969 to filter the headspace air. The 241-A-431 vent building was taken out of service at this time and the 216-A-16, 216-A-17, 216-A-23A, and 216-A-23B French drains were decommissioned. Discharge records were not kept for these drains, but estimates of the total discharges are included in Appendix A (WIDS).

In 1959, moisture dripping from a vent pipe bonnet at the 241-A-08 proportional sampler pit contaminated the ground near the 241-A-271 building (UPR-200-E-18).

### 3.3.3 Other PUREX Low-Level Waste Streams

PUREX process condensate was sent to crib 216-A-5 from startup until contamination broke through to the groundwater in November 1961, then to the 216-A-10 ditch until that broke through in May 1987, then finally to crib 216-A-45 until September 1991. Crib 216-A-38 was built to replace 216-A-10 but it was not used (Maxfield 1979). These cribs are outside the scope of this report.

PUREX steam condensate and drainage went to crib 216-A-6 from startup until January 1961, when 216-A-6 overflowed and caved in. From 1961 until 1992, it was sent to crib 216-A-30. In July 1964, 216-A-30 overflowed and 216-A-6 was reactivated until October 1966, when it overflowed again and was abandoned for good. From PUREX restart in 1983 until final shutdown in 1992, PUREX steam condensate and drainage was sent to the 216-A-37-2 ditch. Cribs 216-A-6 and 216-A-30 operated together from 1964 to 1966, and 216-A-30 and 216-A-37-2 operated together from 1983 to 1992 (Maxfield 1979; WIDS). These cribs are outside the scope of this report.

The 241-A-152 diversion box sump was originally equipped with an automatic siphon that discharged to the 216-A-7 crib in lieu of a catch tank. The crib received drainage from the diversion box sump from January 1956 until July 1959, when the 241-A-302B catch tank was built and piped to the sump drain. The catch tank was set up to overflow to the crib; however, no such overflow is documented. On November 22, 1966, 2.46E+05 L (65,000 gallons) of organic TBP-Soltrol waste was trucked from PUREX and discharged to the crib via the vent riser. In 1985, project B-231 isolated the 241-A-302B catch tank (H-2-57452; Eliason 1967). The crib discharge history for 216-A-7 is shown in Table C-3 in Appendix C.

There is a discrepancy regarding the discharges to crib 216-A-7. Lundgren (1970) states that the crib was still active at the time of publication (January 1970). Eliason (1967) states that the crib was abandoned in July 1959, when the catch tank was installed. Crib discharge records show no discharges after December 1956. It is possible that discharges continued from December 1956 to

July 1959 but were not recorded due to the low volumes involved. After July 1959, the crib was most likely not used, and any catch tank contents were pumped out to the tanks. (GE 1955, Courtney and Cox 1954).

Crib 216-A-9 received PUREX acid fractionator condensate and condenser cooling water from March 1956 to January 1958. This waste stream was then diverted to the 216-A-29 ditch via the PUREX chemical sewer (see Section 3.3.3). From April 1966 through October 1966, the crib received N Reactor decontamination waste via the manhole at the crib site. The crib was inactive but on standby from then until August 1969, when it was decided to discharge the acid fractionator condensate back to the crib. When this was tried, it was discovered that the effluent pipeline had failed, and so the waste was diverted back to ditch 216-A-29 (Lundgren 1970). The crib discharge history for 216-A-9 is shown in Table C-4 in Appendix C.

There is a discrepancy regarding the waste discharged to crib 216-A-9 in 1966-67. Anderson (1976) says that the crib received  $1.82\text{E}+06$  L in 1966 and  $1.89\text{E}+05$  L in 1967 (waste type not specified). McMurray (1967) says there was no discharge in 1966, and Uebelacker (1968) reports a discharge of  $1.89\text{E}+06$  L of N Reactor waste in 1967.

Numerous minor PUREX low-level waste streams went to various cribs around the plant that are outside the scope of this report.

### 3.3.4 PUREX Cooling Water and Chemical Sewer

PUREX cooling water was first discharged to the old A pond east of PUREX, which was a natural depression at the terminus of the original 200-East Area powerhouse drainage ditch. Powerhouse waste was diverted to the 216-B-2 ditch and B pond when PUREX was built, and the PUREX chemical sewer line was routed to the old drainage ditch outfall structure.

This discharge raised the water table under 200-East Area so much that crib 216-A-8 broke through to groundwater in December 1956. It was decided to send the cooling water elsewhere. Ditch 216-A-29 was built that connected the chemical sewer ditch and the cooling water line outfall. In December 1957, the old A pond was eliminated by tying the chemical sewer and the cooling water lines together at ditch 216-A-29, which emptied into the 216-B-3 pond.

A valve box was built in the cooling water discharge line to allow diversion to either the 216-A-29 ditch and B pond or to the newly built 216-A-25 Gable Mountain pond via an underground line. PUREX cooling water was diverted to the Gable Mountain pond (70%) and B pond (30%). The Gable Mountain pond was taken out of service in 1975 and decommissioned in 1987 (Gerber 1993).

After PUREX restart in 1983, cooling water went to B pond, which was modified for this purpose by the construction of three expansion lobes. B pond was decommissioned in 1995, when the 200-Area Liquid Effluent Retention Facility (LERF) opened. Although cooling water and chemical sewer waste were normally uncontaminated, occasional UPRs contaminated the 216-A-29 ditch. These UPRs are outside the scope of this report.

### 3.3.5 PUREX Waste in Tank 241-A-105

Tank 241-A-105 received PAW beginning in January 1963, and reached boiling on March 5. An apparent small leak was noticed in November 1963, when the tank was half full. The leak was thought to self-seal. Because experience had indicated that adding waste to a self-boiling tank that had been allowed to settle for a period of time could cause a temperature excursion, the filling continued. Tank 241-A-105 was filled to capacity in December 1964. On January 28, 1965, a sudden steam release occurred in 241-A-105. The earth in the immediate vicinity of the tank was reported to have trembled, and a temporary lead cover on a riser on tank 241-A-103 was dislodged allowing steam to vent from this opening for about 30 minutes. At the time of the bump, construction personnel were preparing to make a final weld in line 4105 connecting tank 241-A-105 with the 241-AX-151 diverter station. Several liters of liquid were ejected onto the ground in the excavation. Radiation dose rates of 4 Sv/hr (400 R/hr) were measured 30 cm (1 ft) from the spill. The 241-A-105 tank instrument enclosure had a dose rate of 5 Sv/hr (500 R/hr) at 30 cm (1 ft), and the liquid level electrode tape was broken. This event differed from previous tank bumps in that it occurred while the airlift circulators were operating (Beard et al. 1967).

An attempt to install an air sparger in a 10-cm (4-in) riser disclosed an obstruction 2.4 m above the normal position of the tank bottom. Additionally, airlift circulator dip tube static pressure readings indicated that either the piping was broken or the circulators had been physically elevated about 1.8 m. Nine holes were drilled through the tank dome and confirmed that the tank bottom was bulged upward by 2.6 m, providing a void volume of  $3.03E+05$  L underneath the bottom of the tank liner. A description of analyses of tank conditions following the bump is in Beard et al (1967). The tank would not be emptied until it was scheduled for sluicing or until further deterioration was detected. A third leak detection caisson was built near tank 241-A-105 in 1967 (see Section 4.0). The initial leakage amount was between  $1.90E+04$  L and  $5.70E+04$  L (Jansen 1965; Beard et al. 1967).

New leakage from the tank was noticed in October 1967 (UPR-200-E-126). The tank was sluiced to the 244-AR vault beginning in August 1968. The sluicing was stopped in November 1970 with a sludge heel remaining in the tank, because readings from the laterals indicated that the sluicing had aggravated the leak. At this time, another  $1.90E+04$  to  $1.14E+05$  L leaked from the tank. To cool the remaining sludge, cooling water was added to the tank weekly from November 1970 to December 1978. The total amount of cooling water added was  $2.31E+06$  L. Pursuant to Washington State law, all cooling water that was not evaporated is included in the leak volume estimate. Allen (1991) estimates the volume of evaporated cooling water at  $1.43E+06$  to  $1.55E+06$  L. The final leakage amount is therefore between  $7.95E+05$  L and  $1.05E+06$  L (WHC 1991; Hanlon 2001). The 1900-L waste volume given by WIDS for UPR-200-E-126 is incorrect.

### 3.3.6 PUREX Shutdown and Restart

PUREX was placed in standby in 1972 to allow accumulation of N Reactor spent fuel, and sluicing of A and AX Farms (see Section 3.4). The standby was intended to be 18 months, but various events prevented restart until 1983. PUREX steam condensate went to the 216-A-37-2 ditch. Process condensate went to crib 216-A-45 (Gerber 1993). These ditches are outside the scope of this report.

Crib 216-A-8 was reactivated for the restart, receiving steam condensate from the DSTs in AY and AZ Farms. Unfortunately, the Sr concentration in the tank condensate was too high, so the discharge was rerouted to the DSTs after only 3 days in 1983. This condensate was again discharged to 216-A-8 for a few months in 1984. This waste was rerouted to the DSTs in 1985, and the crib was deactivated permanently. The overflow line from catch tank 241-A-417 was capped at the tank in 1987, and the 216-A-508 distribution box was grouted in April 1995 (Aldrich 1984; Aldrich 1985; Aldrich 1986; WIDS).

Final PUREX shutdown was in 1988, and the closure order came in 1992. Following final PUREX shutdown, cribs 216-A-26, 216-A-30, 216-A-37-2, 216-A-45, and the 216-A-29 ditch received discharges until the 200 Area LERF opened in 1995. These cribs are outside the scope of this report (Gerber 1993; WIDS).

### 3.4 FISSION PRODUCT RECOVERY (1961-1967) AND WASTE FRACTIONIZATION OPERATIONS (1967-1978)

The concept of recovering fission products with industrial uses (primarily  $^{137}\text{Cs}$ ) began in the mid-1950s. The country's largest source of fission products was at Hanford. Removal of these isotopes from the PUREX waste stream would also make waste storage cheaper and waste disposal easier. Methods for scavenging Cs and Sr from liquid waste were developed during the Uranium Recovery Mission (see Section 3.2), and reduced storage costs so much that immediate research was begun in the mid-1950s on scavenging REDOX and PUREX waste for similar savings. There was also a growing commercial market for these isotopes. Since the isotope separation process involved precipitation and centrifugation, the first idea was to use B Plant to do this, since it had this equipment and was no longer needed. Plans were made to refurbish B Plant to remove Cs and Sr from PUREX waste (Tomlinson 1956).

An urgent need for  $^{90}\text{Sr}$  by the Space Nuclear Applications Program (SNAP) resulted in an acceleration of the fission product recovery project in August 1960. An improvement in the PUREX process allowed modifications to the plant head-end that facilitated recovery. The 244-CR vault was reactivated for the program, and the Hot Semiworks complex would be a pilot plant until B Plant modifications were complete. Hot Semiworks was modified and renamed Strontium Semiworks and production began in July 1961. PAW was pumped via diversion box 241-A-152 and line V051 to 244-CR vault, allowed to age, then sent via line 8900 to Strontium Semiworks for purification. Sr product was loaded into shipping casks at 201-C for offsite shipment to customers (SNAP generators). Sr-depleted PAW waste from Strontium Semiworks (HS) was sent to tanks 241-C-107/8/9 in C Farm. The 271-CRL laboratory was built in C Farm in 1962 (Beard and Swift 1960; Judson 1960; GE 1961; Anderson 1990; Tomlinson 1963). Figure 5 shows facilities constructed in C Farm to support waste fractionization operations.

As well as  $^{90}\text{Sr}$ ,  $^{137}\text{Cs}$  was recovered from PUREX waste during this time. Originally, in 1961, Cs was separated in 212-A. Beginning in 1963, stored PUREX supernate waste (PSN) from 241-C-103 was pumped to the 241-C-801 cesium loadout facility in C Farm and Cs product was loaded into shipping casks for offsite shipment. Newly constructed line V109 from 241-A-101 to 241-C-151 allowed PSN from A Farm to refill 241-C-103. Depleted PSN was returned to 241-C-102 and was eventually transferred (along with CWP) to BY Farm for in-tank

solidification (ITS). ITS is described in Williams (1999). Use of the 241-C-801 facility ended in 1969 (Michels 1961; Beard et.al 1964; Anderson 1990; Tomlinson 1963).

B Plant was used for partial Sr recovery work from 1963 to 1967. Beginning in August 1963, PAW was sent from the 244-CR vault to B Plant via line 8902 to 241-C-151, 241-B-154, and 241-BX-154. It was precipitated and concentrated, allowed to age, and later sent to Strontium Semiworks via line V743 for final purification. HS waste was sent to C Farm as before. Process condensate and other waste from B Plant (FP) was sent to B Farm, and was also sent (via tank 241-B-112) to 241-AX-101 in 1965 (Anderson 1990; Caudill and Zahn 1961; GE 1963). Figure 6 shows facilities constructed in A and AX Farms for waste fractionization operations.

Beginning in late 1967, B Plant went into full operation and began isolating Cs (by ion exchange) and Sr. Sr purification was also done in B Plant, and so Strontium Semiworks was no longer needed and was shut down (the facility was retired in 1967 and was decommissioned from 1983-87). Sr was now recovered by solvent extraction in B Plant instead of the previous precipitation method. PAW was now routed to B Plant via 241-AX-151 and the new 244-AR vault for Sr recovery, instead of via the 244-CR vault. In addition, B Plant received PSN from feed tank 241-C-105, via line V130, for Cs recovery by ion exchange. More than 95% of the Sr and Cs in PAW was removed in B Plant. Line V103 from 241-C-151 was modified in 1968 to bypass 241-C-104 and allow PSN transfer from AX Farm to 241-C-105. Redox supernate from SX Farm was also sent to B Plant for fractionization in 1970-'71. OWW was no longer mixed with PAW for storage; it was now mixed with CWP and sent to 241-C-102, and from there to BX Farm for ITS (see Section 3.3.1) (Buckingham 1967; Anderson 1990; Liverman 1975).

In between PAW transfers, sludge was sluiced out of the A/AX tanks for Sr recovery. Tank 241-A-101 was sluiced first in 1968, then 241-A-104 in 1969, and 241-A-106 in 1970. In the 244-AR vault, the sludge, called PUREX sludge waste (PSW), was dissolved in acid. The resulting PUREX acidified sludge (PAS) was pumped to the 244-CR vault via the 241-AX-151 diverter station and line 8656 for lag storage, and from there to B Plant via line 8653. Since PUREX was operating almost constantly, little sluicing was done until PUREX shutdown in 1972 (see Section 3.3.6). Following shutdown, the 244-AR vault was modified for full-time sludge processing and tank sluicing was accelerated. Sr and Cs were encapsulated and stored in the Waste Encapsulation and Storage Facility (WESF) beginning in 1974. Encapsulation was completed in 1985 (Anderson 1990; Rasmussen 1980).

B Plant produced four waste streams. High-level B, Sr-depleted PAW slurry similar to HS, went to AX Farm for storage. Intermediate-level BL (which was primarily ion-exchange waste, but also included waste concentrator concentrate), from PSW and PSN processing, went to B/BX/BY tanks for ITS (which ended in 1974). Process condensate went to the 216-B-12 crib, and organic waste to the 216-B-56 crib. Cooling water was discharged to B pond. Aside from the B waste, these waste streams are outside the scope of this report (Doud and Roddy 1964; Buckingham 1967; Agnew 1994).

Fractionization of stored waste continued until 1978, when the last of the stored waste in A and AX Farms was retrieved. Tank 241-A-102 was sluiced in 1973, 241-A-103 in 1974, 241-AX-101 in 1975, 241-AX-102 in 1976, 241-AX-103 in 1977, and 241-AX-104 in 1978. Following

sluicing, the sound tanks (241-A-101, -102, -103, 241-AX-101, and -102) were authorized for saltcake storage, and leakers were stabilized and isolated (see Section 3.5) (Anderson 1990; Rasmussen 1980).

As the tanks were sluiced, the sound tanks were refilled with CWP, OWW, B, and other Hanford waste types, all mixed together. By the mid-70s, every type of waste was being commingled in A/AX/C Farm, primarily in tanks 241-A-103, 241-C-103, and 241-C-104 (Anderson 1990).

In the sluicing operations that occurred from 1969 to 1971, the concentrated slurry layer in the 244-AR vault accumulation tank was washed with water prior to transfer to the acidification tank. After agitation and settling, the wash water was pumped to either tank 241-C-105 or 241-C-106. Some solids were transferred to these tanks. The solids in 241-C-106 contained several megacuries of Sr-90, which caused the waste to approach boiling temperatures. Tank 241-C-106 had not been designed as a boiling waste tank, and Section 3.5 describes efforts to deal with this situation (Walker 1977; Rodenhizer 1987).

The 244-AR vault stack drainage went to crib 216-A-41 from January 1968 to 1974. After that, it was rerouted to the vessel vent seal pot system. Cooling water, if uncontaminated, went to the Gable Mountain pond. Contaminated cooling water was diverted to the 216-A-40 lined retention basin and returned to 244-AR. The 244-AR vault has been inactive since 1978. It was upgraded in the mid-1980s in preparation for the PUREX restart, but by then B Plant was being refitted as a waste vitrification pilot plant, and PUREX waste that was generated after the restart was stored in DSTs and was not fractionized. The 244-AR vault is scheduled for interim stabilization (see Section 3.5) by September 30, 2003 (Maxfield 1979; Laney 2000).

The 216-C-8 French drain received an unknown amount of floor drain waste and ion exchange resin regeneration waste from experiments in the 271-CRL laboratory in C Farm beginning in June 1962. The ion exchange studies were terminated in June 1965 and the equipment removed (Lundgren 1970; H-2-31890). The total volume discharged to the crib is likely to be small, since crib discharge records do not mention 216-C-8.

In June 1966, a radioactive liquid line in the 241-AX-801B building pressurized and spilled 20 L of liquid onto the floor. Dose rates exceeded 50 mSv/hr (5 R/hr) at 3 m. The 216-A-39 crib was constructed to receive the waste. A hole was cut through the back side of 241-AX-801B, and a fire hose was used to flush the contamination out the door and into the crib (WIDS).

Line V122 from tank 241-C-105 to diversion box 241-C-152 (the PSN feed line to B Plant) began leaking in 1970 (UPR-200-E-82) and was replaced with line V115. A leak in line 812 from the 244-AR vault to diversion box 241-C-151 in 1971 contaminated a 36-m<sup>2</sup> area with PSN (UPR-200-E-86).

Three UPRs occurred in AX Farm during this period. Surface contamination occurred around 241-AX-151 in 1972, resulting from an inadvertent pressurization in the 244-AR vault (UPR-200-E-42). A spray leak in the 241-AX-103 pump pit occurred on February 12, 1974 (UPR-200-E-115). Removal of a contaminated electrode cable from 241-AX-104 in 1969 dripped a negligible amount of contamination onto the ground (UPR-200-E-119).

### 3.5 STABILIZATION AND ISOLATION 1975-PRESENT

Three tanks in A Farm, two tanks in AX Farm, and three tanks in C Farm have leaked. In accordance with Hanford operating policy at the time, liquid waste removal from a tank of questionable integrity was expedited and the tank was removed from service. Interstitial liquid was removed by saltwell jet pumping (Liverman 1975). Figure 7 shows facilities constructed in C Farm for saltwell pumping, and Figure 8 shows facilities constructed in A and AX Farms.

Tank 241-A-104 leaked 9500 L in May 1975 and was pumped down to a sludge heel (UPR-200-E-125). Tank 241-C-101 leaked 91 000 L in 1970 (UPR-200-E-136). Tank 241-C-203 leaked 1500 L in 1976 (UPR-200-E-137). Tank leaks which were not assigned UPR numbers occurred in 241-A-103, 241-AX-102, 241-AX-104, 241-C-110, 241-C-111, and the other three C Farm 200-series tanks. Volume estimates for these leaks are taken from Hanlon (2001). Leakage from tank 241-A-105 (UPR-200-E-126) is discussed in Section 3.3.5. Tank leaks are described in Table 2 of Appendix A.

There is a discrepancy in the reported volume of UPR-200-E-136. WIDS gives a range of 64 000 L to 91 000 L, while Hanlon (2001) reports the volume as 76 000 L. Information is not available to resolve this discrepancy.

Interim stabilization is the process of removing all supernatant liquid and as much drainable liquid as possible; this process began in 1972. The saltwell system for A/AX/C Farms included a pump pit for each tank, the saltwell and jet pump, piping from the pump pits to the receiver tank, and associated instrumentation and controls. Tank 241-C-103 was the receiver tank for C Farm, and 241-A-102 was the receiver tank for A and AX Farms. The 244-A lift station and new encased underground lines were constructed in 1975 that connected C Farm, A Farm, and the cross-site transfer line. The C Farm tanks were interim stabilized beginning in 1976, with the interstitial liquid pumped from 241-C-103 to the 242-S evaporator via line V228 from C Farm to the cross-site transfer line. Transfers to 242-S were discontinued when the 242-A evaporator started operations (Liverman 1975; Smith 1975; H-2-65052).

The 242-A evaporator began operating in March 1977 with saltwell receiver 241-A-102 as the feed tank and 241-AX-101 as the slurry receiver tank. C Farm saltwell waste was pumped from 241-C-103 to 241-A-102 via the 244-A lift station. The evaporator also receives waste from the 241-A-350 drainage lift station, which was built in 1976. Cooling water was discharged to the Gable Mountain pond and condensate went to 216-A-37-1 ditch. When AW Farm was built in 1980, DST 241-AW-102 replaced SST 241-A-102 as the feed tank. In April 1989, after final PUREX shutdown, the 242-A evaporator was shut down. Project B-534 renovated the evaporator, and project W-105 built the 200 Area LERF for evaporator condensate. The evaporator restarted in April 1994 and is still in use (Smith 1975; Maxfield 1979; Luen 1989; Wisness 1994).

Since 1968, all waste tanks constructed have been DSTs, and AEC policy in 1975 was to direct all liquid waste to DSTs. SSTs were removed from service in 1980, and DST 241-AN-101 replaced 241-A-102 as the saltwell waste receiver tank in 1981. Tank 244-CR-003 in the 244-CR vault has been used as a double-contained receiver tank (DCRT) for C Farm since 1979.

A new valve pit was built near tank 241-C-103 that tied into the existing saltwell piping and discharged to 244-CR-003. Waste was transferred from the 244-CR vault to AW Farm for evaporation via the 244-A lift station, the 241-A valve pits, and the 241-AW valve pits. The 244-CR vault has not been used since 1995. It is not yet scheduled for interim stabilization, but no future use has been identified (H-2-73799; Hanson 1980; Parkman 2000).

Following interim stabilization, SSTs were interim isolated by establishing at least one physical barrier between the tank contents and the environment, to preclude inadvertent addition of liquid. Cutting and blanking process piping to and from the tank, blanking all risers, and equipping the tank with a filtered ventilation system accomplished this. In A/AX Farms, the 241-AX-151 diverter station, the 241-A-152 diversion box, and the 241-A-302B catch tank were isolated by project B-231 in 1984-1985. In C Farm, all diversion boxes and the 241-C-301 catch tank were isolated by project B-231 (Liverman 1975; Hanlon 2001; WIDS).

Two leaking tanks in A Farm and two leakers in AX Farm were stabilized and isolated at the end of sluicing activities in 1978. Except for 241-A-101, 241-AX-101, 241-C-103, and 241-C-106, all tanks are interim stabilized. Tanks 241-A-101 and 241-AX-101 are still being saltwell pumped. Tank 241-C-103 has a layer of organic waste floating atop the aqueous supernate that will be removed prior to saltwell pumping. This removal will not use the 244-CR-003 DCRT. The stabilized tanks are also interim isolated, except that isolation is not complete on 241-A-102 and 241-C-105 (Hanlon 2001; Horner 2001).

Water additions to 241-A-105 (see Section 3.3.4) stopped in December 1978 and the 296-P-17 exhauster was installed in January 1979. The tank was interim stabilized in 1979 and interim isolated in 1985. The exhauster was removed from service in October 1991, and the tank is now on passive ventilation (Hanlon 2001; WIDS).

By 1982, the portion of the A Farm vapor header from AX Farm to the 241-A-401 condenser building was in danger of leaking, so project B-419 replaced that section of header. This project also isolated AX Farm from the A-702 ventilation system, and provided an isolation valve for A Farm (following this, the system served only AY and AZ Farms). This was intended to isolate the A Farm tanks; however, a ventilation path to the 241-A-401 condenser building via the old TK-401 deentrainment vessel was inadvertently left open. Project B-222 later isolated individual tanks in A Farm by filling the seal loops in the ventilation header with grout. The 296-P-17 exhauster on 241-A-105 provided ventilation to all A Farm tanks via the overflow lines between the tanks until it was removed (Braun 1982; Prosk and Smith 1986; H-2-62895).

When the waste in tank 241-C-106 reached boiling temperatures in mid-1971, it was connected to an exhauster to cool the waste. Cooling water was also added to the tank. BL waste was added to the tank from 1974 through 1976. The exhauster was replaced twice in 1976 due to excessive contamination. The 296-P-16 exhauster was installed in 1984 (project B-480). Because of continuing high temperature in the tank, the sludge was sluiced to 241-AY-102 in 1999 (project W-320). A special ventilation system, 296-C-006, and a new transfer line to 241-AY-102 were built for the sluicing operation. Following sluicing, the 296-C-006 ventilation system was abandoned in place. The 296-P-16 system will stay in use pending an interim isolation decision (Walker 1977; Anderson 1990; Wang 1994; H-2-93797).

Wind-borne contamination from 241-C-151 in January 1985 (UPR-200-E-68) was either decontaminated to background levels or covered for later decontamination. Following this incident, a radiation survey conducted on April 20, 1985, revealed a contaminated area south of C Farm that indicated the burial of previously undocumented contaminated material (UPR-200-E-72). The contamination was physically fixed in place with Turco Fabri-Film™ and the area posted as a Surface Contamination Area (WIDS).

On December 13, 1993, a project W-049H (200 Area Treated Effluent Disposal Facility) pipeline excavation resulted in the discovery of contaminated soil surrounding the vitrified clay pipeline from 241-A-08 to the 216-A-34 crib (UPR-200-E-145).

On March 23, 2001, the diverter station 241-AX-152 catch tank was declared an "assumed leaker." This leak has not yet been assigned a UPR number (Hanlon 2001).

#### 4.0 MONITORING TEST WELLS

Monitoring test wells were drilled in each tank farm as part of original construction to check for tank leakage. To avoid groundwater contamination, these wells were drilled only to 46 m (150 ft) and did not extend to the upper aquifer (groundwater depth was 76 m [250 ft]). Wells were checked weekly. Test wells were also drilled near cribs as part of original construction to monitor vadose zone contamination. Typically, wells would be drilled to 46 m (150 ft), but major disposal sites had at least one 92 m (300 ft) well to check for nuclide migration to groundwater (Parker 1944; Brown and Ruppert 1950). The test wells are described in Table 4.1 and shown on the figures in Appendix D.

At the time of initial construction, knowledge of the groundwater hydrology of the Hanford area was limited to a few reports from the 1910's and 1920's. These reports were general in scope and limited in content. The continuing need to dispose of 1C and 2C waste into the ground led the AEC to contract with the U.S. Geological Survey to drill a series of test wells in the late 1940's to evaluate the 200 Area plateau soil for waste disposal suitability and for general groundwater research (Brown and Ruppert 1950).

Monitoring wells in other locations were drilled as needed. In the 1970's, additional wells were drilled in all three tank farms to monitor groundwater contamination (see Figure 6a). An extensive discussion of monitoring wells inside the tank farms is included in Gaddis (1999).

In addition to the monitoring wells, two 3.7-m (12-ft) diameter leak detector caissons, extending approximately 21 m below grade, were installed in A Farm during original constructions. Three horizontal leak detection wells (called "laterals") extend radially from each caisson, 2.4 m below the tank bottom. The laterals are approximately 3 m below the base pad elevation. Radiation probes are inserted into each lateral to provide information used to evaluate tank integrity and to determine changing conditions of the tank contents (Anderson 1990).

A third leak detector caisson was built for tank 241-A-105 in 1967 (see Section 3.3.4). This caisson had lateral wells located 0.6 m below the tank bottom, which were equipped with thermocouples to monitor sludge temperature (WHC 1991).

TABLE 4.1: TEST WELLS SURROUNDING A, AX, AND C FARMS

Location	WELL IDENTIFICATION			COORDINATES				DIMENSIONS			NOTES
	Hanford Site No.	Washington State No.	Installed Date	Hanford		Lambert		Dia in.	Depth		
				North	West	North	East		ft	m	
W of A Farm	299-E24-3	A5897	Jun 1956	41010.8	48310.4	135983.2	575165.1	8	333	101.5	1
W of A Farm	299-E24-4	A5898	Jun 1956	41182.9	48482.9	136035.2	575112.4	8	330	100.5	1
W of A Farm	299-E25-5	A5899	Jun 1956	41275.4	48727.2	136063.0	575038.0	8	329	100.3	1
S of A Farm	299-E24-19	A4754	Sep 1989	41075.8	47821.4	136003.8	575317.2	4	301	91.7	None
W of A Farm	299-E24-20	A4756	Mar 1991	41226.0	48038.0	136049.4	575251.1	4	304	92.6	None
W of A Farm	299-E24-63	A5818	Jun 1956	41335.0	48644.0	136081.7	575066.2	8	50	15.2	None
E of A Farm	299-E25-2	A4766	Mar 1955	41265.5	47175.1	136062.2	575514.0	8	375	114.3	1
E of AX Farm	299-E25-4	A4788	Apr 1956	41615.0	46739.0	136168.9	575646.5	8	289	88.1	1
E of AX Farm	299-E25-5	A6025	May 1956	41667.0	46632.0	136184.9	575681.2	8	293	89.3	1
E of AX Farm	299-E25-6	A4796	May 1956	41598.0	46619.0	136163.9	575683.7	8	290	88.4	1
NE of AX Farm	299-E25-10	A4760	Jul 1958	42000.0	46900.0	136268.0	575630.0	8	293	89.3	None
E of AX Farm	299-E25-40	A4789	Sep 1989	41759.6	47334.8	136212.3	575464.6	4	274	83.5	None
SE of AX Farm	299-E25-41	A4790	Sep 1989	41541.8	47330.9	136146.0	575466.3	4	279	85	None
S of A Farm	299-E25-46	A4793	Aug 1992	40944.2	47681.5	135964.0	575359.7	4	310	94.5	None
E of A Farm	299-E25-54	A6043	Mar 1955	41205.0	47169.0	136043.4	545512.4	8	452	46.3	None
E of AX Farm	299-E25-169	A6584	Jan 1966	41675.0	45550.0	136185.2	575696.5	6	85	25.9	1
E of AX Farm	299-E25-170	A6585	Jan 1966	41600.0	46650.0	136134.4	575673.6	6	208	63.3	1
E of AX Farm	299-E25-181	A6591	Jul 1981	41685.0	47040.0	136190.1	575554.8	6	12	3.6	None
S of A Farm	299-E25-184	A6594	Jun 1981	41085.0	47800.0	136006.4	575323.6	6	50	15.2	None

TABLE 4.1: TEST WELLS SURROUNDING A, AX, AND C FARMS

Location	WELL IDENTIFICATION				COORDINATES				DIMENSIONS			NOTES
	Hanford Site No.	Washington State No.	Installed Date	Hanford			Dia	Depth				
				North	West	North		East	ft	m		
E of AX Farm	299-E25-205	A6609	Feb 1984	41490.0	46680.0	136130.9	575664.6	Unk	25	7.6	2	
SE of A Farm	299-E25-209	A6613	Feb 1984	40800.0	46600.0	135920.7	575689.6	Unk	25	7.6	2	
NE of C Farm	299-E27-7	A4816	Oct 1982	43097.6	48132.0	136619.6	575220.7	6	281	85.6	None	
W of C Farm	299-E27-12	A4810	Oct 1989	42981.4	48678.4	136583.8	575034.3	4	270	82.3	None	
SW of C Farm	299-E27-13	A4811	Oct 1989	42671.9	48644.0	136498.5	575065.1	4	275	83.8	None	
SE of C Farm	299-E27-14	A4812	Oct 1989	42700.1	48143.6	136498.5	575217.6	4	266	81.1	None	
NW of C Farm	299-E27-15	A4813	Oct 1989	43134.7	48543.0	136630.6	575095.5	4	262	79.8	None	

Notes: 1 Grouted  
2 Backfilled

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