RPP-ENV-33418
Revision 1

HANFORD C-FARM LEAK ASSESSMENTS REPORT: 241-C-101, 241-C-110, 241-C-111, 241-C-105 AND UNPLANNED WASTE RELEASES

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Acronyms

1C	first decontamination cycle waste from bismuth phosphate plant
bgs	below ground surface
Btu	British thermal unit
cal	calories
Ci	curies
cfm	cubic feet per minute
cm	centimeter
c/m	counts per minute
COC	contaminant of concern
c/s or cps	counts per second
CSR	cesium removal waste
CW	cladding (or coating) removal waste
DST	double-shell tank
ECN	engineering change notice
FeCN	ferrocyanide waste
ft	feet
gal	gallon
g or gm	gram
H or hr	hour
HLO	Hanford Laboratory Operations (defunct organization)
HLW	high-level waste
HPT	health protection technician
HRR	high resolution resistivity
HS	Hot Semiworks building 201-C
IDMS	Integrated Data Management System
in.	inch
IX	ion exchange
kCi	kilocuries
kg	kilogram
kW	kilowatts
lbs	pounds
MW	Metal waste; high-level waste containing fission products and uranium derived from reprocessing spent nuclear fuel using the bismuth phosphate process
ORNL	Oak Ridge National Laboratory
OWW	organic wash waste
P1	PUREX HLW supernate also referred to as PSN waste type
pCi	pico-curies
PNNL	Pacific Northwest National Laboratory
PSN	PUREX supernate neutralized also referred to as P1 waste type
PSS	PUREX sludge supernate
PUREX	Plutonium Uranium Extraction
r or rad	radiation absorbed dose
RSN	REDOX neutralized supernate
SIM	Soil Inventory Model
SGE	Surface Geophysical Exploration
SST	single-shell tank
TBP	Tri-Butyl Phosphate
TFeCN	tank farm ferrocyanide waste
TWINS	Tank Waste Information Network System
UPR	Unplanned Release
UR	Uranium Recovery waste, same as TBP waste
W	watts

Executive Summary

CH2M HILL Hanford Group Inc. developed jointly with DOE-ORP and Washington Department of Ecology (Ecology) a process to re-assess selected tank leak estimates (volumes and inventories) and to update single-shell tank (SST) leak and unplanned releases (UPRs) volumes, and inventory estimates as emergent field data is obtained (RPP-32681, 2007, *Process to Estimate Tank Farm Vadose Zone Inventories*). This process does not represent a formal tank leak assessment in accordance with procedure TFC-ENG-CHEM-D-42, *Tank Leak Assessment Process*. Waste Management Area (WMA) C which encompasses the 241-C Tank Farm was selected for this re-assessment.

Tank waste loss events were re-assessed for SSTs 241-C-101, 241-C-110, and 241-C-111, which have previously been designated as suspected of having leaked waste to the ground. Additionally, information on contamination in the soil surrounding SST 241-C-105 was reviewed to establish an inventory for the waste present in the soil below 15 ft. Table ES-1 summarizes the results of the re-assessment of tank waste loss events for these four SSTs and provides a comparison to the waste loss estimates contained in HNF-EP-0182, rev. 219 *Waste Tank Summary Report for Month Ending June 30, 2006*. The estimated volume of waste lost and the waste type can be used to derive an estimated inventory of constituents using the *Hanford Soil Inventory Model, Rev. 1* (RPP-26744).

DOE/RL-88-30, rev. 16, 2007, *Hanford Site Waste Management Units Report*, contains the official listing of UPRs identified at the Hanford site. The operational history for the 241-C Tank Farm was reviewed to determine if additional information exists for the three UPRs (200-E-153-PL, 200-E-133, UPR-200-E-72) within the WMA C not associated with tank waste loss events. No significant new information was located for these UPRs. However, potentially new UPRs were identified through review of the operational history for the 241-C Tank Farm. Tank waste may have potentially been inadvertently discharged through the spare inlet nozzles on the SSTs or through previously unidentified pipeline failures. The spare inlet nozzles on SSTs are suspected as not being sealed. Waste may have potentially been discharged to the soil adjacent to a SST if the SST was filled to a level that resulted in submerging the spare inlet nozzles. Table ES-2 summarizes potential tank waste loss events associated with spare inlet nozzles for the 241-C SSTs. Additional pipeline failures that may have resulted in the loss of tank waste within the 241-C Tank Farm are summarized in Table ES-3. Insufficient information was available to estimate a volume of inventory of tank waste potentially discharged to the soil from the spare inlet nozzles or newly identified pipeline failures.

Table ES-1. Summary of Tank Waste Loss Events

Tank	Analysis	HNF-EP-0182 Waste Loss Estimate (gallons)	RPP-ENV-33418 Waste Loss Estimate (gallons)
C-101	Data appears to be inconsistent and high uncertainty remains whether evaporation or tank leak occurred. Until better supporting evidence is obtained, no changes to leak estimate in HNF-EP-0182.	20,000	20,000 Maybe P1 waste type or dilute condensate
C-105	Data indicates leaks from multiple sources near tank C-105 including a potential leak at the base of the tank. Waste volume in soil adjacent to tank calculations based on dry well logging data.	0	40 to 2,000 P1 waste type
C-110	Waste loss appears to be the result of a tank overflow through spare inlet nozzles.	2,000	Less than 2,000 CSR waste type
C-111	Evaporation calculations, plotted liquid level data, and evaporation rates clearly indicate that the liquid level decrease can be attributed to evaporation.	5,500	0

Table ES-2. Potential Waste Losses Through Spare Inlets on WMA C SSTs		
Tank	**Date**	**Waste Type Present in Tank**
C-101	June 1965 – December 1967	Received waste from CR Vault. Tank contains CR Vault waste (28kgal), PUREX P2 (452kgal), and Coating Waste (CWP2) (94kgal).
C-103	October 1953 – March 1957	Tributyl Phosphate Plant (TBP) Waste
	June 1961 – December 1961	PUREX CWP2
C-104	August 1958	PUREX CWP1
	June 1965 – March 1966	After receiving 15,000 gallons of unknown waste type (likely PUREX CWP2 based on RL-SEP-332, page B-2) from 244-CR Vault, the tank was filled above the spare inlets. Majority of waste in tank is PUREX CWP2
C-105	Pre-October 1967	Waste type unknown; soil contamination found beneath spare inlet nozzles during excavation in October 1967
C-106	November 1951	Water added to metal waste (MW2)
C-106	December 1965 – March 1966	PUREX P2 HLW supernate
C-109	June 1961 – December 1961	PUREX CWP2
	June 1965 – March 1968	Tank received 19,000 gallons from 201-C Sr Semiworks (HS). Tank contains 112,000 gallons of evaporator bottoms (BT-SltCk), 300,000 gallons of PUREX CWP2, and 142,000 gallons of Sr Semiworks waste (HS).
C-111	May 1957	TBP Waste
	September 1957	Scavenged 242-B BT-SltCk waste (i.e. concentrated 1C/CW and TBP wastes)
C-201	December 1955 – January 1956 June 1961 – June 1963	201-C Hot Semiworks waste from PUREX flowsheet tests (Note: this is not waste type HS).
C-202	January 1957 – March 1957 June 1957 – October 1958 June 1961 – December 1963	201-C Hot Semiworks waste from PUREX flowsheet tests (Note: this is not waste type HS). Last waste transferred into tank was 201-C building flush solutions.
C-204	March 1968 – March 1970	201-C Hot Semiworks waste from PUREX flowsheet tests (Note: this is not waste type HS) and 201-C building flush solutions.

Table ES-3. Potential Pipeline Failures Not Previously Reported in DOE/RL-88-30, revision 16				
Date	**Waste Type [(1)]**	**Waste Discharged (Gallons)**	**Event Description from Reference**	**References**
6-1964	HS - 201C Strontium Semiworks Waste	No estimate	"The underground process line from the 252-C diversion box to 112 tank, C Tank farm, failed. The failed pipeline was isolated. Jumpers were fabricated and installed to establish a new process route." The failed pipeline is line V172.	RPP-RPT-29191, page 115
11-1964	Cesium Depleted PUREX HLW Supernate (P1)	No estimate	Installation was completed on an alternative effluent return route from the 801-C Cesium Loadout Building to Tank 103-C. See drawing H-2-4574, *Process & Service Piping Tanks to Loadout Station* for details of this piping. A three-way ball valve was inserted in the 801-C effluent return line to SST C-102 to enable routing waste to SST C-103 or C-102.	RPP-RPT-29191, page 115
2-1965	PUREX CWP2	No estimate	"On February 18, 1965 the 244-CR Vault was found flooded up to approximately the level of the tank tops. Immediate steps were taken to reduce the liquid level by jetting the solution to the 011 Tank. Partial cause of the flooding is attributed to a failure in the coating waste line which enters the 151-CR diversion box. Drainage from this diversion box collects in the 002-CR vault sump. Water from a sampler flush line and drainage from rain and snow contributed to the liquid level in the vault. To date, the 001, 002, and 003 sumps have been emptied, and the 011 sump is being emptied, to the 011 Tank. This liquid is being pumped from the 011 Tank to Tank 103-A in the 241-A Tank Farm. In trying to establish a coating waste routing from the Purex Plant to the 241-C Tank Farm a leak was also discovered in the underground line adjacent to the 152-A Diversion Box. Because of the two apparent leaks in this line it has been abandoned as being unusable."	RPP-RPT-29191, page 116
3-1965	PUREX CWP2	No estimate	"A liquid level rise in Tank 103-C, the cesium feed tank, was apparently caused by a failed line in the encasement between the 152-CR diversion box and Tank 102-C which permitted coating waste from the Purex Plant to leak into the encasement and drain to Tanks 101-C, 102-C, and 103-C via the tank pump pits. Coating waste has been routed through a spare line to Tank 102-C and no further leaks have been detected. The coating waste solution accumulated in Tank 103-C did not significantly affect cesium loading capability as a cask was loaded normally following the incident." Note: Pipeline 8041 is inside a concrete encasement was used to route the PUREX CW to SST C-102 (see drawing H-2-44501, sheet 92). This encasement traverses from	RPP-RPT-29191, page 116

Table ES-3. Potential Pipeline Failures Not Previously Reported in DOE/RL-88-30, revision 16				
Date	**Waste Type (1)**	**Waste Discharged (Gallons)**	**Event Description from Reference**	**References**
			diversion box 241-CR-152 along the west side of SSTs C-101, C-102, and C-103. In order for the PUREX CW to drain into SSTs C-101, C-102, and C-103, the encasement containing the failed transfer pipeline must have partially filled with waste. The integrity of this encasement is unknown and may have leaked waste to the soil. Drawing H-2-2338, sheet 45 indicates pipeline 8041 is out of service. Pipeline 8041 connects from nozzle U-3 in the 241-CR-152 diversion box and nozzle U-2 in pit 02C atop SST C-102.	
5-1966	PUREX CWP2	No estimate	"A leak in the PUREX coating waste route (152-CR diversion box) was detected by an abnormal liquid level increase of the 002CR vault sump. The leaking flexible jumper in the 152CR diversion box was replaced." Note: Diversion box 241-CR-152 and 244-CR Vault sump are concrete structures with painted surfaces. It is uncertain whether leaked waste was contained inside diversion box 241-CR-152 and 244-CR Vault sump.	RPP-RPT-29191, page 118
Pre-1988	PUREX P2 supernate	No estimate	Pipeline V-103 - "Earlier investigations of the extremely high levels of contamination found between Tanks 104-C and 105-C are described in reference (10). The following observations were documented at the time and were the bases for the conclusion that both tanks were sound: The fill line V-103 was stated to have been abandoned at an earlier date due to pipeline leakage, and the activity noted in DW 30-03-02 could have been due to migration of pre-existing contamination that was first seen in the exploratory scans. This line was part of the old PUREX supernate (PSN) transfer route from Tank 241-AX-101. The material was thermally hot, and water injection was required to maintain a temperature below 60^{o}C. The cause of failure was believed to have been due to thermal shock induced by the intermittent transfers. In-tank photographs failed to show any evidence that either tank was unsound. However, the Tank 241-C-105 photos indicated that the tank had been filled to a level above that of the cascade and sidefill pipelines. The possibility of leakage through the wall penetration seals was discussed. The liquid levels in Tank 241-C-105 and -104 remained at a high level for almost six	Environmental Protection Deviation Report 87-10, page 4

Table ES-3. Potential Pipeline Failures Not Previously Reported in DOE/RL-88-30, revision 16				
Date	**Waste Type (1)**	**Waste Discharged (Gallons)**	**Event Description from Reference**	**References**
			months after the first exploratory well scans, and the observed activities, including that in DW 30-03-02, had remained stable throughout, whereas seepage from either tank would normally have been seen as steadily increasing radiation at the 35 to 41 feet farm excavation depth. The activity at this depth however has diminished in all wells since 1974."	
Unknown	Unknown	No estimate	Line V112 is identified as a leaker adjacent to diversion box 241-C-151. The date and amount of waste leaker from this pipeline is unknown.	RPP-25113, page 7
Notes: (1) Waste types are defined in RPP-26744, Hanford Soil Inventory Revision 1.				

1.0 INTRODUCTION

There have been numerous studies and investigations in an attempt to estimate the inventory of contaminants in the tank farms vadose zone. Most effort to date has focused on leak volume estimates. Vadose Zone inventories are then estimated based on process knowledge of the composition of waste in the tank at the time the release occurred. For some major tank leaks and unplanned releases (UPRs), historical records confirm the waste loss event and provide a strong technical basis for leak volume and inventory estimates. However, for many tank leaks and UPRs little data is available.

The *Tank Waste Summary Report* (HNF-EP-0182) provides the commonly accepted basis for tank leak volume estimates, but it does not provide associated inventory estimates or UPR volumes. Tank leak volume estimates reported in HNF-EP-0182 have not been updated for many years. The *Tank Farm Vadose Zone Contamination Estimates* (RPP-23405) summarizes vadose zone tank leak characterization and investigations. It is consistent with many of the tank leak volume estimates listed in HNF-EP-0182 and provides UPR volume estimates. However, RPP-23405 shows large differences in estimated leak volumes, both higher and lower, compared to some tank leak volume estimates in HNF-EP-0182. The RPP-23405 volume estimates were used in the *Hanford Soil Inventory Model, Rev. 1* (SIM) (RPP-26744) to estimate leak inventories for the *Initial Single-Shell Tank System Performance Assessment for the Hanford Site* (DOE/ORP-2005-01). RPP-23405 does not address volume uncertainties and some of the leak volume estimates, data interpretations, and conclusions presented in RPP-23405 are in question.

CH2M HILL Hanford Group Inc. developed jointly with DOE-ORP and Washington Department of Ecology (Ecology) a process to re-assess selected tank leak estimates (volumes and inventories) and to update tank leak and UPR volumes, and inventory estimates as emergent field data is obtained (RPP-32681, 2007, *Process to Estimate Tank Farm Vadose Zone Inventories*). This process does not represent a formal tank leak assessment in accordance with procedure TFC-ENG-CHEM-D-42, *Tank Leak Assessment Process*. This report documents the results of applying the process described in RPP-32681 for re-assessing UPRs and tank leak estimates for single-shell tanks (SSTs) in the 241-C tank farm. This revision of this report contains the re-assessment for SSTs 241-C-101, 241-C-110, 241-C-111 and 241-C-105, as well as UPRs within the 241-C Farm.

2.0 BACKGROUND

Approximately 53 million gallons of radioactive waste from chemical processing and plutonium processing operations are stored in 177 underground storage tanks on the Hanford Site. Of these, 149 are SSTs, which consist of a single steel liner inside a concrete shell. Nominal capacities range from 55,000 to 1,000,000 gallons. For the immediate future, plans call for retrieval of waste from the SSTs and transfer to the 28 double-shell tanks (DST), with eventual transfer for treatment in the Waste Treatment and Immobilization Plant.

Sixty-seven of 149 SSTs have been identified as "confirmed or suspected leakers" over the operational lifetime (1945 - 1980) of the SST farms (HNF-EP-0182). Historically, SST integrity was assessed by two independent methods. From the beginning of Hanford Site tank farm operations, the primary leak detection system was routine monitoring of liquid-surface levels within each tank. Originally liquid levels were measured using pneumatic dip tubes (HW-10475-C, *Hanford Technical Manual Section C*, page 908). This practice was later replaced and a manual tape with a conductivity electrode was used to detect the liquid surface (H-2-2257, 1951, *Conductor Reel for Liquid Level Measurement*). The biggest limitations of the manual tape measurements were failures of the electrodes, solids forming on the electrode and measurement precision. The statistical accuracy of the manual tape and electrode measurement technique was 0.75 in. (~2,060 gallons), as determined in July 1955 (HW-51026, 1957, page 4, *Leak Detection – Underground Storage Tanks*, General Electric Company, Richland WA). Later, liquid-level determinations were automated in many of the SSTs to provide more accurate and reliable measurements. However, surface-level measurements remain highly uncertain in the waste tanks that contained boiling wastes (e.g. 241-A, 241-AX, and 241-SX tank farms), when supernatant has been removed from tanks leaving solids or precipitated salts, or where solid crusts have formed on the waste surfaces.

Routine monitoring of gross gamma activity in drywells near the SSTs provided a secondary leak detection method. As with the tank waste surface-level measurements, there are uncertainties associated with the use of gross gamma logging data as a leak detection system. Three sources of uncertainty are as follows:

1. <u>Number and location of wells</u>: There were rarely more that 6 drywells surrounding the 100-series SSTs (circumference approximately 235 ft). Consequently, the absence of gamma activity in a well does not necessarily indicate that a tank did not leak.

2. <u>Waste type:</u> The overall effectiveness of gross gamma logging in drywells as a leak detection system depends on the waste type in the tank. The gross gamma logging system is most effective with waste types containing high concentrations (activities) of mobile gamma emitting radionuclides (e.g. Ru-106 or Co-60) and less effective with low-activity waste types such as aluminum cladding waste.

3. <u>Other contamination sources</u>: Gamma activity observed in drywells may also have originated from near-surface waste loss events, transfer line leaks, and tank overfills.

During the active operation of the SST farms, either an anomalous liquid-level measurement or a significant increase in gamma activity in a drywell was generally sufficient reason for the tank to be listed as “questionable integrity” or an “assumed leaker” as discussed in SD-WM-TI-356, *Waste Storage Tank Status and Leak Detection Criteria*. When a tank was designated as “questionable integrity” it was pumped to a “minimum heel” and taken out of service. In a limited number of cases the “questionable integrity” designation was followed up with additional investigations. However, in many cases no additional investigations were performed. In the late 1980s, all SSTs that had been flagged as potential or known leakers were combined into the list contained in the monthly waste tank summary report (HNF-EP-0182) and flagged as “confirmed or assumed leakers.” Because of the uncertainty associated with the measurements, unexplained waste level decreases were generally considered as an inadequate basis for designating a tank as a “confirmed leaker.” The “confirmed leaker” designation required an observed waste level decrease combined with increasing gamma activity in a nearby drywell. The “assumed leaker” designation could be assigned based on either measurement (an observed waste level decrease or increasing gamma activity in a nearby drywell), without confirmation from the other measurement.

The uncertainties, associated with both the primary and secondary leak detection systems for the SSTs, led to a number of decisions. By the early 1960s, decisions were made to move from the single-shell tanks to the double-shell tank design. The double-shell design provided both secondary containment and reliable leak detection systems. A decision was also made to pump liquids stored in the SSTs into the DSTs to remove pumpable liquid and interim stabilize the SSTs.

3.0 SCOPE AND CRITERIA

An assessment team comprised of representatives from DOE-ORP, Ecology, and CH2M HILL Hanford Group, Inc. was assembled to review available information relating to waste loss events in the 241-C Tank Farm. The assessment team membership is listed in Table 3-1.

Table 3-1. Waste Loss Event Assessment Team

Name	Organization	Role
Joe Caggiano	Washington State Department of Ecology	Regulatory oversight
Michael Connelly	CH2M HILL Hanford Group Inc.	Knowledge and experience in reviewing, analyzing, and interpreting drywell, lateral survey, and High Resolution Resistivity (HRR) data.
Jim Field	CH2M HILL Hanford Group Inc.	Contractor manager for process Knowledge and experience in reviewing, analyzing, and interpreting in-tank (i.e., surface liquid level and liquid observation well) data.
Les Fort	Washington State Department of Ecology	Regulatory oversight
Michael E. Johnson	CH2M HILL Hanford Group Inc.	Knowledge and experience with operations of the tank farm and individual tank, tank history, tank waste characteristics, and in-tank processes.
Bob W. Lober	U.S. Department of Energy Office of River Protection	Tank Farms Programs and Project Division representative
Jeffery Lyon	Washington State Department of Ecology	Regulatory oversight; review and approval of leak volumes and compositions

In accordance with RPP-32681, the following steps were conducted in reassessing waste losses within the 241-C Tank Farm:

- Data regarding any waste leaks from ancillary equipment in the area of the facility being reassessed are collected, as well as any reported unplanned releases (UPRs).

- Data regarding any past or present waste leaks from tanks, as well as any reported UPRs, are collected, and collated with any reported ancillary equipment waste leaks.

- All of the information from previously reported waste tank leaks and UPRs are compiled to determine the best estimation of the volumes of tank waste which leaked to the vadose zone and the time at which these leaks occurred.

- Data regarding the waste composition at the time of the leak from the waste tank, ancillary equipment or UPR is compiled from the available sources, such as Tank Waste Information System Best Basis Inventory, Hanford Defined Waste model etc., and is applied to the facility being reassessed.

- The waste leak volume estimates are combined with the waste compositions at the time of leak to determine the best estimation of the radionuclide and chemical inventory which entered the soil.

4.0 REASSESSMENT OF WASTE LOSS EVENTS IN 241-C TANK FARM

The information gathered and the reassessment results for each of the SSTs and UPRs in the 241-C Tank Farm are discussed in this section. Several processes were conducted at the Hanford site that generated wastes transferred to the 241-C Tank Farm. These processes and the waste types generated are discussed in the *Standard Inventories of Chemicals and Radionuclides in Hanford Tank Wastes* (HNF-SD-WM-TI-740). Additional subsections will be added to this section as additional SSTs and UPRs in the 241-C tank farm are reassessed.

The 241-C Tank Farm consists of twelve, nominally 530,000 gallon capacity SSTs and four nominally 55,000 gallon capacity SSTs. Figure 4-1 and Figure 4-2 depict the two types of SSTs present in the 241-C Tank Farm. The larger capacity SSTs are collectively referred to as the 100-series SSTs, whereas the smaller capacity SSTs are referred to as the 200-series SSTs. Drywells were installed around the 100-series SSTs (Figure 4-3) to aid in detecting waste loss events. No drywells are installed adjacent to the 200-series SSTs.

<u>HRR Information</u>: High resolution resistivity was used between August and December 2006 to conduct geophysical investigation within the 241-C Tank Farm (RPP-RPT-31558). The preliminary geophysical investigation was performed by collecting resistivity data using 69 drywells within the tank farm and with a set of 8 monitoring boreholes (e.g., groundwater wells), 1 buried electrode, and four surface electrode arrays outside of the farm. The four surface electrode arrays were run parallel to the tank farm fence line. Only the well to well electrode readings provided resistivity data having the capability to identify and delineate contaminant plume features within and around tank farms.

Areas of low resistivity are shown in Figure 4-4 for the 241-C Tank Farm. Areas with low resistivity are most likely associated with increased soil moisture or inorganic salt concentration, which could be due to waste loss events. Specific areas of low-resistivity values within the 241-C tank farm are a region near tanks 241-C-101, 241-C-102, 241-C-104, C-105, and 241-C-107, along with a smaller low-resistivity zone near tank 241-C-108.

Figure 4-1. Nominally 530,000 Gallon Capacity 75-Ft Diameter SST

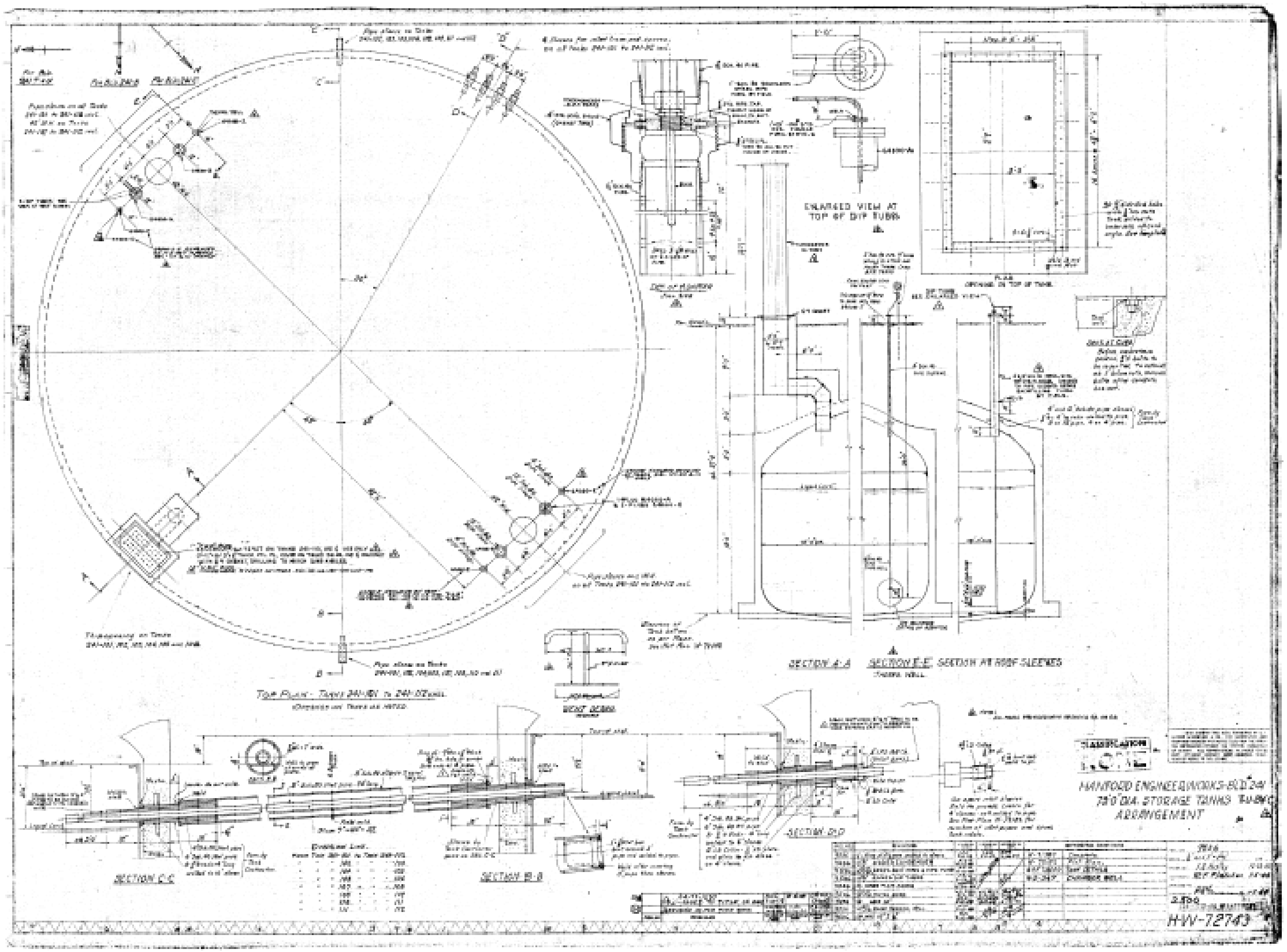


Figure 4-2. Nominally 55,000 Gallon Capacity SST

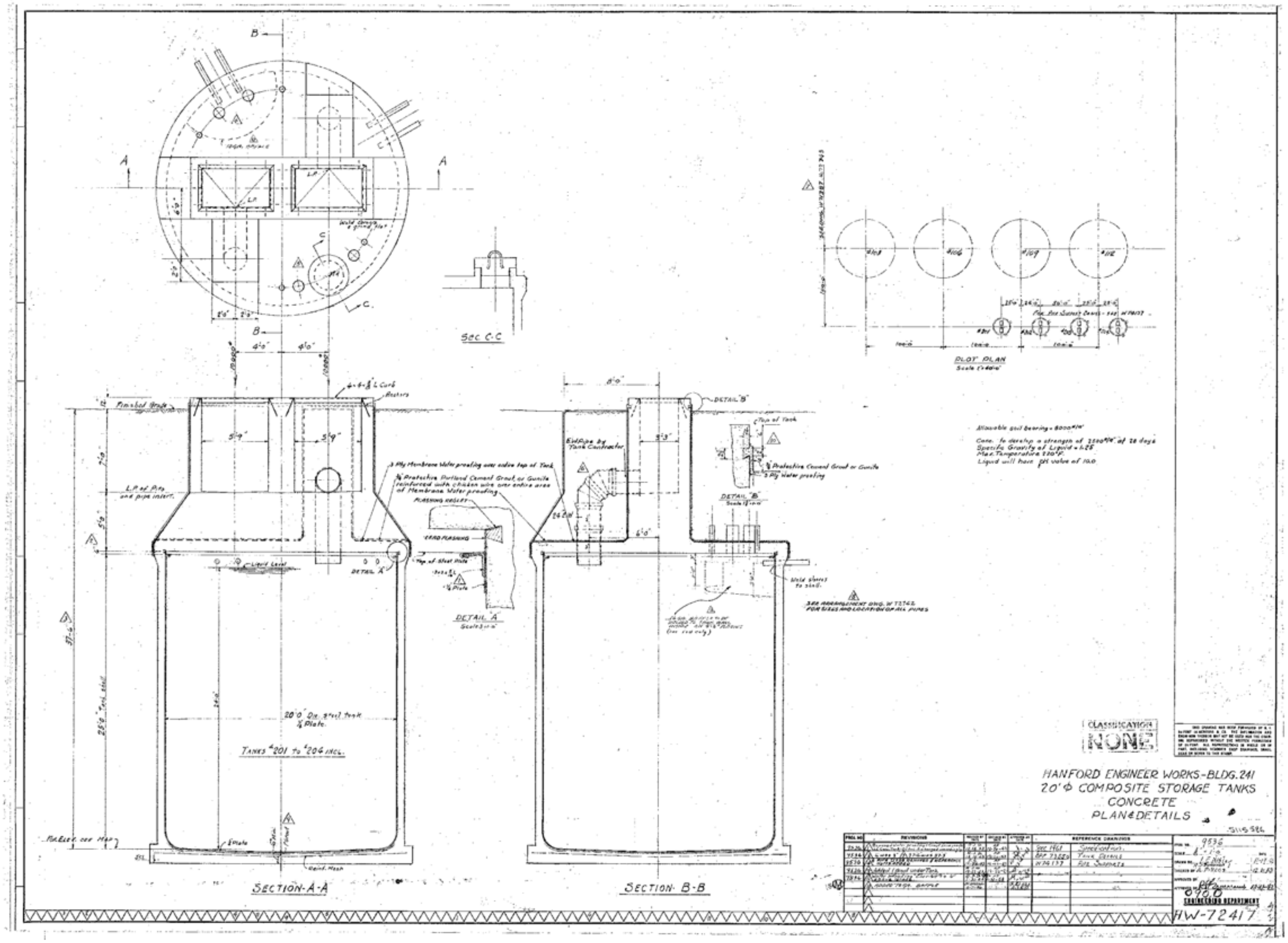


Figure 4-3. Drywell Locations in 241-C Tank Farm

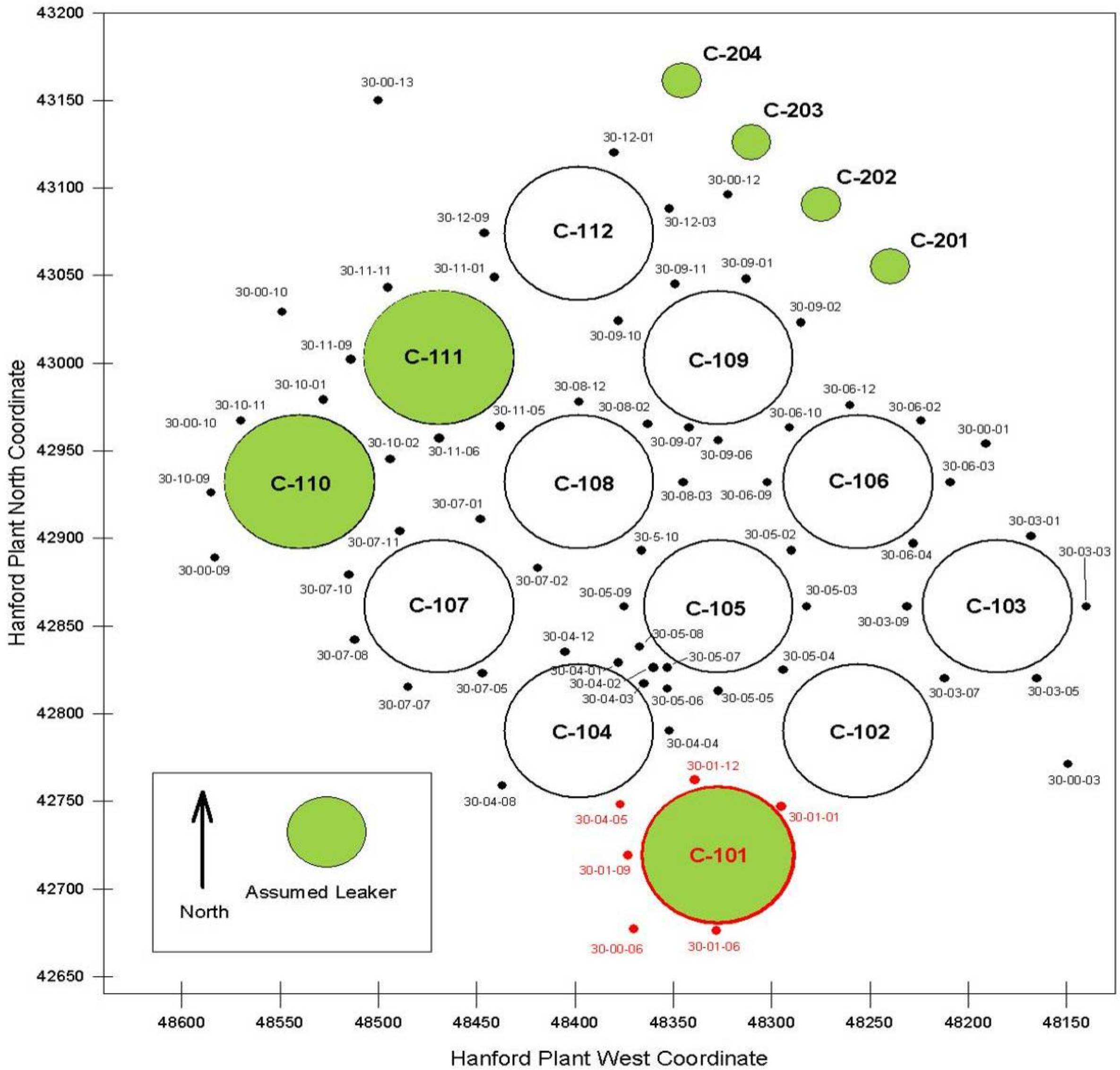
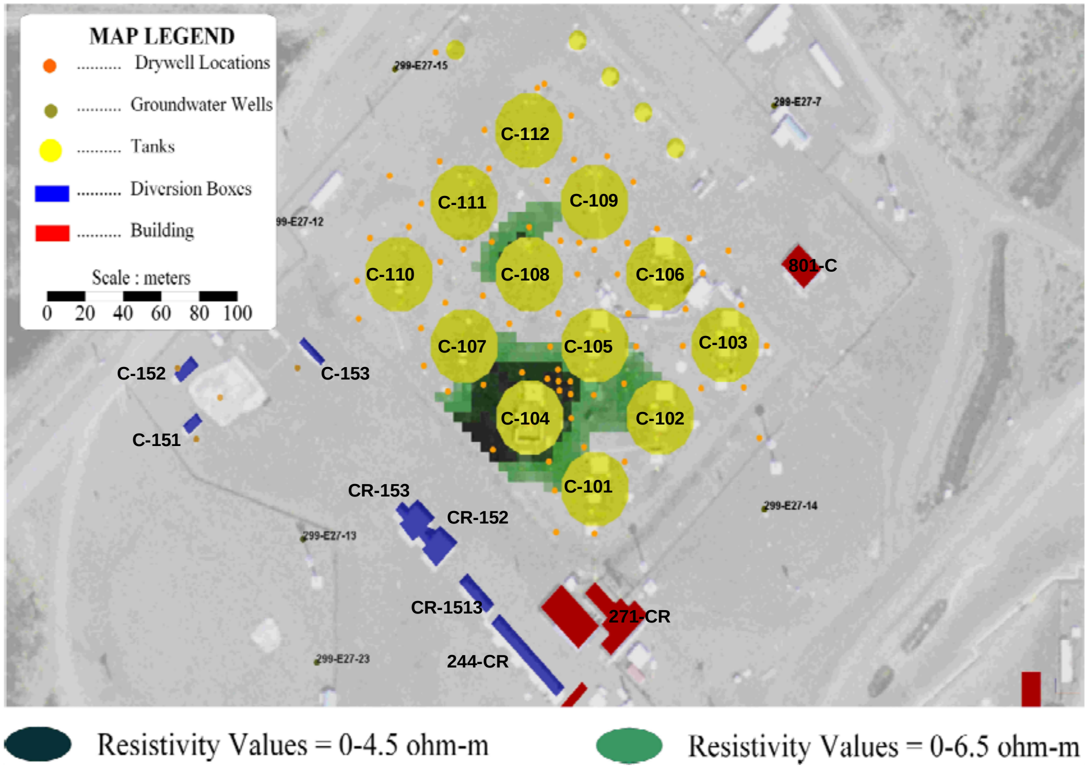


Figure 4-4. Areas of Low Resistivity within 241-C Tank Farm (Aug. – Dec. 2006)



4.1 Reassessment of Tank 241-C-101 Waste Loss Event

4.1.1 Background

Tank 241-C-101 has a capacity of 2,006,000 liter (530,000 gallon) and a diameter of 22.9 m (75 ft). Tank 241-C-101 is presently passively ventilated and is the first tank in a three-tank cascade that includes tanks 241-C-102 and 241-C-103. Figure 4-5 provides the orientation of tanks 241-C-101, 241-C-102 and 241-C-103 along with piping connections to tank 241-C-101. The base of tank 241-C-101 is approximately 38 feet below grade. The inlet nozzles on the tank side wall are approximately 20.5 feet below grade; whereas the cascade overflow pipeline to tank 241-C-102 (not visible in Figure 4-5) is approximately 21 feet below grade. Figure 4-1 provides details of these piping penetrations into the single-shell tank.

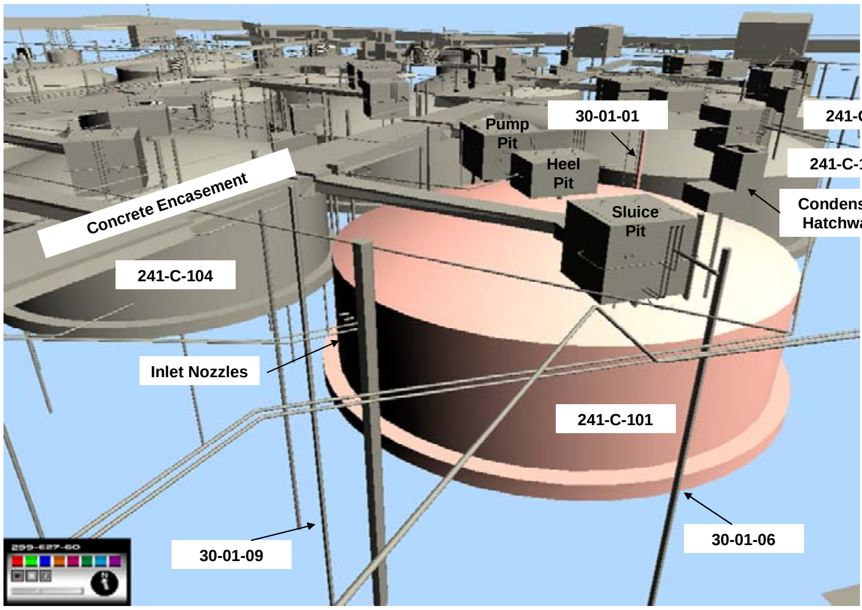
Tank 241-C-101 began receiving metal waste (MW) from the 221-B Plant bismuth phosphate process in March 1946. In May 1946, the tank was declared full and began cascading waste to tank 241-C-102. Tank 241-C-102 was filled with MW in August 1946 and MW supernatant cascaded to tank 241-C-103. The cascade of tanks 241-C-101, 241-C-102 and 241-C-103 was filled with MW in October 1946. MW from the 221-B Plant was then diverted to other single-shell tanks for storage.

The MW sat undisturbed in tank 241-C-101 until the fourth quarter of 1952. A uranium precipitate formed in the MW, settling to the bottom of the tank as a sludge layer. The MW supernatant and sludge were removed from tank 241-C-101 from the fourth quarter 1952 through May 14, 1953. MW removal from tanks 241-C-102 and 241-C-103 was also conducted during this period. These tanks were inspected and deemed fit for re-use to store additional waste.

Tank 241-C-101 received Tri-Butyl Phosphate (TBP) Plant waste intermittently from 221-U Plant[1] beginning on May 15, 1953 (HW-28377, page 4). During August 1953, tank 241-C-101 was filled with TBP Plant waste and supernatant was cascaded to tank 241-C-102. TBP Plant supernatant waste was pumped from tank 241-C-101 to tank 241-C-103 in September 1953. The reason why waste was not cascaded from tank 241-C-101 to 241-C-102 and then to 241-C-103 is not provided in the monthly tank farm reports. The cascade overflow line from tank 241-C-101 to tank 241-C-102 may have been plugged. The cascade overflow line to tank 241-C-102 is first noted in the tank farm monthly reports as being partially plugged in June 1954 (HW-32389, page 4). All three tanks were noted as being filled with TBP Plant waste in October 1953.

[1] The Tri-Butyl Phosphate Plant was also known as the uranium recovery plant, which was located in the 221-U Plant.

Figure 4-5. Orientation of Tanks 241-C-101, 241-C-102 and 241-C-103



In December 1955, TBP Plant supernatant waste was transferred from tank 241-C-101 to the 244-CR Vault for precipitation of cesium and strontium using ferrocyanide (so-called In Farm scavenging)[2]. The TBP Plant waste along with the ferrocyanide (FeCN) precipitate was discharged to tank 241-C-109 for settling of the precipitate, with the supernatant then transferred to 216-BC-4 crib (HW-44784, page 20). Tank 241-C-101 was then refilled (total waste volume 485,000 gallons) with TBP Plant supernatant from tank 241-C-104 in January 1956.

In September and October 1956, 354,000 gallons of TBP Plant supernatant were transferred from tank 241-C-101 to 244-CR Vault for In Farm scavenging, leaving approximately 131,000 gallons of waste in tank 241-C-101. The TBP Plant waste along with the ferrocyanide (FeCN) precipitate was discharged to tank 241-C-112 for settling of the precipitate, with the supernatant then transferred to 216-BC-10 crib (HW-48518, page 19). The volume of waste in tank 241-C-101 was later revised to 98,000 gallons in February 1957 as a result of a new waste surface electrode measurement.

Tank 241-C-101 continued to be used through 1957 as the feed tank to the In Farm scavenging process conducted in the 244-CR Vault. Tank 241-C-101 received TBP Plant supernatant and 242-B Evaporator bottoms wastes from the tanks listed in Table 4-1. The

[2] Tank 241-C-101 was sometimes referred to as tank 101-CR when used in conjunction with the 244-CR Vault for In Farm scavenging operations.

scavenged waste was transferred to tanks 241-C-108, 241-C-109, 241-C-111 and 241-C-112 for settling of the FeCN precipitate before discharge to the 216-BC trenches.

Table 4-1. TBP Plant Supernatant and 242-B Evaporator Bottoms Transferred to Tank 241-C-101

Tank	Volume, gallons	Date	Reference
241-BY-101	455,000	June 1957	HW-51348, page 5
241-BY-102	717,000	June 1957	HW-51348, page 5
241-BY-101	227,000	July 1957	HW-83906-C RD, pages 64
241-BY-103	551,000	July 1957	HW-83906-C RD, pages 64
241-BY-103	162,000	August 1957	HW-83906-C RD, pages 72
241-B-101	228,000	August 1957	HW-83906-C RD, pages 72
241-B-102	424,000	August 1957	HW-83906-C RD, pages 72
241-B-103	297,000	August 1957	HW-83906-C RD, pages 72
241-B-107	265,000	September 1957	HW-83906-C RD, page 80
241-B-108	399,000	September 1957	HW-83906-C RD, page 80
241-B-109	403,000	September 1957	HW-83906-C RD, page 80
241-B-106	379,000	October 1957	HW-83906-C RD, page 88
241-B-112	495,000	October 1957	HW-83906-C RD, page 88
241-BX-110	88,000	October 1957	HW-83906-C RD, page 88
241-BX-110	113,000	November 1957	HW-83906-C RD, page 97
241-BX-111	511,000	November 1957	HW-83906-C RD, page 97
241-BX-108	484,000	November 1957	HW-83906-C RD, page 97
241-BX-109	243,000	December 1957	HW-83906-C RD, page 104

Tank 241-C-101 contained approximately 98,000 gallons of sludge and approximately 27,000 gallons of supernatant following the completion of the In Farm scavenging process in January 1958. The tank did not receive any waste again until 1960. Beginning in December 1960 (HW-68292, page 4) and intermittently until 1962, tank 241-C-101 received plutonium-uranium extraction (PUREX) process cladding removal waste (CW) from the PUREX Plant. During 1962, tank 241-C-101 was filled and further additions of PUREX cladding removal waste led to the cascade of supernatant to tanks 241-C-102 and 241-C-103. The PUREX cladding removal waste was subsequently transferred from tanks 241-C-102 and 241-C-103 to tanks 241-BX-101 and 241-BX-102. Tank 241-C-101 stopped receiving PUREX cladding removal waste in June 1962 (HW-74647). The PUREX coating removal waste was transferred to tank 241-B-107 in the fourth quarter of 1963, leaving ~94,000 gallons of sludge in tank 241-C-101.

In the fourth quarter of 1963, tank 241-C-101 received 276,000 gallons of PUREX HLW supernatant (PSN) from tank 241-A-102 in order to prepare tank 241-A-102 for use in sluicing sludge from tank 241-A-103 (HW-80379, page 4). Tank 241-C-101 also received 172,000 gallons of PSN from tank 241-A-103 in the first quarter of 1964 (HW-83308, page 4), bringing the total waste volume to 546,000 gallons, which is above the cascade overflow level. In the second quarter of 1965, tank 241-C-101 is reported to have received 28,000-gallons of waste from 244-CR Vault and the tank liquid level was reported as 574,000-gallons (RL-SEP-659, page 4), which exceeds the nominal operating capacity of 530,000 gallons and the cascade overflow level. However, there is no record that waste cascaded from tank 241-C-101 into tank 241-C-102 during this timeframe.

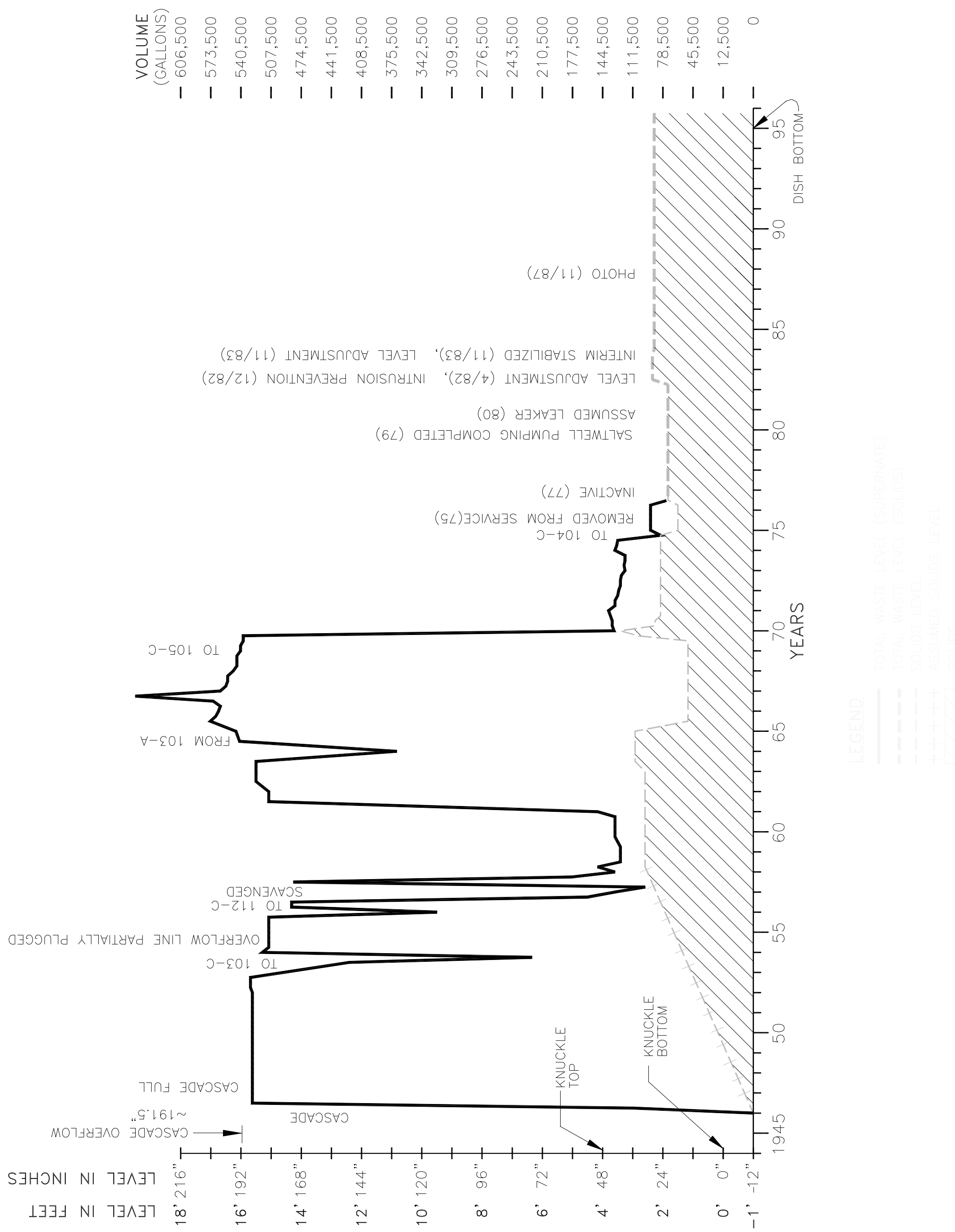
No additional transfers of waste into or waste removals from tank 241-C-101 are reported until the fourth quarter of 1969. Table 4-2 summarizes the waste level in tank 241-C-101 for 1963 through 1970. During the period between January 1965 and September 1969, the liquid level decreased in tank 241-C-101 from 574,000 gallons to 538,000, a decrease of 36,000 gallons. No records could be located indicating the basis for the decrease in tank 241-C-101 liquid level. In the fourth quarter of 1969, the supernatant in tank 241-C-101 was transferred to tank C-105 and then to B Plant for processing through the cesium ion exchange system. The pumpable liquid was removed from tank 241-C-101 in 1969, leaving approximately 47,000 gallons of supernatant (~17 in.) covering 87,000 gallons (~40.7 in.) of sludge. The liquid level continued to decrease from 1970 through 1974.

Tank 241-C-101 was removed from service in the first quarter of 1976. It was categorized as a confirmed leaker in 1980 with an approximate leak volume of 20,000 gallons. Intrusion prevention was completed in December 1982, and the tank was interim-stabilized in November 1983 (HNF-EP-0182, rev. 219). Table 4-2 and Figure 4-6 summarize the waste history for tank 241-C-101.

As of June 30, 2006, tank C-101 contains 88,000 gallons of sludge (HNF-EP-0182, rev. 219). The estimated volume is equivalent to 39.5 in. referenced to the tank center bottom. For inventory estimates, the waste is designated as PUREX coating removal waste and TBP sludge with 4,000 gallons of drainable interstitial liquid and no pumpable liquid (TWINS).

Table 4- 2. Tank 241-C-101 Waste Inventory 1963 – 1970			
Period	**Tank 241-C-101 Waste Volume (Kgal)**	**Comments**	**Reference**
01/01/63 – 6/30/63	524	Tank contains a mixture of PUREX coating removal waste and TBP Plant waste. Tank contains 109,000 gallons of sludge.	HW-78279, page 4
07/1/63 – 12/31/63	370	Transferred 430,000-gallons of supernatant out of Tank 241-C-101 to 241-B-107. Tank 241-C-101 received 276,000-gallons of PUREX HLW from tank 241-A-102. Tank contains 109,000 gallons of sludge.	HW-80379, page 4
01/01/64 – 06/30/64	542	Tank 241-C-101 received 172,000-gallons of PUREX HLW from tank 241-A-103.	HW-83308, page 4
07/01/64 – 12/31/65	546	New electrode (reading confirmed)	RL-SEP-260, page 4
01/01/65 – 06/30/65	574	Received 28,000-gallons of waste from 244-CR Vault	RL-SEP-659, page 4
07/01/65 – 09/30/65	568		RL-SEP-821, page 4
10/01/65 – 12/31/65	565		RL-SEP-923, page 4
01/01/66 – 03/31/66	563		ISO-226, Page 4
04/01/66 – 06/30/66	571	New electrode reading	ISO-404, Page 4
07/01/66 – 09/30/66	565		ISO-538, Page 4
10/01/66 – 12/31/66	563		ISO-674, Page 4
01/01/67 – 03/31/67	557		ISO-806, Page 4
04/01/67 – 06/30/67	555		ISO-967, Page 4
07/01/67 – 09/30/67	555		ARH-95, Page 5
10/01/67 – 12/31/67	549		ARH-326, Page 5
01/01/68 – 03/31/68	545		ARH-534, Page 5
04/01/68 – 06/30/68	545		ARH-721, Page 5
07/01/68 – 09/30/68	545		ARH-871, Page 5
10/01/68 – 12/31/68	541		ARH-1061, Page 5
01/01/69 – 03/31/69	541		ARH-1200A, Page 5
04/01/69 – 06/30/69	538		ARH-1200B, Page 5
07/01/69 – 09/30/69	538		ARH-1200C, Page 5
10/01/69 – 12/31/69	132	7,000 gallons liquid; transferred 404,000 gallons to B Plant via tank C-105	ARH-1200D, Page 5
01/01/70 – 03/31/70	134	47,000 gallons liquid	ARH-1666A, Page 5

Figure 4-6. Tank C-101 Waste Surface Level History



4.1.2 Historical Basis for Leak Declaration

Prior to 1980, no estimate of the potential waste loss from tank 241-C-101 was made. A review team was established in 1979 to evaluate information available on nine single-shell tanks suspected to have leaked waste to the environment (RHO-CD-896). The 1980 review team membership included the following tank farm organizations:

- Surveillance
- Process Control
- Effluent Control
- Chief Scientist

RHO-CD-896 indicates tank 241-C-101 was pumped to a minimum heel in 1969 (~44 in.) following an unexplained liquid level decrease from 194.5 in. in January 1968 to 190.5 in. in December 1969 (RHO-CD-896, pg. 48). Also, radioactivity was detected in the three of the five drywells around this tank (RHO-CD-896, pg. 46):

- 30-00-06
    - Available data from 1968 – 1979 show only background
- 30-01-01
    - No radioactivity when initially monitored,
    - 450 c/s at 33 feet in August 1971
    - Activity slowly receded to 50 c/s (1979)
- 30-01-06
    - Drywell activity at several depths
    - Maximum peak 4,250 c/s at 73 feet when first monitored (1970)
    - Activity slowly receded to 70 c/s at 73 feet (1979)
- 30-01-09
    - Extensive drywell activity found at several depths when first monitored (1970) with maximum activity ~17,000 c/s between 29 and 36 foot levels
    - Activity (15,000 c/s) at 26 feet is stable with very little decay
    - Activity at 36 feet (~6,400 c/s) has decreased to ~200 c/s (1979)
- 30-01-12
    - Very low level activity (~12 c/s) in top 20 feet when first monitored and activity is presently stable at background levels

Tank liquid level data presented in Table 4-2 indicates the liquid level in tank 241-C-101 may have began decreasing as early as 1965. This tank was classified as having questionable integrity in 1970. The tank was classified as a confirmed leaker in 1980 based on recommendations of the 1980 review team.

The findings of the individual review team members are summarized in Table 4-3 (RHO-CD-896, pg. 52-54). The review team concluded 17,000 to 24,000 gallons of waste had leaked from tank 241-C-101 during January 1968 through December 1969 (RHO-CD-896, pg. 4).

Table 4-3. 1980 Review Team Findings for Tank 241-C-101

Tank Farm Group	Leak Estimate
Surveillance	Recommended classifying tank as confirmed leaker with estimated waste loss of 24,000 gallons
Process Control	Recommended classifying tank as confirmed leaker with estimated waste loss of 10,000 to 24,000 gallons
Effluent Control	Recommended classifying tank as confirmed leaker, however, no estimate of waste loss
Chief Scientist	Recommended classifying tank as confirmed leaker, however, no estimate of waste loss

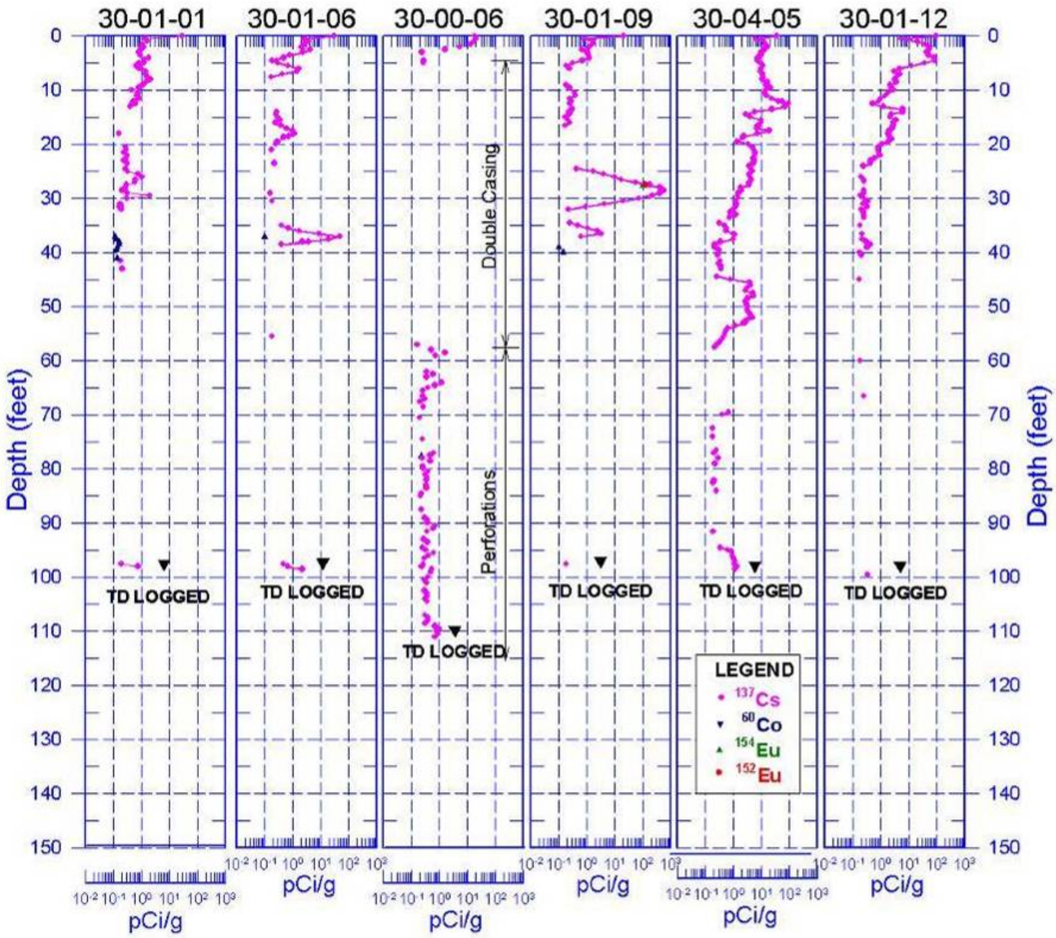
4.1.3 Data Review and Observations

Drywell Information: In 1970, several new dry wells (30-01-01, 30-01-06, 30-01-09 and 30-01-12) were installed around tank 241-C-101. Drywells 30-01-01 and 30-01-12 were installed in March 1970. Drywell 30-01-06 was installed in January 1970. Drywell 30-01-09 was installed in April 1970.

During the drilling of the fourth drywell on March 17, 1970, 5,000 - 10,000 c/m contamination was encountered at the 38-foot level and drilling was terminated (ARH-1526-1, page 130). Drilling of the fourth drywell was resumed on March 18, 1970 and 5,000 to 10,000 c/m contamination was encountered between the 42 and 48 foot level, but after 48 foot, no contamination was seen (ARH-1526-1, page 132). Drilling of the fourth drywell around tank 241-C-101 was reported as being completed on March 24, 1970 (ARH-1526-1, page 138). Contamination was not reported as being encountered during the drilling of other wells around tank 241-C-101. It is not clear which drywell is referred to as the "fourth" in ARH-1526-1. Since this is the last drywell installed around tank 241-C-101 in 1970, it is thought that the "fourth" drywell is in reference to drywell 30-01-09. According to RHO-CD-896 page 46, drywell number 30-01-09 was found to have contamination between the 29 and 36 foot levels when first monitored, which is consistent with the "fourth" drywell being 30-01-09.

These drywells are shown on Figure 4-3 (GJ-HAN-85). Prior to 1970, the only drywell located near tank 241-C-101 was 30-00-06, which was installed in 1944. Elevated gamma radioactivity was detected in drywells 30-01-01, 30-01-06 and 30-01-09 when they were first monitored. Figure 4-7 provides the gamma logging for the drywells adjacent to tank 241-C-101, which were obtained in 1997.

Figure 4-7. Tank 241-C-101 Drywell Gamma Activity Monitored in 1997



During the period between 1965 and 1968, the tank volume exceeded the 546,000 gallon level at which the spare inlet lines would become submerged. At this level, the spare inlet lines would have been covered by about 10 in. of tank waste. A cap with a gasket covered each of the spare inlet lines (drawing W-72743, section D-D), however these caps were not leak tight. Waste loss through the spare inlet lines may have occurred.

The spare inlet lines are located slightly less than the 9 o'clock position on tank C-101, near drywells 30-01-09 and 30-01-06. The contamination at 25 to 30ft. bgs in drywell 30-01-09 and ~35 to 40 ft. bgs in drywell 30-01-06 is at an elevation consistent with waste leakage from the spare inlet lines and spreading downward to an area near these drywells (GJ-HAN-85, section 5). Drywells 30-01-06 and 30-01-09 were not installed until January 1970 and April 1970, respectively. Therefore, there is no monitoring data for these drywells prior to 1970. The observed liquid level decrease in tank C-101 can not be directly linked to leakage of waste from the spare inlet lines due to the absence of drywell monitoring data prior to 1970.

Tank Waste Information: The PSN waste transferred into tank C-101 during 1963 and 1964 originated from tanks A-102 and A-103. Both tanks were operated as boiling waste tanks to evaporate water from the stored PSN waste. The temperature of the PSN waste stored in tank A-102 was measured to be in a range between 94°C and 170°C from January 1963 through May 1963, prior to the transfer to tank C-101. The higher temperature readings in tank A-102 were experienced when the waste liquid level decreased from ~350-inches to ~300-inches. On May 15, 1963, the liquid level in tank A-102 was increased to 345-in. and the waste temperature was reported to be 105°C (IDMS References to Non-record Information, Tank Farm Information Center, Accession # D197260431). The temperature of the PSN waste stored in tank A-103 in January through June 1964 ranged from 76°C to ~94°C (RHO-CD-1172, page B-226).

Tanks A-102 and A-103 were equipped with air-lift circulators, which aided in cooling the waste temperature. However, tank C-101 was not equipped with an airlift circulator. Clearly the waste stored in tanks A-102 and A-103 were capable of generating sufficient heat to cause liquid evaporation. After transferring 448,000 gallons of PSN waste from tanks A-102 and A-103 to tank C-101, evaporation of this waste would still be expected to occur in tank C-101.

Additional information supporting the potential to evaporate water from the PSN waste stored in tank C-101 was the ^{137}Cs content of this waste. The ^{137}Cs concentration was 3.85 Ci/gallon (Larkin 1969). A complete estimate of the composition of the waste present in tank 241-C-101 from 1964 through 1969 is provided in RPP-26744, *Hanford Soil Inventory Model Rev. 1*. At this ^{137}Cs concentration and a liquid volume of ~465,000 gallons (574,000 gallons – 109,000 gallons sludge), sufficient radiolytic decomposition heat would be generated to account for evaporation of up to ~2,550 gallons/month , or ~7,680 gallons/quarter[3] assuming no heat losses to the tank structure or surrounding soil.

[3] Calculation conversion factors are 4.72E-03 W/Ci for Cs-137 decay; 8.60E+5 cal/KWH, and 540 cal/gm heat of evaporation.

Tank C-101 was equipped with an atmospheric condenser during the period of 1963 through 1971, as evident in IDMS Photographs N1318496 and N03669016. The condensers were located at the 3 o'clock position on the tanks within 241-C Farm. A drawing of the atmospheric condensers is shown in Figure 4-8 (W-72927). The condensers were approximately 20-ft (H), 6-ft (W) and 4-ft (L) and consisted of 50, 1inch diameter finned tubes. The bottoms of the condenser tubes were open to the tank atmosphere via the condenser hatchway, as shown on drawing W-72743, reproduced as Figure 4-1, Section A-A. The top of the condenser tubes vented to the atmospheres. The condensers are a passive system that did not use cooling water or fans during operation.

The function of these condensers was to condense water evaporated from tank wastes and reflux the condensed water back into the single-shell tank. The condensed water could have formed a separate waste layer atop of the denser PSN waste in the tank. The 241-A Tank Farm also contained PSN waste in the 1950's and 1960's. The available composition of the condensate from the 241-A Tank Farms is reported in Table 4-4. The composition of the condensate collected in tank C-101 would likely be similar to that reported in Table 4-4.

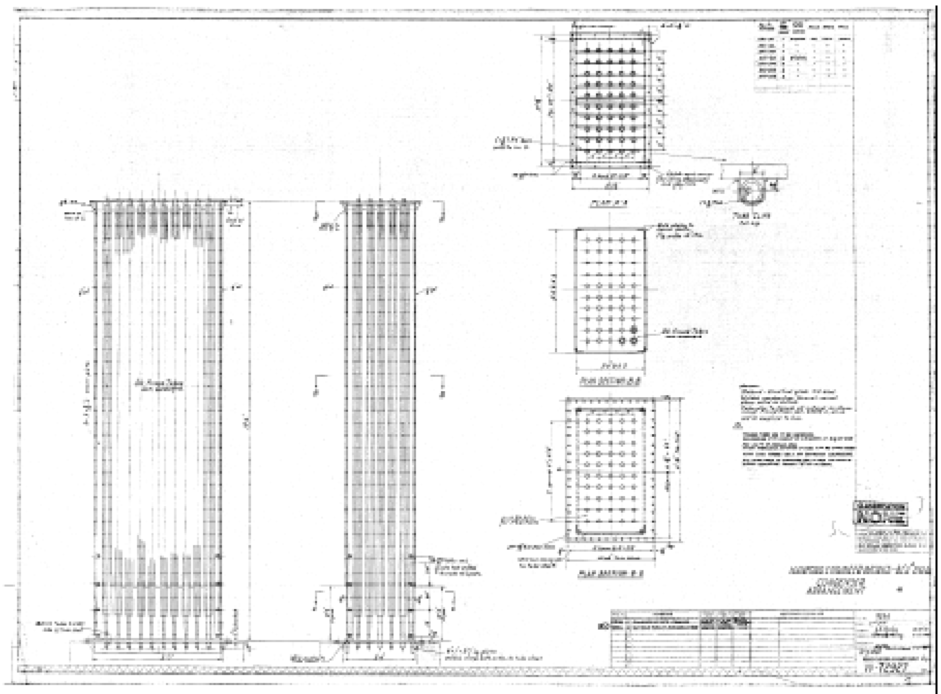
Table 4-4. Analyses of 241-A Tank Farm Condensate

Constituent	**1959 Analyses**[4]	**1961 Analyses**[5]
	mg/L	mg/L
Tri-butyl or butyl phosphate	30 to 190	30 to 200
Shell spray base (or hydrocarbon)	< 10	10 to 70
Ammonium ion	not reported	35 to 200
Sodium	< 1.5	1 to 2
Nitrate	not reported	1 to 5
Nitrite	not reported	5 to 10
Iron	0.1	
Nickel, chromium, copper, aluminum, zirconium, manganese, cobalt, calcium, and magnesium (each)	< 0.01	
	μCi/ml	μCi/ml
Cs-137	2.3E-02	1E-2
Nb-95	2.5E-2	1E-2
Zr-95	1.2E-2	1E-2
Ru-106	7.2E-3	1E-3
Ru-103	5.6E-3	not reported
Sr-89	3.7E-3	1E-3
Sr-90	4.4E-4	1E-4
Ce-144	5E-3	1E-3
Y-91	3E-3	1E-3
I-131	not reported	1E-5
Gross beta	9.1E-2	not reported
Gross alpha	< 1.2E-6	not reported

[4] HW-63949, pg. 17
[5] HW-79174, pg. 16-17

Review of available documentation did not identify information indicating that the condensers installed on the tanks in 241-C Tank Farm failed to perform this function. Information was found that demonstrated operating personnel did report the condensers in the 241-S Tank Farm failed to adequately condense evaporated waste and result in the discharge of water vapor to the atmosphere in 1952 – 1954 (ARH-780, pg. 23). Therefore, it is unlikely that waste evaporation was a significant source for the liquid level declines observed in tank C-101 between 1965 through 1969 given the presence of the condenser on the tank.

Figure 4-8. Atmospheric Condenser for Single-Shell Tanks



4.1.4 Tank C-101 Assessment

On March 6 and March 20, 2007 the preceding information regarding tank C-101 was presented and discussed with the assessment panel. Discussions focused on the summary information in Table 4-5.

Discrepancies in leak levels reported in a 1980 tank integrity assessment were discussed. Estimates of the leak volume appear to range from 10,000 to 24,000 gal. The reason for the differences, and why liquid level decreases before 1968 were not discussed in the 1980 evaluation, remain unknown.

The data shows there was a 36,000 gallon liquid level decrease in the tank between January 1965 and September 1969. The source of the leak could be a spare inlet port, the cascade overflow line to tank C-102 (although reported as plugged, it may have only been partially plugged), a tank leak and/or evaporation. The liquid level continued to decrease below the level spare inlet port (17 ft 4 in).

Some evaporation may have occurred, but if the condenser shown in the drawings and period photographs were operating as expected, even though there was sufficient heat load in the tank to evaporate the supernate, evaporated liquid would have been condensed back to the tank and the majority of the liquid level decrease could not have been due to evaporation. There is no evidence to indicate there was significant contamination near the condenser or any indication the condenser was not functioning at the time of the liquid level decrease.

The low activity found in drywells near the tank is inconsistent with a 20,000 to 36,000 gal PUREX supernate leak. One possibility is that the leaked waste volume was not PUREX supernate waste. The operation of the condenser on tank C-101 would have deposited condensate as a separate waste layer atop of the denser PUREX supernate waste. This condensate, which would have significantly lower concentrations of gamma emitting radionuclides than the PUREX supernate waste (see Table 4-4), may have been the waste type leaked from tank C-101. This hypothesis is consistent with the low concentrations of gamma radioactivity detected in the drywells around tank C-101. However there is a lack of conclusive data to support this hypothesis.

4.1.5 Conclusions

There is insufficient data available to establish a minimum range or leak mass for tank C-101. The upper range appears to be 36,000 gallons. The mass of the C-101 leak is in question because of inconsistencies in low radioactivity measurements in surrounding drywells and expected dry well radioactivity for a large leak of high activity waste. The group agreed that a 1,000 gallon release, as contained in RPP-23405, is possible, but indefensible and agreed, for lack of better supporting evidence, to leave the estimated leak volume at 20,000 gallons as in HNF-EP-0182. Based on the four organizations assessing the data in 1980, the 20,000 gallon leak volume estimate apparently represents a compromise estimate based on unspecified evidence or evaluation that is not documented in the record.

The Initial SST System Performance Assessment (DOE/ORP-2005-01) used a leak estimate of 1,000 gallons and performed a sensitivity assessment assuming the tank C-101 leak was 5,000 gallons. This sensitivity assessment showed the tank C-101 leak would exceed performance criteria for the groundwater. Therefore, a 20,000 gallon leak from tank C-101 would also exceed performance criteria for the groundwater. The leak estimates in RPP-23405 and DOE/ORP-2005-01 should not be changed until more data is obtained. Ecology’s response to the C-101 leak assessment is shown in Table.4-6.

Table 4-5. C-101 Tank Leak Information

	When	Amount	Range (gal)	Possible sources	Comments
Current "Hanlon" estimate	1980		20,000	liquid level decrease	Average based on 1980 team findings
liquid level decrease	Jan 65-Sept 69	574,000 to 538,000 decrease	36,000	spare inlet leak, leak, evaporation	PUREX
1980 team findings	Jan 1968 to Dec 1969	4 in decrease from 194.5 to 190.5	11,000		
	Jan 1968 to Dec 1969		17,000 to 24,000	on p.4 RHO-CD-896	Basis for 17,000 unknown. Average of 17,000 and 24,000 is 20,000 gal
Surveillance	N/A		24,000		
Process Control	N/A		10,000-24,000		Basis for 10,000 unknown.
drywell data	1970-79	Max 17,000 c/s 29-36 ft bgs	Indicates minimal contamination at drywell. Inconsistent with leak events such as SX-108 and T-106.	Found 1970 in drywell 30-01-09	Contamination also in 30-01-06 at 73 ft. Contaminants decayed to < 200 c/s by 1979
SGE data	obtained 2006			shows resistivity anomaly NW of C-101 around C-104	Anomaly NW of spare inlet ports
Evaporation	Jan 65-Sept 69		0-30,500 gal	Heat load calculations show pot 550 gal/month or 30,500 in 56 months.	Condensers on tanks. Amount of evaporation that actually occurred is unknown. No temp data, but sources show potential 180 F temp.
Soil Inventory Model Estimates for 1000 gal		Tc	0.22	Ci	PSN (P1) Supernatant waste type
		Cs-137	852	Ci	
		Sr-90	7.7	Ci	
		Cr	1.5	Kg	
			0-36,000 possible leak volume range		

Table 4-6. Ecology Response to C-101 Leak Assessment

Criteria evaluated	**Acceptable data set**	**Basis**	**Comment**
range of values:	10,000 gallons to 36,000 gallon leak	Max- based on in tank level measurements Min – Tank Farm Contractor Process Control organization determined a minimum volume; reported in the leak assessment report.	C-101 tank dry well indicates low mass of contaminants; SGE indicates plume in area near tank located near tanks C-104 and C-105
recommended value, to be used for any modeling reference case, SST PA Base Case or other Risk Assessments:	20,000 gallons	Conclusion of previous leak assessments; value is a compromise that reflects the uncertainty of the data sets provided	Soil information is inconsistent with liquid level loss information; C-102 tank levels can not be used to confirm a liquid overflow from tank C-101; C-101 condenser on passive ventilation outlet should have minimized evaporative loss
Type of Waste:	PSN or P1	Type of waste identified in 1980 reports; information presented in 2007 leak assessment evaluation.	
Tank designation:	Assumed Leaker	Liquid loss and drywell information	
Type or location of tank leak:	Unknown, information implies loss was below tank outlets and below plugged cascade line	1980 report; information presented in 2007 leak assessment evaluation.	Liquid level indicated drop below plugged cascade line,
Conclusion: Tank leak information is insufficient to make definitive conclusion of volume or the mass of contaminant loss; soil data is inconsistent with waste volume and type. Recommended value is the value previously stated in Hanlon reports that represents an unexplained and unexplainable compromise by the 1980 evaluation team that is not well documented.			
Recommendations: (1) Area in vicinity of C-101, C-104, and C-105 requires DQO and further soil investigation; (2) further tank assessments necessary to establish relationship of nearby plume (C-104/105) to C-101 tank; (3) maintain HNF-EP-0182 volume estimate and notes related to C-101			

4.2 Reassessment of Tank 241-C-110 Waste Loss Event

4.2.1 Background

SST C-110 has a nominal capacity of 2,006,000 liters (530,000 gallons), a diameter of 23 m (75 ft) (HNF-EP-0182), and is passively ventilated. The tank is equipped with four inlet nozzles and a cascade overflow line connection to SST C-111. The centerline of the inlet nozzles on the tank side wall are approximately 17 feet 4 inch (~547,500 gallons) above the center of the tank bottom. The centerline of the cascade overflow pipeline to SST C-111 is approximately 16 feet 11.5 inch (~535,000 gallons) above the center of the tank bottom. The steel liner of the tank is 19 feet (~602,600 gallons) above the center of the tank bottom.

SST C-110 began receiving waste in May 1946 (HW-7-4193-DEL, 1946, *Monthly Report – May 1946*, page 21), and by August 1946 (HW-7-4739-DEL, 1947, *Hanford Engineer Works Monthly Report August 1946*, page 23) was filled with first decontamination cycle waste (1C) and coating removal waste (CW) from the bismuth phosphate process conducted in the 221-B Plant. Beginning in August 1946, waste received into SST C-110 overflowed to SST C-111 through the cascade line and then to SST C-112 beginning in November 1946 (HW-7-5505-DEL, 1946, *Hanford Engineer Works Monthly Report November 1946*, page 28). The three tank cascade was reported as being filled to 100% in March 1947 (HW-7-6048-DEL, 1947, *Hanford Engineer Works Monthly Report March 1947*, page 23). The waste volume in SST C-110 was not reported separately from the other two tanks in the cascade and only a total percent filled was reported until March 1952. The 1C/CW supernatant waste was transferred from SST C-110 to SST B-106 in July 1952 for processing in the 242-B Evaporator, leaving approximately 231,000 gallons of 1C/CW sludge in this tank (HW-27839, 1952, *Waste Status Summary Period 7/1952 thru 9/1952*, page 20).

Beginning in November 1952, SST C-110 was an active receiver of Tri-Butyl Phosphate (TBP) Plant[6] waste. The cascade overflow line to SST C-111 became plugged on November 15, 1952 (HW-27840, page 20). No information was located that indicated the plugged cascade overflow was ever unplugged. As a result of the plugged overflow line, SST C-110 contained ~538,000 gallons of waste, which corresponds to a height of 17-ft 0.5-in. (referenced from center of tank bottom). Since the spare inlet nozzles are at a height of 17-ft 4-in. (referenced from center of tank bottom), it is unlikely that waste was lost through the spare inlet nozzles to the soil.

In February 1956, the TBP Plant supernatant waste was transferred from SST C-110 to 241-CR vault for ferrocyanide scavenging of cesium and strontium (HW-41812, *Waste Status Summary; Separations Section, Separations – Projects and Personnel Development Sub-Section, February 29, 1956*, p 4). SST C-110 contained approximately 231,000 gallons of 1C/CW sludge and 34,000 gallons of TBP Plant supernatant following this transfer. The ferrocyanide scavenged waste was transferred from 241-CR vault to SST C-109 for settling of the ferrocyanide precipitate, with the supernatant discharged to a crib.

SST C-110 then received a total of 226,000 gallons of organic wash waste (OWW) from plutonium-uranium extraction (PUREX) plant from June 1956 (HW-43895, *Waste Status*

[6] The Tri-Butyl Phosphate Plant was also known as the uranium recovery plant or 221-U Plant.

Summary; Separations Section, Separations – Projects and Personnel Development Sub-Section, June 30, 1956, p 4) through September 1956 (HW-45738, *Waste Status Summary; Chemical Processing Department, Planning and Scheduling – Production Operation, September 30, 1956*, p 4). The total waste volume in SST C-110 was 491,000 gallons after these transfers.

No waste was added or removed from SST C-110 from October 1956 through October 1967. In November 1967, approximately 73,000 gallons of supernatant was transferred from SST C-110 to the cell 23 evaporator in 221-B Plant for concentration (ARH-N-82, *Fission Process Products Summary,* p 121). SST C-110 contained approximately 191,000 gallons of 1C/CW sludge and 244,000 gallons of OWW supernatant in December 1967 (ARH-326, *Chemical Processing Division Waste Status Summary October 1, 1967 through December 31, 1967*, p 5). An additional 215,000 gallons of OWW supernatant was transferred from SST C-110 to SST C-102 in the second quarter of calendar year 1969 (ARH-1200 B, *Chemical Processing Division Waste Status Summary April 1, 1969 through June 30, 1969*, p 5). The total west volume in SST C-110 was ~220,000 gallons following these transfers.

From 1970 until 1972, evaporator bottoms waste and ion exchange waste totaling 1,569,000 gallons were sent to SST C-110 from SSTs BY-104, BX-104 and BX-103. During this time, ~1,423,000 gallons of supernatant waste was transferred from SST C-110 to SSTs C-108, C-109, C-112, and C-104. SST C-110 would have been filled and emptied periodically during 1970 through 1972 as a result of these transfers. <u>The available tank waste data only lists the quarter ending volume in SST C-110 during 1970 through 1972; therefore no information is available on the transient liquid waste height in SST C-110.</u> As of the end of the 1st quarter 1972, SST C-110 contained ~189,000 gallons of solids and ~187,000 gallons of supernate. The remaining supernatant was transferred from SST C-110 to SST C-112 in 1975 and to SST C-103 in 1976. The supernate contained in SST C-110 was analyzed in June 1975 and is reported Figure 4-9 (IDMS accession #D196216683, p. 30, *Analysis of Tank Farm Samples Sample: T-5491 Tank 110-C Received: June 19, 1975*).

The interstitial liquid was salt well pumped from SST C-110 in 1976 and 1977. Additional supernatant was transferred to DST AN-103 in 1983. Waste transfer histories are presented in LA-UR-97-311. More detailed transfer information is presented in Chemical Processing Department Waste Status Summaries referenced in LA-UR-97-311 waste transfer tables.

SST C-110 was removed from service in 1976 and was primary stabilized in September 1979. In 1984 it was categorized an "assumed leaker". The tank was saltwell pumped from November 1991 through January 1992 and again from September 1994 through May 1995 (HNF-SD-RE-TI-178, *Single-Shell Tank Interim Stabilization Record,* p 129). The tank was evaluated and determined to meet interim-stabilization criteria in May 1995 and intrusion prevention was completed in September 1996 (HNF-EP-0182). A tank surface-level diagram is shown in Figure 4-10 (WHC-SD-WM-ER-313).

Figure 4-9. Analysis of SST C-110 Supernate from 1975 Sampling Event

Atlantic Richfield Hanford Company

Date: September 19, 1975

To: R. L. Walser

From: R. E. Wheeler, 2-2449 [signature]

Subject: ANALYSIS OF TANK FARM SAMPLES
Sample: T-5491 Tank: 110-C
Received: June 19, 1975

Vis.-DTR: Light yellow No solids 100 mrad/hr @ 4"

pH: 11.8

SpG: 1.134

OH: 0.831 M

Al: 3.83×10^{-2} M

NO_2: 0.807 M

NO_3: 0.541 M

D.T.A.: No exotherm below 200°C

GEA: ^{134}Cs - 56.74 µCi/gal
^{137}Cs - 3.20×10^{5} µCi/gal

$^{89,90}Sr$: 32.93 µCi/gal

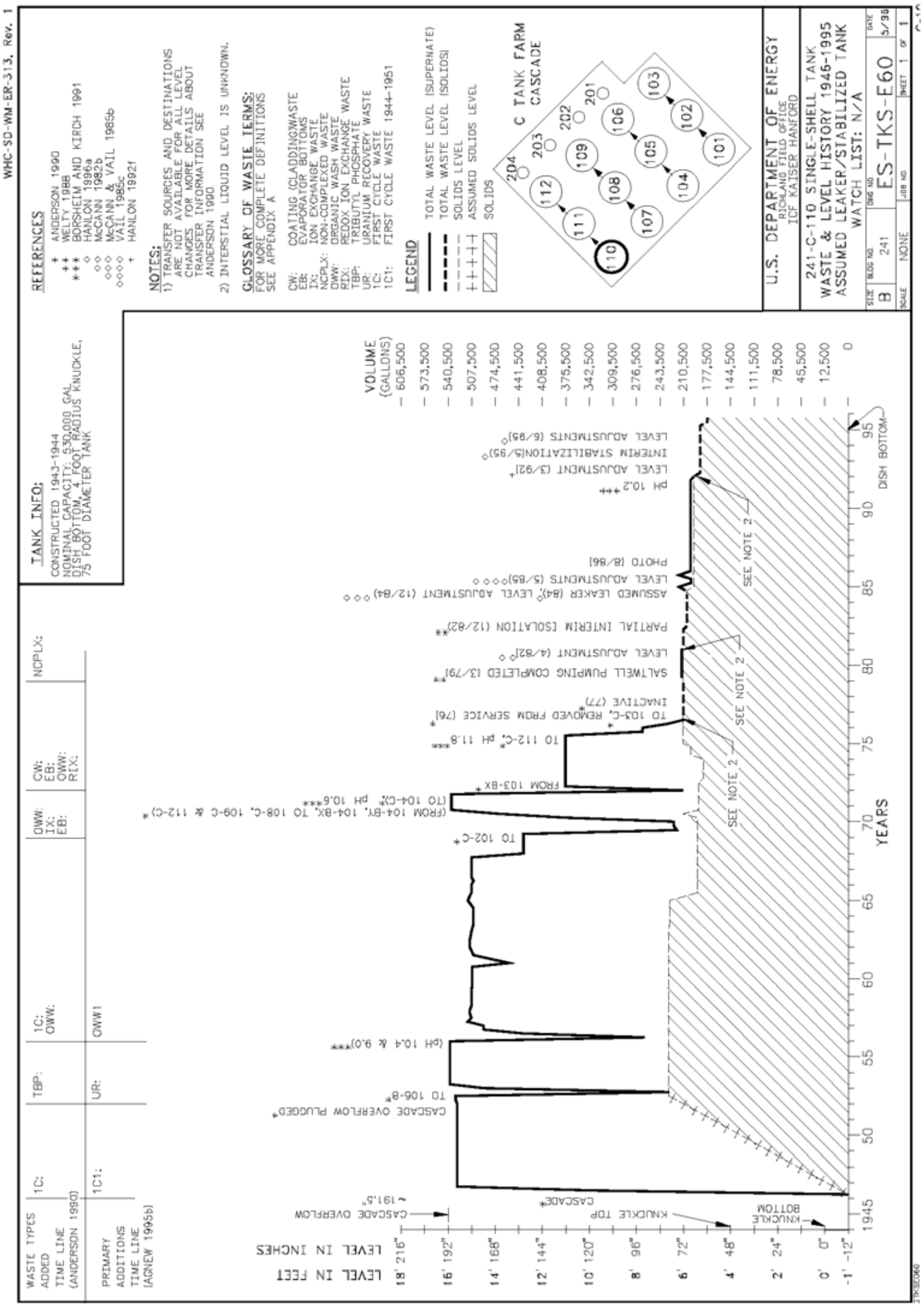
Water: 83.36 %

Cooling Curve: 25°C for 45 min. No solids.
20°C for 45 min. No solids.
15°C for 40 min. No solids.
10°C for 50 min. No solids.
5°C for 45 min. No solids.

REW:eyw

cc: JS Buckingham
WR Christensen ←
RM Gingetet
RE Wheeler
JC Womack

Figure 4-10. Tank C-110 Waste Surface Level History



A manual tape with an electrode was used for many of the liquid level measurements reported in the 1950's through the 1970's. The statistical accuracy of the manual tape and electrode measurement technique was 0.75 in. (~2,060 gallons), as determined in July 1955 (HW-51026, 1957, page 4, *Leak Detection – Underground Storage Tanks*, General Electric Company, Richland WA). While an error was made in determining the reference level for the ENRAF gauges used for determining the waste level in SSTs C-201 thru C-204 (see H-2-817634, sheet 6, revision 25 and ECN 722598-R1, ECN-720817-R4, ECN-722597-R1, and ECN-720817), no information was located concerning errors in SST C-110 liquid level measurements or positioning of the manual tape and electrode.

As of June 30, 2006, the tank contains 178,000 gallons (177,000 gallons sludge and 1,000 gallons supernatant), corresponding to a waste height of 72.2 in.. The volume is based on average surface-level readings and in-tank photo estimates that show an uneven surface. For inventory estimation purposes, the sludge is designated as first decontamination cycle bismuth phosphate waste (1C) mixed with coating removal waste (CW) (TWINS).

4.2.2 Historical Basis for Leak Declaration

SST C-110 was declared as "questionable integrity" in 1977 and an "assumed leaker" in 1984 following the discovery of unexplained activity in drywell 30-10-09. Drywell 30-10-09 was installed in 1974 and first monitored in October 1974. Figure 4-3 shows the location of dry wells in 241-C Farm. The gross gamma peak readings above background were detected in drywell 30-10-09 from October 1974 through February 1976 at approximately 53 to 56 ft below ground surface (bgs). A measurable decrease in the liquid waste surface was not detected during this period.

An estimated leak volume for SST C-110 of 2,000 gallons was assigned in 1989. "This estimate was made because radiation was detected at an associated drywell, but there was no detectable surface level decrease. A liquid surface was being measured at the time radiation was detected in the drywell. For a manual tape reading it is unreasonable to assume that more than 2,000 gallons leaked without a surface level decrease" (Baumhardt, R. J. 1989, *Single-Shell Tank Leak Volumes)*.

4.2.3 Data Review and Observations

The tank was classified as "questionable integrity" because the source of contamination in the associated drywell 30-10-09 was unknown, but there was no detectable surface level decrease. A stable liquid level was observed from 1972 through mid-1975 at 132 in. (as referenced from the bottom of the tank knuckle). The total waste volume was approximately 376,000 gallons of which the supernatant volume was approximately 165,000 gallons. This provides a strong indication that the tank was not leaking prior to 1975. Since 1975, no data (drywell, surface level, or transfer data) provides any indications of a loss of tank integrity. In the third quarter of 1975 and in 1976, approximately 165,000 gallons of supernatant in SST C-110 were transferred to SSTs C-112 and C-103, leaving only sludge in SST C-110.

There are no laterals in C tank farm and it could not be determined whether contamination exists directly beneath SST C-110. The only contamination that has been observed in the vicinity of

SST C-110 was found in drywell 30-10-09, 10 ft below the tank base at approximately 55 ft bgs. Drywell 30-10-09 in located on the west side of the 241-C Tank Farm and no other tanks are located in the vicinity of this drywell. Three inlet pipelines and a spare inlet line connecting to SST C-110, as well as spare line V-137 from diversion box 241-C-153 are located slightly south of drywell 30-10-09 at approximately the 8 o'clock position on SST C-110 (see drawing H-2-61962, *Plot Plan 241-C Tank Farm*). A cap with a gasket covered each of the spare inlet lines, as shown in Figure 4-1 (drawing W-72743, *Hanford Engineering Works Bldg. 241, 75' Diameter Storage Tanks T-U-B & C Arrangement,* section D-D), however these caps were not leak tight and installation has not been verified.

In November 1952, the cascade overflow line from SST C-110 to C-111 was noted as being plugged (see section 4.2.1). The tank on filling with TBP Plant waste failed to cascade to SST C-111 (HW-26486, *Manufacturing Department Radiation Hazards Incident Investigation* and HW-27627, *Radiological Sciences Department Investigation Radiation Incident*), but the SST C-110 was not reported as being filled above the spare inlet nozzles. An estimated 5-gallons of waste was inadvertently discharged to the surface ground on November 26, 1952 when a pump was being installed in SST C-110 (HW-27627). The resulting ground and equipment contamination was reported as being removed. This pump was used to transfer waste from SST C-110 to SST C-111, since the cascade overflow line was plugged.

The process piping in the vicinity of drywell 30-10-09 are transfer pipelines V-141, V-137, V-138, V-139, V-140, and line 8712, as shown in Figure 4-11. Line 8712 is a 6-inch drain line from 244-CR Vault to a ditch. Line V-137 is a 3-inch line from diversion box 241-C-153 to an inlet nozzle on SST C-111. Lines V-138, V-139, and V-140 are 3-inch lines from diversion box 241-C-153 to inlet nozzles on SST C-110. Line V-141 was connected in 1966 to a pump which was inserted through SST C-110 riser R-3 for transferring supernatants from SST C-110 to diversion box 241-C-153 (see drawings H-2-37010, *110-C TK ARRG'T AS BUILT* and H-2-33086, *Transfer Pipe TK 241-C-110 To 241-C-153 Div. Box*). Line V-141 has since been stubbed off and is located at approximately the 7 o'clock position on SST C-110. Line V-141 traverses near drywell 30-00-09. No evidence of waste leakage from this pump or any of these lines was located. Therefore, it is unlikely these lines are the source of the contamination detected in drywell 30-10-09.

Contamination was observed when drywell 30-10-09 was installed and first monitored in October 1974. Figure 4-12 provides the historical gross gamma log results for drywell 30-10-09 (GJPO-HAN-18, July 1998, *Vadose Zone Characterization Project at the Hanford Tank Farms, C Tank Farm Report*). Contamination was also found in drywell 30-10-02 when first monitored in September 1974. The peak gross gamma activity detected in drywell 30-10-09 was ~240 cps at a depth of 54 ft bgs (WHC-SD-WM-TI-356, 1988, *Waste Storage Tank Status and Leak Detection Criteria*, page 30-10-03). Analysis of the decay rates for gamma activity for drywell 30-10-09 shown in the gross gamma plots (Figure 4-13) indicates that the radioactive decay curve from 1975 to 1979 is consistent with ^{106}Ru (half-life 368.2 days), which may or may not have came from the tank (RPP-8321, 2001, *Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-C Tank Farm – 200 West Area*, page 351).

Figure 4-11. SST C-110 and Associated Pipelines

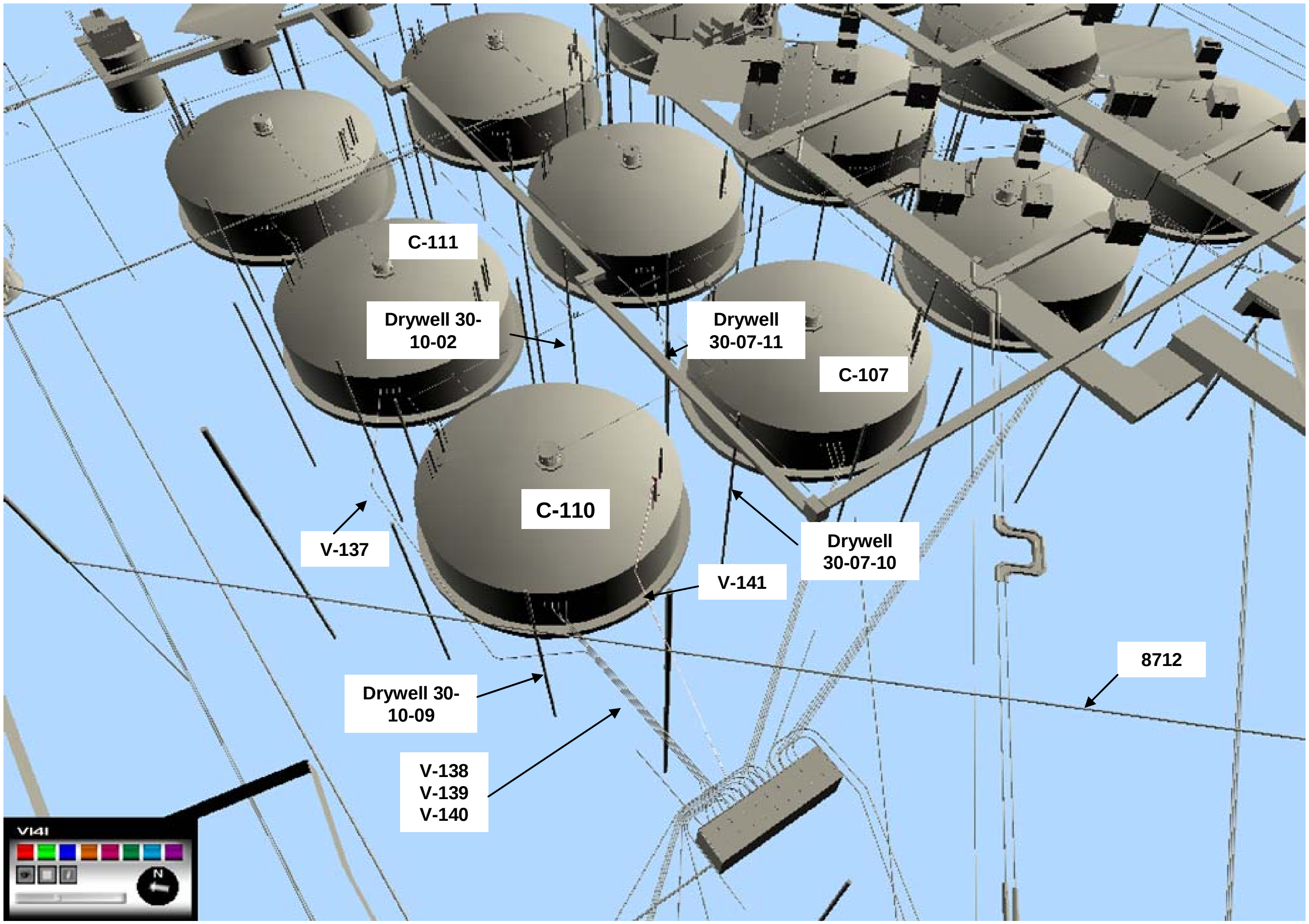


Figure 4-14 shows the 1997 spectral gamma logging for drywells in the vicinity of SST C-110 (GJPO-HAN-18). There are very low concentrations (less than 10-pCi/gm) of ^{137}Cs detected in the soil surrounding SST C-110. If a tank waste leak had occurred, higher concentrations of ^{137}Cs would be expected in the soil surrounding SST C-110.

No contamination was found in drywell 30-07-10, which is adjacent to SST C-107 and located on the east side of SST C-110, as evident by the historical gross gamma logs provided in Figure 4-15 (RPP-8321, page 286). As shown in Figure 4-16, near-surface (0 to 10 ft bgs) ^{137}Cs contamination has been detected in drywell 30-07-11, which is adjacent to SST C-107 and located on the east side of SST C-110 (RPP-8321, page 290). Contamination was also found in drywell 30-10-02 when first monitored in September 1974. The peak gross gamma activity detected in drywell 30-10-02 was ~65 cps at a depth of 47 ft bgs (WHC-SD-WM-TI-356, page 30-10-03). Analysis of the decay rates for gamma activity for drywell 30-10-02 shown in the gross gamma plots (Figure 4-17) indicates that the radioactive decay curve from 1975 to 1979 is consistent with ^{137}Cs (RPP-8321, page 347). The liquid level in SST C-110 was steady at 132 in. (from the side wall knuckle) from 1972 through mid-1975 when contamination was observed in these drywells.

In June 1975, the supernate in SST C-110 was sampled and analyzed (see Figure 4-9). The supernate present in SST C-110 was a combination of evaporator bottoms and B Plant ion exchange waste. The ^{106}Ru concentration in the SST C-110 supernate can be approximated using the waste spreadsheets in the Hanford Defined Waste Model - Revision 5 (RPP-19822). RPP-19822, page A-48 identifies the B Plant ion exchange waste as “CSR” waste type. RPP-19822 predicts the concentrations of ^{106}Ru and ^{137}Cs present in the CSR waste type are 4.05E-11 and 1.50E-02 Ci/L, decayed to January 1, 2001. Correcting for radionuclide decay, the estimated concentrations of ^{106}Ru and ^{137}Cs present in the CSR waste type are 1.64E-03 and 2.69E-02 Ci/L, decayed to June 1, 1975. The ratio of ^{106}Ru to ^{137}Cs present in the CSR waste type as June 1, 1975 is estimated to be 0.061:1. Applying this ratio of ^{106}Ru to ^{137}Cs to the June 1975 sample analysis for SST C-110 supernate yields an estimated ^{106}Ru concentration of 0.02 Ci/gal (decayed to June 1975).

As discussed previously, the maximum activity detected in drywell 30-10-09 was 240 cps at 40 to 60 ft bgs in July 1975. The activity detected in drywell 30-10-09 was shown to correlate to a radionuclide decay rate for ^{106}Ru. The maximum ^{106}Ru activity detected in drywell 30-10-09 in July 1975, 240 cps, corresponds to an estimated 800 pCi/gm (“Estimate for ^{106}Ru in 30-10-09”, E-mail dated April 24, 2007 from R. McCain, S. M. Stoller Corporation to M. E. Johnson, CH2M HILL Hanford Group). The estimated ^{106}Ru concentration in the soil around drywell 30-10-09 is a very rough estimate of equivalent ^{106}Ru concentration based on the total gamma data. This estimate of ^{106}Ru concentration in the soil was used to estimate the volume of waste potentially lost from SST C-110. The ^{106}Ru concentration and the estimated waste loss volume should not be considered as absolute values, but only a rough order of magnitude estimate.

Figure 4-12. Historical Gross Gamma Logs for Borehole 30-10-09

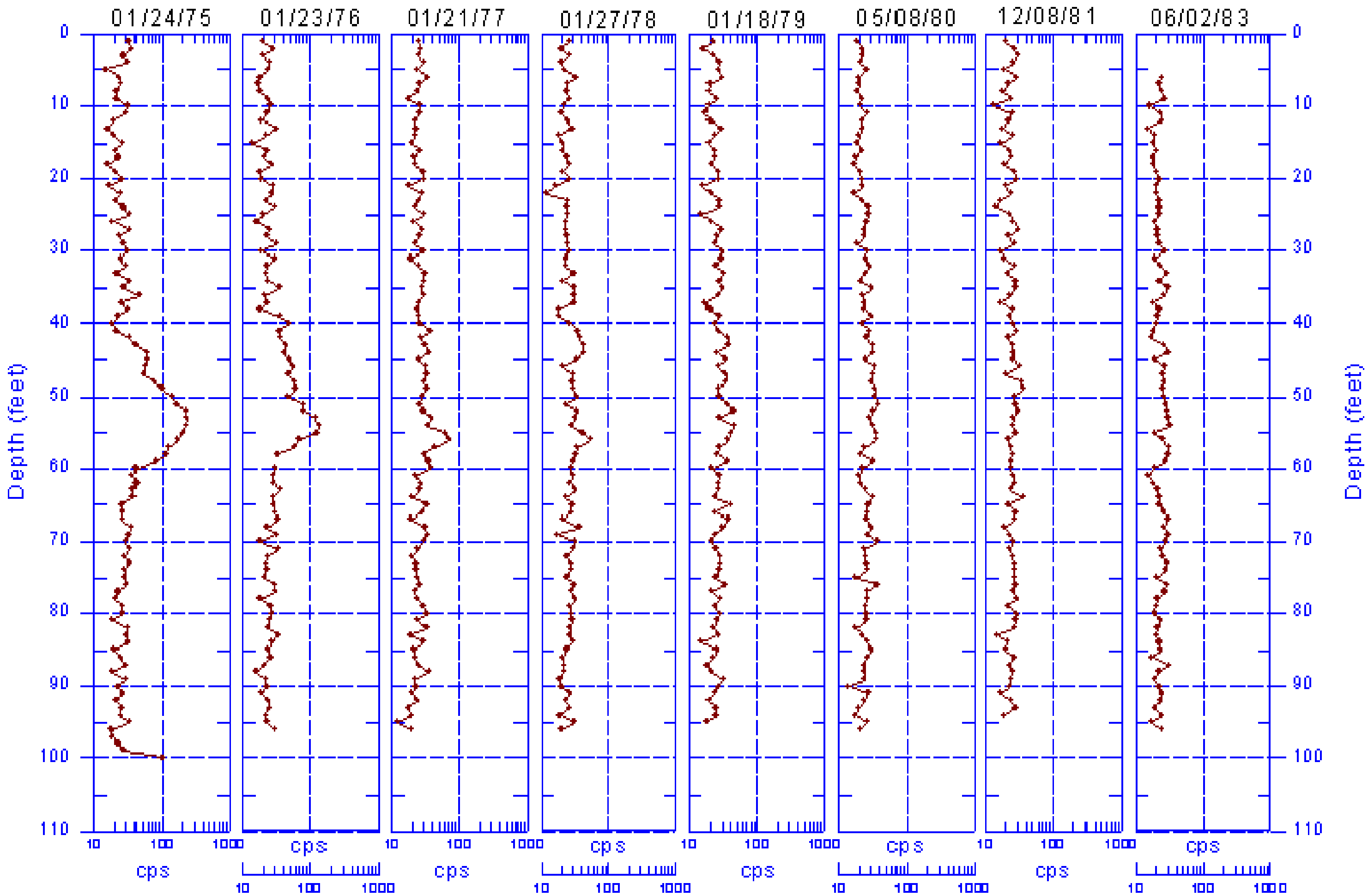


Figure 4-13. Drywell 30-10-09 Historical Gross Gamma Logging Correlated with ^{106}Ru Decay

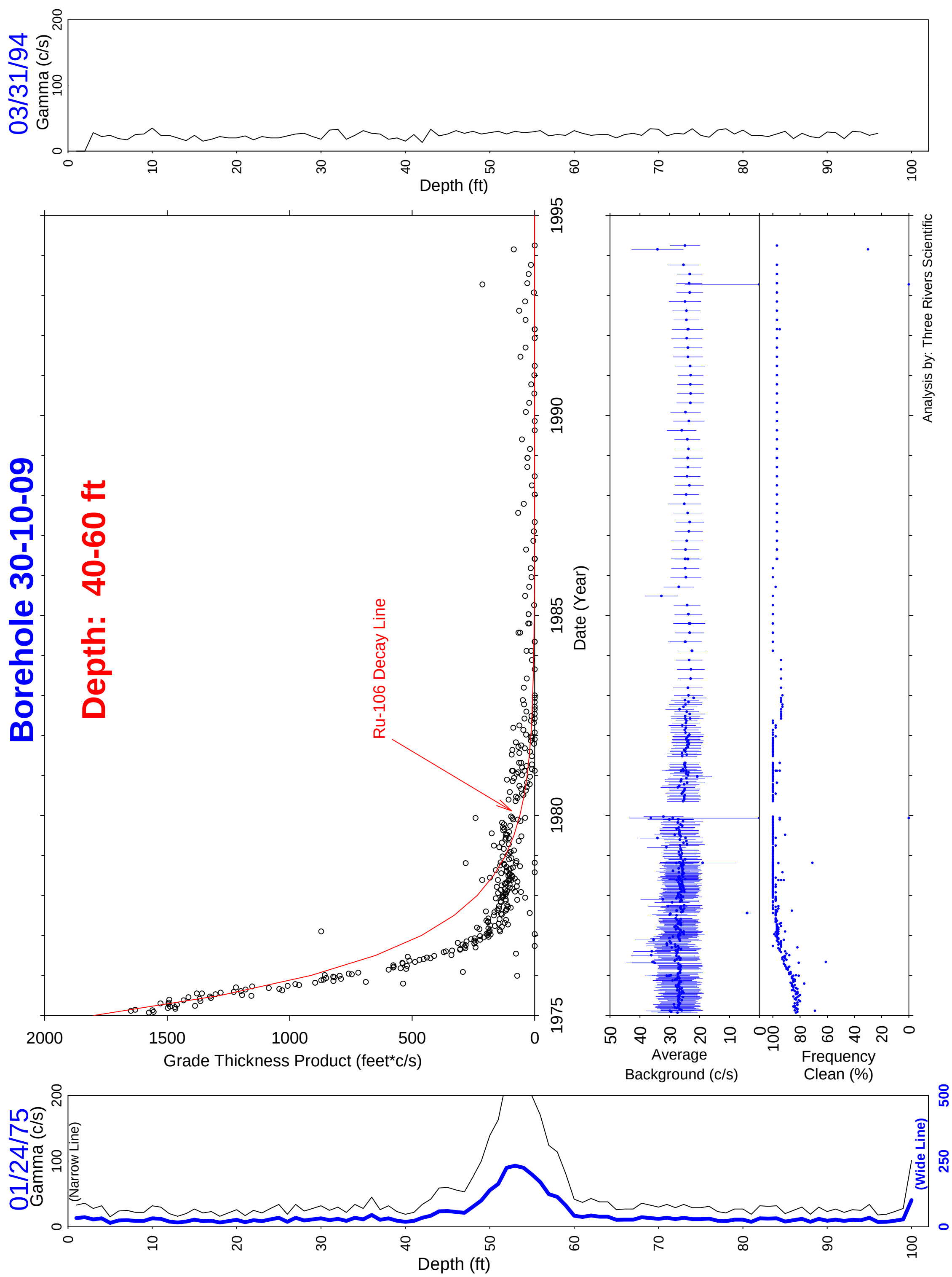


Figure 4-14. Spectral Gamma Logging for Drywells around SST C-110 (1997)

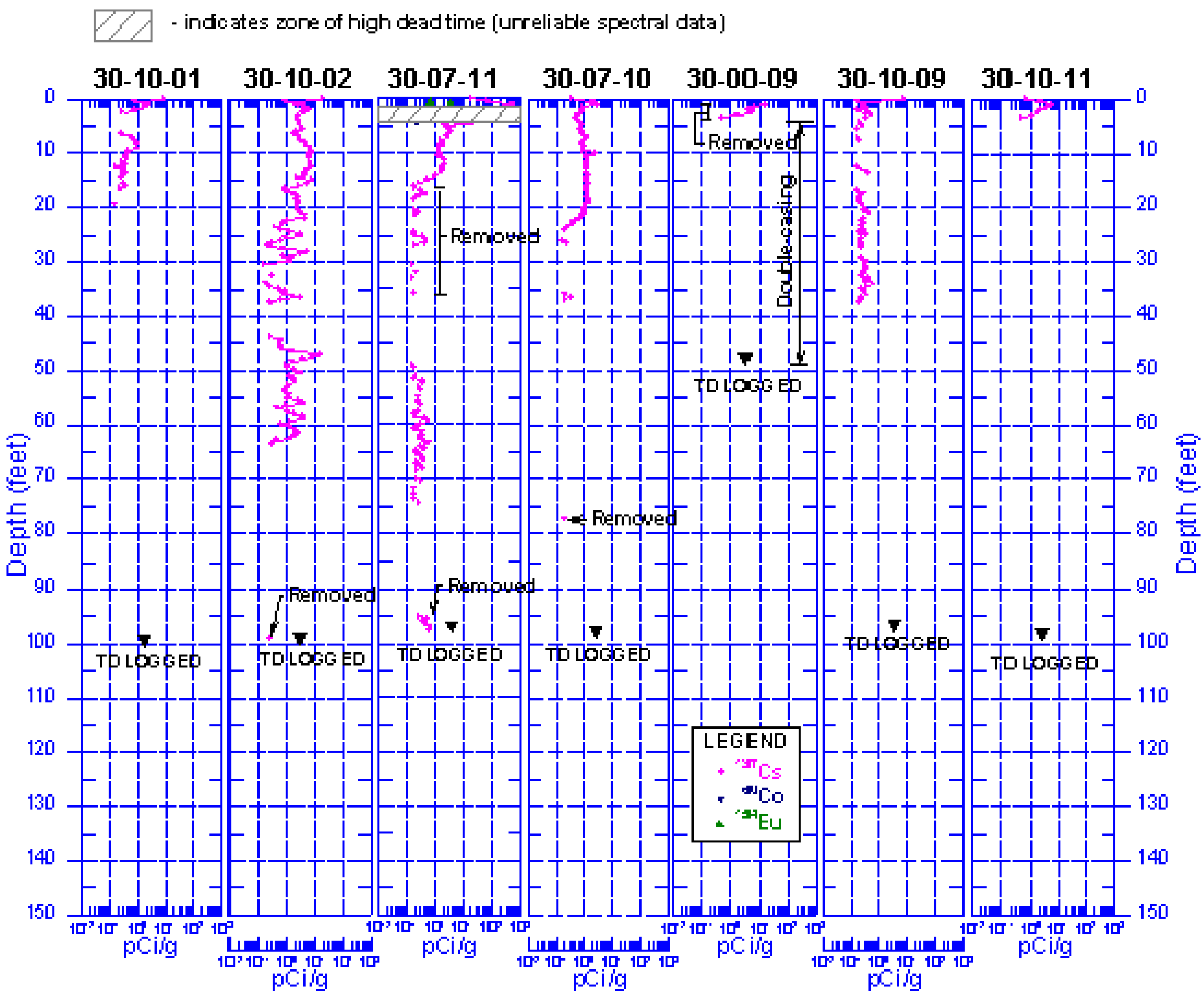


Figure 4-15. Drywell 30-07-10 Historical Gross Gamma Logging

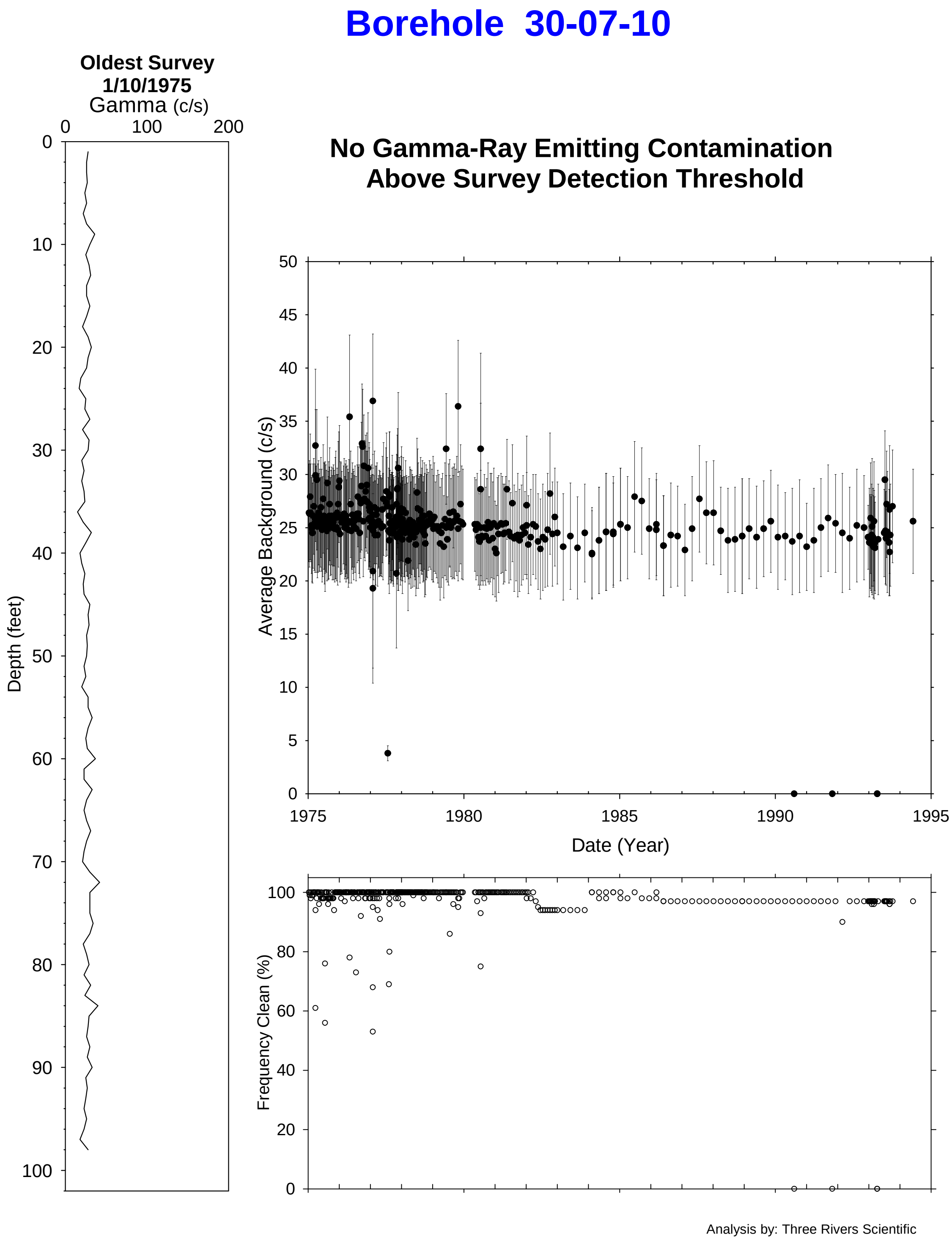


Figure 4-16. Drywell 30-07-11 Historical Gross Gamma

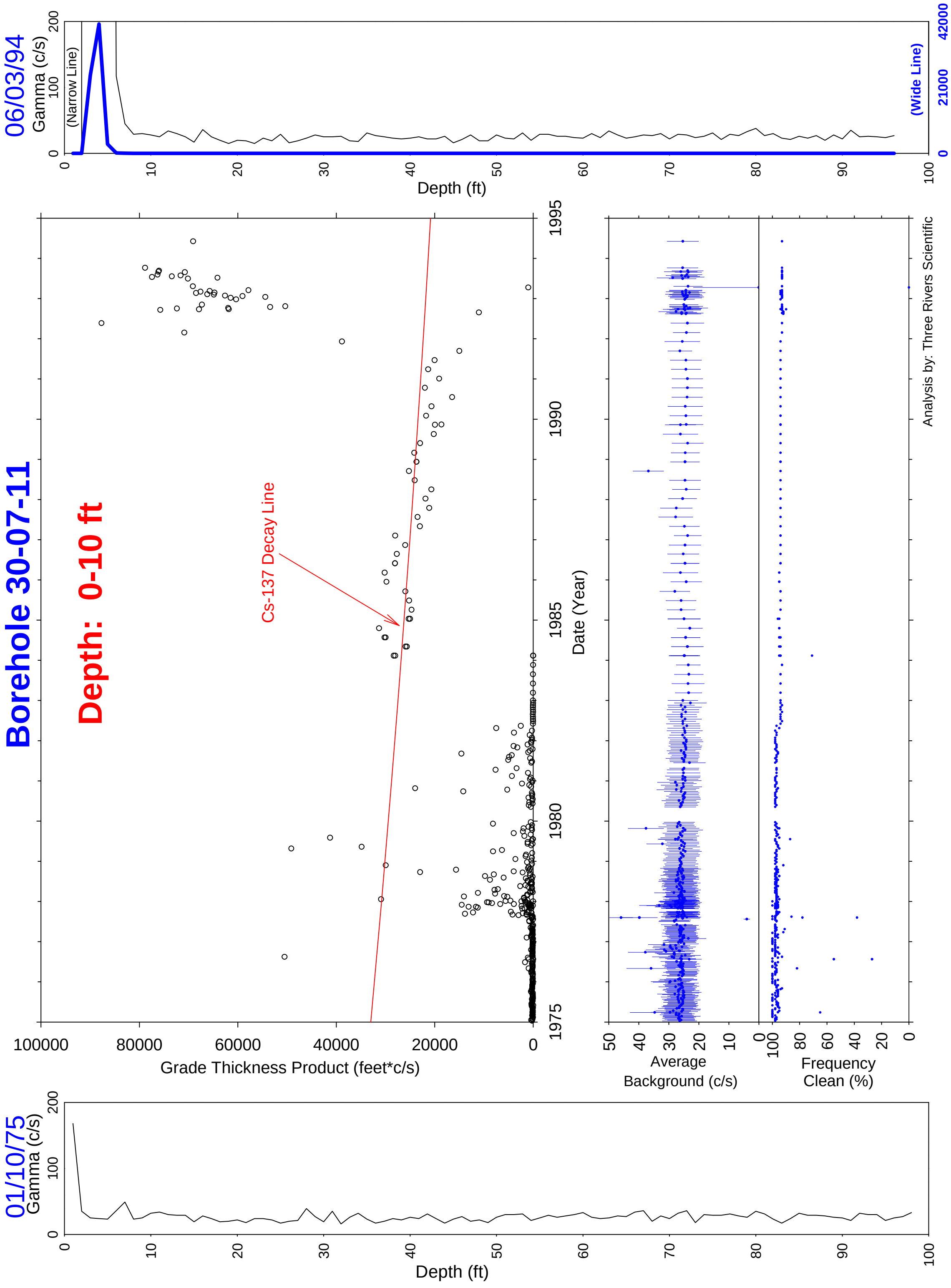
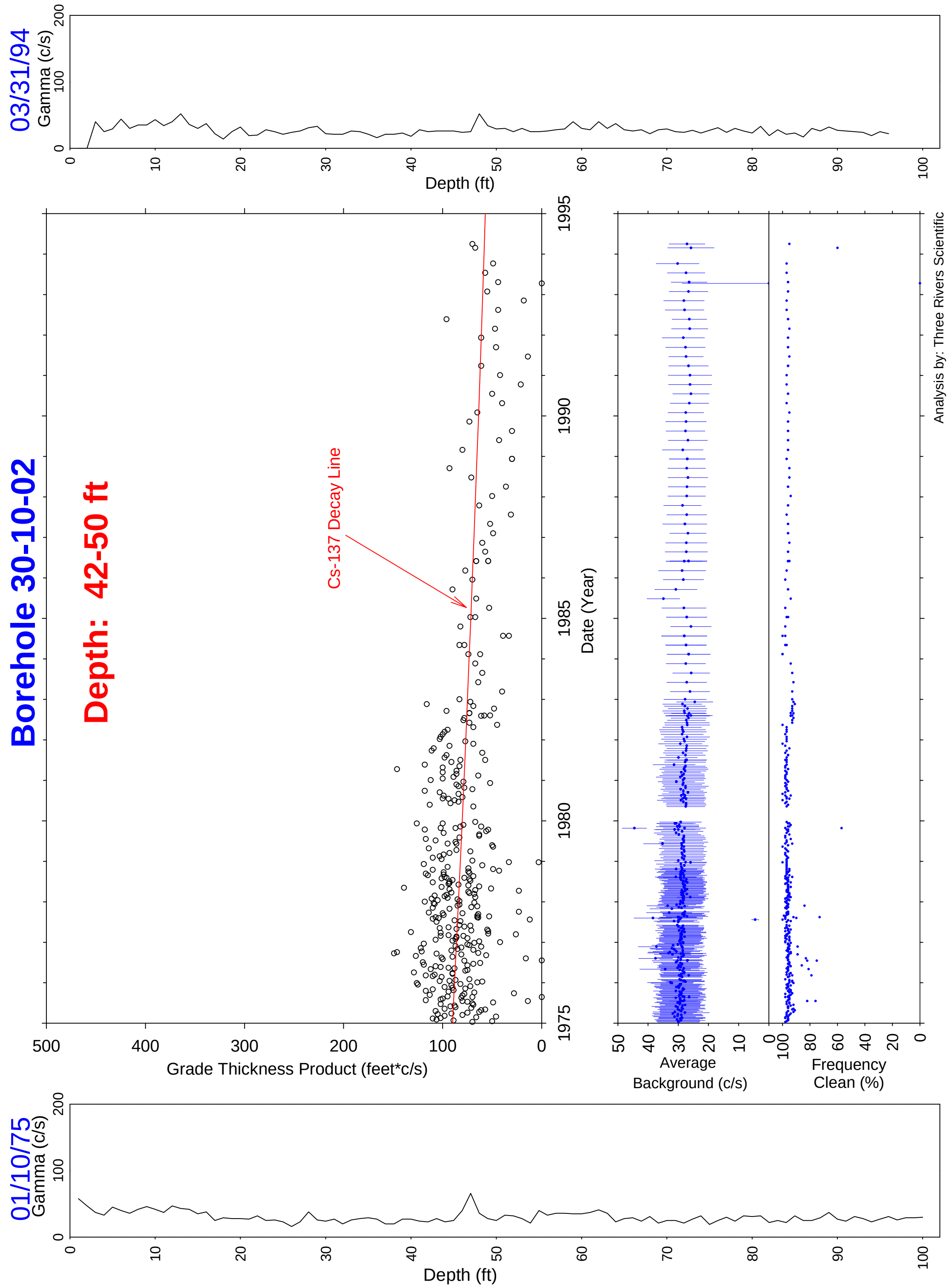


Figure 4-17. Drywell 30-10-02 Historical Gross Gamma



The ^{106}Ru activity was localized to 40 to 60 ft bgs; with the peak activity detected ~54 ft bgs. If we assume a spherical leak volume centered on the drywell with a radius of 10-ft., the estimated volume of contaminated soil is ~4,200-ft^3 (~119 m^3). Using a soil density of 2 gm/cm^3 yields an estimated contaminated mass soil of ~238 MT. Assuming the concentration of the ^{106}Ru activity detected in drywell 30-10-09 is 800 pCi/gm, the ~238 MT of contaminated soil would contain an estimated 0.2 Ci of ^{106}Ru. Since the estimated ^{106}Ru concentration in the SST C-110 supernate was ~0.02 Ci/gal in June 1975, the volume of SST C-110 supernate corresponding to 0.2 Ci of ^{106}Ru is ~10 gallons. Assuming a larger volume of contaminated soil would not significantly alter the estimated leak volume.

4.2.4 Tank C-110 Assessment

On April 3, 2007 the preceding information regarding tank C-110 was presented and discussed with the assessment panel. Discussions focused on the summary information in Table 4-6. There was no liquid level decrease observed for this tank, only an increase of < 250 cps in 1974-1978 gross gamma measurements in drywells 30-10-09 and 30-10-02. Drywells were not installed before 1974. There was also no indication of anomalies observed in Surface Geophysics Exploration (SGE) data. However, there is also no nearby source for the contamination other than tank C-110.

The only basis discussed and referenced for a tank C-110 leak was a "Questionable integrity" designation based on a 1989 letter *Single-Shell Tank Leak Volumes* (Baumhardt 1989). As stated in the letter, it was "unreasonable to assume that more than 2,000 gallons leaked without a surface level decrease." This is roughly equivalent to a +/- ¾ inch undetected decrease, which is reasonable for manual tape measurements being used at the time.

The most probable source determined for a leak from this tank was at the overflow ports. Based on surface level history the waste was closest to the height of the overflow ports (17 ft 4 in.) before 1954 and in 1971-72. Although the waste level was not reported as being over the overflow ports, it was very close and the assessment group noted that tank elevations in drawings have been found to be in error by several in.. Consequently an overflow is plausible.

The gamma measurements observed follows a ^{106}Ru decay curve indicating the observed gamma activity was ^{106}Ru. Because of the short half-life of ^{106}Ru, the ^{106}Ru would have not have been seen in gamma measurements if the leak occurred before 1954. So the most probable period for a tank overflow is 1971-72. If an overflow occurred during 1971-72 the composition of the supernatant waste stream would have been that measured in 1975 showing ~ 0.32 Ci/gal of Cs-137. This is about five times higher than the predicted Soil Inventory Model waste type estimate for a 1969 leak.

As a rough check on waste type and volume estimates ^{106}Ru gamma measurements were compared with equivalent ^{137}Cs measurements for a CSR (i.e. cesium removal) waste type.

Table 4-6. Tank C-110 Leak Information Summary

	When	Estimated Leak Volume (gallons)	Range of Leak Volume (gallons)	Possible Sources	Comments
Declared questionable integrity	1977	No estimate	No estimate	No source identified	Tank was identified as questionable integrity based on unexplained activity identified in drywell 30-10-09.
Declared "assumed leaker	1984	No estimate	No estimate	No source identified	Tank was identified as questionable integrity based on unexplained activity identified in drywell 30-10-09.
Current HNF-EP-0182 leak volume estimate	1989	2,000	No range provided	No source identified	"This estimate was made because radiation was detected at an associated drywell, but there was no detectable surface level decrease. A liquid surface was being measured at the time radiation was detected in the drywell. It is unreasonable to assume that more than 2,000 gallons leaked without a surface level decrease." (Baumhardt, R. J. 1989).
Liquid Level Decrease	N/A	N/A	N/A	N/A	No unexplained liquid level decreases observed. Liquid level data indicates spare inlet nozzles were **not** submerged. **Steady liquid level at ~144 in. (~376,000 gallons) reported for April 1972 through June 1975**
Drywell data	October 1974 through April 1978	No estimate	No estimate	No source identified	A gross gamma peak reading at 53 to 56 ft bgs observed on drywell 30-10-09. Initially ~210 cps (10-1974), increasing slightly to ~240 cps (07-1975), then declining to ~50 cps (04-1978). **Activity in drywell 30-10-09 correlated to Ru-106 decay curve.** A gross gamma peak reading at ~47 ft bgs observed on drywell 30-10-02. Initially ~65 cps (09-1974), increasing slightly to ~72 cps (01-1975), then declining to ~50 cps (04-1980). **Activity in drywell 30-10-09 correlated to ^{137}Cs decay curve.**
SGE data	October 2006	No estimate	No estimate	No source identified	No areas of low resistivity are found around SST C-110
1980 Prior leak investigations		No estimate	No estimate		SST C-110 was **not** evaluated in the 1980 report (RHO-CD-896)
SIM Estimate		2,000			Assumes leak date of 1969 and uses TBP-UR and 1C1 as waste types in tank.
Mean Inventory	^{137}Cs	~75 Ci			For a leak in 1971-72 the composition of the supernatant waste stream would have been that measured in 1975 with a CSR waste type and ~ 0.32 Ci/gal of ^{137}Cs, about five times higher than the ^{137}Cs estimate in SIM
	^{99}Tc	0.02 Ci			
	^{90}Sr	16.3 Ci			
	Cr	1.5 kg			

4.2.5 Conclusion

The C-110 leak appears to be the result of a tank overflow 17 ft 4 in (208 in) above the tank bottom. As a worst case, the liquid level in SST was steady at 144 in. from the tank center from 1971 to 1975, indicating that if there was a breach in the tank wall, it was above this level.

Because no liquid level decrease was observed, based on liquid level accuracy for the manual tape and electrode instrumentation in the tank in 1971-72, the volume of the leak was previously determined to be less than 2,000 gallons. Rough calculations of the gamma activity observed in dry wells indicate that the volume of the leak could have been significantly smaller. The supernatant was predominantly CSR waste. Supernatant samples of this waste obtained in 1975 provide waste composition measurements. The C-110 supernatant composition measured in 1975 appears to be consistent with the measured ^{106}Ru dry well activity.

4.3 Reassessment of Tank 241-C-111 Waste Loss Event

4.3.1 Background

SST C-111 has a capacity of 2,006,000 liters (530,000 gallons) and a diameter of 22.9 m (75 ft) (HNF-EP-0182). SST C-111 is passively ventilated and is the second tank in a three-tank cascade that includes SSTs C-110 C-112. A tank surface-level diagram is shown in Figure 4-18 for the period of 1945 through 1995 (WHC-SD-WM-ER-313). A manual tape with an electrode was used for many of the liquid level measurements reported in the 1950's through the 1970's. The statistical accuracy of the manual tape and electrode measurement technique was 0.75 in. (~2,060 gallons), as determined in July 1955 (HW-51026).

SST C-111 entered service in August 1946. No record was found indicating SST C-111 was connected to an exhauster or had an atmospheric condenser. First decontamination cycle waste (1C) and coating removal waste from the bismuth phosphate process conducted in the 221-B Plant was transferred to SST C-110, which having been filled with waste cascaded into SST C-111. In November 1946, SST C-111 was declared full (530,000 gallons) and the waste cascaded into SST C-112 (HW-7-5505-DEL, page 28). The three tank cascade was reported as being filled to 100% in March 1947 (HW-7-6048-DEL, page 23). The waste volume in SST C-111 was not reported separately from the other two tanks in the cascade and only a total percent filled was reported until March 1952.

In July and August 1952, supernatant was transferred out of SST C-111 to SST B-106 for processing in the 242-B Evaporator, leaving approximately 36,000 gallons of waste in SST C-111 (HW-27839, pg 9 and 20). Beginning in November 1952, the cascade of SSTs C-110, C-111, and C-112 were the active receiver of Tri-Butyl Phosphate (TBP) Plant[7] waste. After filling SST C-111 to 139,000 gallons with TBP waste, the cascade overflow line from SST C-110 to SST C-111 became plugged on November 15, 1952

[7] The Tri-Butyl Phosphate Plant was also known as the uranium recovery plant or 221-U Plant.

(HW-27840, page 20). No information was located that indicated the plugged cascade overflow was ever unplugged. As a result of the plugged overflow line, TBP waste was transferred from SST C-110 using a pump and a temporary overground pipeline to SST C-111 (HW-26486 and HW-27627). SST C-111 was filled to ~536,000 gallons of TBP waste as of January 1953 (HW-27841, page 20, *Waste Status Summary Separations Section Period: January 1953*, General Electric Company, Richland WA). No waste additions or removal occurred from SST C-111 from February 1953 through December 1955.

In January 1956, 483,000 gallons of TBP waste was transferred from SST C-111 to 244-CR vault for in-farm scavenging of ^{137}Cs. SST C-111 then served primarily as one of the settling tanks for ferrocyanide waste (designated as waste type TFeCN) resulting from in-farm scavenging of ^{137}Cs (HW-41812, pg. 4). In August 1956, 474,000 gallons of TFeCN supernatant was transferred to the 216-BC-7 disposal site, leaving 20,000 gallons of supernate and 36,000 gallons of sludge in SST C-111 (HW-45140, pg. 4, *Separations Section Waste Status Summary for August 1, 1955 - August 31 1956*, General Electric Company, Richland WA).

SST C-111 periodically received plutonium-uranium extraction (PUREX) organic wash waste (OWW) and PUREX cladding waste (CW) from September 1956 through April 1957. SST C-111 received 8,000 gallons of PUREX OWW in October 1956 (HW-46382, pg. 4), 6,000 gallons of PUREX OWW in December 1956 (HW-47640, pg. 4), 53,000 gallons of PUREX CW in January 1957 (HW-48144, pg. 4), 91,000 gallons of PUREX CW in February 1957, (HW-48846, pg. 4), and 119,000 gallons of PUREX CW in March 1957 (HW-49523, pg. 4). SST C-111 contained approximately 332,000 gallons of waste on March 31, 1957.

In April 1957, SST C-111 received 573,000 gallons of PUREX CW and transferred approximately 373,000 gallons of PUREX OWW and CW to SST BY-111 in April 1957, leaving 532,000 gallons of waste in SST C-111 (HW-50127, pg. 4, *Chemical Processing Department Waste – Status Summary April 1, 1957 – April 30, 1957*). SST C-111 was reported to contain 550,000 gallons of waste in May 1957, as a result of “line drainage” following the transfer to SST BY-111 (HW-50617, pg. 4, *Chemical Processing Department Waste Status Summary May 1, 1957 – May 31, 1957*). 550,000 gallons of waste corresponds to a height of 17-ft 4.9-in. (referenced from center of tank bottom). Since the spare inlet nozzles are at a height of 17-ft 4-in. (referenced from center of tank bottom), it is possible that some PUREX OWW / CW was lost in May 1957 through the spare inlet nozzles to the soil.

SST C-111 was again used from June 1957 (HW-51348, pg. 4, *Chemical Processing Department Waste Status Summary June 1, 1957 – June 30, 1957*) through December 1957 (HW-54519, pg. 4, *Chemical Processing Department Waste Status Summary December 1, 1957 – December 31, 1957*) as the settling tank for ferrocyanide waste resulting from in-farm scavenging of ^{137}Cs (TFeCN). SST C-111 was filled and emptied several times during June through December 1957. The supernatant that had been scavenged of ^{137}Cs was intermittently transferred from SST C-111 to disposal trenches during this time frame. The maximum reported waste volume in SST C-111 was 549,000 gallons (17-ft 4.5-in. above center of tank bottom) in September 1957 (HW-52932, pg. 4, *Chemical Processing Department Waste Status Summary September 1, 1957 – September 30, 1957*). Since the spare inlet nozzles are at a height of 17-ft 4-in. (referenced from center of tank bottom), it is possible that some TFeCN waste was lost in September 1957 through the spare inlet nozzles to the soil. SST C-111 contained 3,000 gallons of supernate and 95,000 gallons of sludge as of December 31, 1957.

SST C-111 did not receive any waste from January 1958 through September 1959. However, the total waste volume was adjusted to 101,000 gallons (6,000 gallons of supernate and 95,000 gallons of sludge) in February 1958 (HW-55264, pg. 4, *Chemical Processing Department Waste Status Summary February 1, 1958 – February 28, 1958*) and 111,000 gallons in September 1959 (HW-62421, pg. 4, *Chemical Processing Department Waste Status Summary September 1, 1959 – September 30, 1959*), based on new electrode readings. SST C-111 received intermittent transfers of PUREX CW supernatant from SST C-105 in October 1959 (187,000 gallon; HW-62723, pg. 4), March 1960 (39,000 gallons; HW-64810, pg. 4), and November 1960 (5,000 gallon; HW-68291, pg. 4), resulting in SST C-111 containing 247,000 gallons of supernate and 95,000 gallons of sludge.

No additional waste was transferred into or removed from SST C-111 from December 1960 through December 1961. In January 1962, SST C-111 was reported to contain 345,000-gallons of waste comprised of 95,000-gallons of sludge and 250,000-gallons of supernatant. The waste contained in SST C-111 was reported to be comprised of 242-B evaporator bottoms (concentrated 221-U TBP Plant supernatant) and PUREX coating removal waste (HW-74647, pg. 4). SST C-111 also contained TBP Plant sludge and cesium ferrocyanide precipitate from the 244-CR vault.

From the July 1962 through June 1964, SST C-111 received approximately 194,000-gallons of waste from the Hot Semiworks. The total volume of waste in SST C-111 was reported as 539,000-gallons (17-ft, 0.9-in. referenced from center of tank bottom) on June 30, 1964. Table 4-8 lists the Hot Semiworks waste transfers and indicates the waste volume present in SST C-111 from 1962 through 1971.

The waste level in SST C-111 began to decrease, as noted in Table 4-9. The waste volume in SST C-111 decreased ~20,000-gallons from January 1, 1965 through June 30, 1965. SST C-111 continued to show a decrease in waste volume from July 1965 through June 1969, losing 1,000 to 5,000-gallons per quarter. In the fourth quarter of calendar year 1969, approximately 350,000-gallons of waste were transferred from SST C-111 to SST C-104 because of a suspected tank leak. The supernatant collected in SST C-104 was then transferred in 1969 through several intermediate tanks to the in-tank solidification unit number 2 for volume reduction. The SST C-111 supernatant did not reside in any of these intermediate tanks for sufficient time to detect waste evaporation. SST C-111 contained approximately 66,000 gallons of supernate and 81,000 gallons of sludge on December 31, 1969, following the supernate transfer to SST C-104. SST C-111 received ~22,000 gallons of waste from catch 241-C-301 in the 2nd quarter of CY

1972. Additional transfers of supernatant out of SST C-111 occurred during 1974 and 1976. Interim stabilization of the SST C-111 was completed in March 1984.

As of June 30, 2006, SST C-111 contains 57,000 gallons of sludge as estimated from a 22.9 inch ENRAF[8] reading. No pumpable liquid remains in the tank, and the waste contains an estimated 9,000 gallons of drainable interstitial liquid. For inventory estimates, the sludge is designated as a combination of PUREX cladding waste (CWP1) , Hot Semi-works waste (HS), ferrocyanide sludge (TFeCN), and first decontamination cycle bismuth phosphate waste (1C) (TWINS, Queried 4/15/04, [SST C-111 Recent Best Basis Derivation Text]).

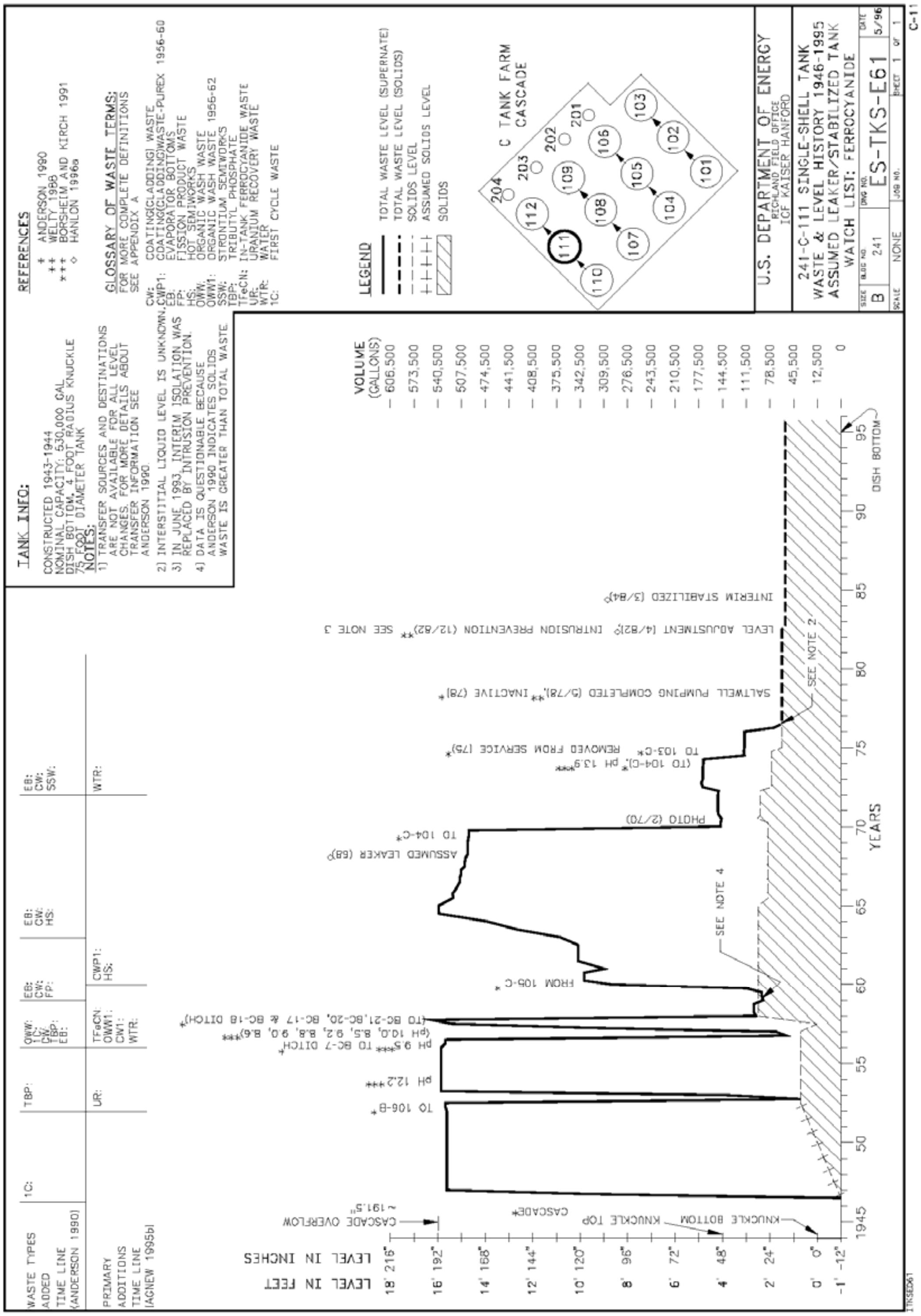
[8] ENRAF - Nonius Series 854 is a trademark of ENRAF-Nonius, N.V. Verenigde Instrumentenfabrieken, ENRAF-Nonius Corporation Netherlands, Rontegenweg 1, Delft, Netherlands.

Table 4-8. SST C-111 Waste Inventory for 1962 through 1971				
Date	**Total Volume (gallons)**	**Sludge Volume (gallons)**	**Reference**	**Comments from Reference Document**
01/01/62 – 06/30/62	345,000	95,000	HW-74647, page 4	88,000-gallons of evaporator bottoms (EB) and 257,000-gallons of coating removal waste (CW) in storage
07/01/62 – 12/31/62	370,000	95,000	HW-76223, page 4	Received 25,000-gallons of waste from HS (201-C Hot Semi-Works)
01/01/63 – 06/30/63	431,000	95,000	HW-78279, page 4	Received 61,000-gallons of waste from HS (201-C Hot Semi-Works)
07/01/63 – 12/31/63	472,000	95,000	HW-80379, page 4	Received 41,000-gallons of waste from HS (201-C Hot Semi-Works)
01/01/64 – 06/30/64	539,000	95,000	HW-83308, page 4	Received total of 101,000-gallons of waste from HS (201-C Hot Semi-Works) into C-111 and C-112. By mass balance and the reported inventories in each tank, 67,000-gallons were received in C-111 and 34,000-gallons were received into C-112
07/01/64 – 12/31/64	539,000	95,000	RL-SEP-260, page 4	No waste additions or removal noted.
01/01/65 – 06/30/65	519,000	81,000	RL-SEP-659, page 4	“New electrode”
07/01/65 – 09/30/65	520,000	81,000	RL-SEP-821, page 4	“New electrode”
10/01/65 – 12/31/65	516,000	81,000	RL-SEP-923, page 4	No waste additions or removal noted.
01/01/66 – 03/31/66	513,000	81,000	ISO-226, page 4	No waste additions or removal noted.
04/01/66 – 06/30/66	510,000	81,000	ISO-404, page 4	No waste additions or removal noted.
07/01/66 – 09/30/66	510,000	81,000	ISO-538, page 4	No waste additions or removal noted.
10/01/66 – 12/31/66	508,000	81,000	ISO-674, page 4	No waste additions or removal noted.
01/01/67 – 03/31/67	508,000	81,000	ISO-806, page 4	No waste additions or removal noted.
04/01/67 – 06/30/67	503,000	81,000	ISO-967, page 4	No waste additions or removal noted.
07/01/67 – 09/30/67	503,000	81,000	ARH-95, page 5	No waste additions or removal noted.
10/01/67 – 12/31/67	502,000	81,000	ARH-326, page 5	No waste additions or removal noted.
01/01/68 – 03/31/68	499,000	81,000	ARH-534, page 5	No waste additions or removal noted.
04/01/68 – 06/30/68	499,000	81,000	ARH-721, page 5	No waste additions or removal noted.
07/01/68 – 09/30/68	499,000	81,000	ARH-871, page 5	No waste additions or removal noted.
10/01/68 – 12/31/68	499,000	81,000	ARH-1061, page 5	No waste additions or removal noted.
01/01/69 – 03/31/69	498,000	81,000	ARH-1200 A, page 5	No waste additions or removal noted.
04/01/69 – 06/30/69	497,000	81,000	ARH-1200 B, page 5	No waste additions or removal noted.
07/01/69 – 09/30/69	497,000	81,000	ARH-1200 C, page 5	No waste additions or removal noted.
10/01/69 – 12/31/69	147,000	81,000	ARH-1200 D, page 5	Transferred 349,000-gallons of supernatant to SST C-104.
01/01/70 – 03/31/70	147,000	81,000	ARH-1666 A, page 5	No waste additions or removal noted.
04/01/70 – 06/30/70	146,000	96,000	ARH-1666 B, page 5	No waste additions or removal noted.
07/01/70 – 09/30/70	150,000	92,000	ARH-1666 C, page 5	No waste additions or removal noted.
10/01/70 – 12/31/70	151,000	92,000	ARH-1666 D, page 5	No waste additions or removal noted.
01/01/71 – 03/31/71	151,000	92,000	ARH-2074 A, page 5	No waste additions or removal noted.
04/01/71 – 06/30/71	151,000	92,000	ARH-2074 B, page 5	No waste additions or removal noted.
07/01/71 – 09/30/71	151,000	92,000	ARH-2074 C, page 5	No waste additions or removal noted.
10/01/71 – 12/31/71	151,000	92,000	ARH-2074 D, page 5	No waste additions or removal noted.

Table 4-9. SST C-111 Waste Volume Change 1964 - 1971			
Date	**Change in Volume (gallons)**	**Cumulative Volume Decrease (gallons)**	**Total Volume (gallons)**
07/01/64 – 12/31/64	0	0	539,000
01/01/65 – 06/30/65	-20,000 (9)	20,000	519,000
07/01/65 – 09/30/65	1,000	19,000	520,000
10/01/65 – 12/31/65	-4,000	23,000	516,000
01/01/66 – 03/31/66	-3,000	26,000	513,000
04/01/66 – 06/30/66	-3,000	29,000	510,000
07/01/66 – 09/30/66	0	29,000	510,000
10/01/66 – 12/31/66	-2,000	31,000	508,000
01/01/67 – 03/31/67	0	31,000	508,000
04/01/67 – 06/30/67	-5,000	36,000	503,000
07/01/67 – 09/30/67	0	36,000	503,000
10/01/67 – 12/31/67	-1,000	37,000	502,000
01/01/68 – 03/31/68	-3,000	40,000	499,000
04/01/68 – 06/30/68	0	40,000	499,000
07/01/68 – 09/30/68	0	40,000	499,000
10/01/68 – 12/31/68	0	40,000	499,000
01/01/69 – 03/31/69	-1,000	41,000	498,000
04/01/69 – 06/30/69	-1,000	42,000	497,000
07/01/69 – 09/30/69	0	42,000	497,000
10/01/69 – 12/31/69	-350,000	Transferred waste to tank 241-C-104	147,000
01/01/70 – 03/31/70	0		147,000
04/01/70 – 06/30/70	-1,000		146,000
07/01/70 – 09/30/70	4,000		150,000
10/01/70 – 12/31/70	1,000		151,000

[9] Waste volume decline due to installation of new electrode for determining liquid level.

Figure 4-18. Tank C-111 Waste Surface Level History



4.3.2 Basis for Leak Declaration

SST C-111 was classified as questionable integrity in 1968 (Baumhardt 1989). SST C-111 was declared a suspected leaker in late 1973 (ARH-2794-D, 1974, *Manufacturing and Waste Management Division Waste Status Summary October 1, 1973 Through December 31, 1973*). As a result, supernatant was transferred out of SST C-111 during 1974. SST C-111 was removed from service in 1975 and the final waste transfer out of the tank was completed in 1976. The tank status was reviewed and classified confirmed as "questionable integrity" in 1981 (RHO-CD-1193, 1981, *Review of Classification of Hanford Single-Shell Tanks 110-B, 111-C, 103-T, 107-TX, 104-TY, and 106-U*).

A leak estimate of 5,500 gallons was assigned in 1989 based on liquid level calculations (Baumhardt 1989), but these calculations were not provided in the reference. In 1974, the volume of waste leaked from SST C-111 was estimated to be 22,000 gallons with a leak date of 1968 (IDMS Accession # D196207372). Also, an unexplained decrease of 8.5 in. in the tank surface-level measurements occurred over a 4-year period (1965-1969), which corresponds to a liquid volume of ~23,000 gallons (RHO-CD-1193, pages 25-33).

4.3.3 Data Review and Observations

The panel first looked for evidence of a leak or contamination outside the tanks or in the vadose zone. There are no laterals in C tank farm and negligible (less than 50 cps) contamination was observed historically in drywells 30-11-01, 30-11-05, 30-11-06, 30-11-09, and 30-11-11 surrounding SST C-111 (RHO-CD-1193, pg. 27). Minor surface level contamination and less than 1-picocuries of ^{137}Cs per gram of soil was detected at depth in these drywells when gamma spectral logging was conducted between 1997 and 2000 (GJPO-HAN-18, 1998, and GJO-98-39-TARA, September 2000, *Vadose Zone Characterization Project at the Hanford Tank Farms, Addendum to the C Tank Farm Report*).
No evidence was found of a pipeline leak in the vicinity of SST C-111 (RPP-RPT-29191, 2006, *Supplemental Information Hanford Tank Waste Leaks* and RPP-25113, 2005, *Residual Waste Inventories in Plugged and Abandoned Pipelines at the Hanford Site*).

HRR Information

High resolution resistivity (HRR) was used between August and December 2006 to conduct geophysical investigation within the 241-C Tank Farm (RPP-RPT-31558). The preliminary geophysical investigation was performed by collecting resistivity data using 69 drywells within the tank farm and with a set of 8 monitoring boreholes (e.g., groundwater wells), 1 buried electrode, and four surface electrode arrays outside of the farm. The four surface electrode arrays were run parallel to the tank farm fence line. Only the well to well electrode readings provided resistivity data having the capability to identify and delineate contaminant plume features within and around tank farms.

Areas of low resistivity are shown in Figure 4-4 for the 241-C Tank Farm. Areas with low resistivity are most likely associated with increased soil moisture or inorganic salt concentration, which could be due to waste loss events. Specific areas of low-resistivity values within the 241-C tank farm are a region near tanks 241-C-101, 241-C-102, 241-C-104, C-105, and

241-C-107, along with a smaller low-resistivity zone near tank 241-C-108. There are no areas of low resistivity detected in the vicinity of SST C-111.

Evaporation

Over 4 years, from 1965 to 1969, an 8.5-in decrease in the SST C-111 waste surface level was observed to follow a typical (exponential) decay curve profile, as shown in Figure 4-19.

Previous reviews of SST C-111 assumed a temperature of less than 100°F at the time that the tank was filled to the 191 in. level with the Hot Semiworks (HS) waste (RHO-CD-1193, pg. 29). This was a primary basis for the conclusion in RHO-CD-1193 that the loss could not be attributed to evaporation. However, after SST C-111 received strontium HS waste, during the second quarter of 1964, temperature records show that the tank heated up to greater than 190°F (RHO-CD-1172, pages B-61 and B-62). The high temperature suggests that the observed decrease in surface level can be explained by evaporation.

A search was conducted of available waste sample analyses to determine if there was sufficient radiolytic decay heat generated from the HS waste stored in SST C-111 to cause the observed waste surface decrease through evaporation. No information could be located that provided the composition of the Hot Semiworks waste transferred into SST C-111. However, the fission product content of the Hot Semiworks waste can be estimated from the Hot Semiworks specifications and standards for strontium purification (RL-SEP-20).

From July 1962 through July 1964, the Hot Semiworks transferred 3,939,000 curies of strontium-90 to offsite users as listed in Table 4-10 (Johnson 2003, interoffice memo 7G400-03-SMM-003, *Shipment of Cesium-137 and Strontium-90 from the Hanford Site (1961 through 1977)*). The Hot Semiworks specifications and standards documents states the concentrations of ^{90}Sr and ^{144}Ce in the feed to the strontium purification process were 48 Ci/L and 150 Ci/L, respectively. This ratio of ^{144}Ce to ^{90}Sr has been used in Table 4-11 to estimate inventory of ^{144}Ce contained in the Hot Semiworks waste that was transferred to SST C-111. The ^{144}Ce inventory in the waste transferred to SST C-111 was decay corrected from the date of processing in the Hot Semiworks to July 1964 using the following equation:

$$C = C_o * e^{-(T * 0.693 / t_{1/2})}$$

Where:
C is the concentration after decay by T years
T is the decay time in years
$t_{1/2}$ is the half life of the isotope,
$t_{1/2}$ is ~0.78 (284.3/365) years for Ce^{144} (RHO-SD-RE-TI-131)

In Table 4-12, the radiolytic heat generation rate for this waste was calculated using the estimated Ce^{144} inventory and a decay heat generation rate of 2.73E-02 Btu/(Ci-hr) for ^{144}Ce / ^{144}Pr (RHO-SD-RE-TI-131). The radiolytic heat generation rate was also determined versus time using the radionuclide decay equation listed above and reported in Table 4-12.

After adding approximately 194,000-gallons of waste from the Hot Semiworks, SST C-111 contained 539,000-gallons of waste. The waste level in SST C-111 began to decrease, as noted in Table 4-9 and depicted in Figure 4-18. The waste volume in SST C-111 decreased by ~20,000-gallons from January 1, 1965 through June 30, 1965. This waste volume decline was described as due to the installation of a new electrode for determining liquid level. The SST C-111 waste volume remained at 519,000 to 520,000-gallons for three months (July thru September 1965). SST C-111 showed a decrease in waste volume from October 1965 through June 1969, losing 1,000 to 5,000-gallons per quarter. In the fourth quarter of calendar year 1969, approximately 349,000-gallons of waste were transferred from SST C-111 to SST C-104 because of a suspected tank leak.

The waste volume decrease in SST C-111 is plotted versus time along with the radiolytic heat generation rate in Figure 4-19. This plot clearly shows the decrease in SST liquid level parallels the radiolytic heat generation rate from the HS waste stored in this tank. The liquid level decrease in SST C-111 stops when the waste radiolytic heat generation rate diminishes.

Evaporative modeling calculations were conducted to evaluate whether evaporation could lead to a 2-in. liquid level (~5,500-gallons) decrease in 1 year without active ventilation. There is no evidence that SST C-111 was connected to an active ventilation system or had an atmospheric condenser between 1965 and 1969. High temperature conditions in SSTs typically create airflow mixing and airflow rates of 3 to 6-cfm are considered plausible under these conditions. The psychometric chart indicates at 190^{o}F and 100% relative humidity, air contains ~1.0 lbs of water per lb of dry air and has a density of ~0.024 lbs dry air/ft^3 (*Chemical Engineering Handbook*, 1973, pg. 20-6, 5th Edition, R. H. Perry and C. H. Chilton, McGraw-Hill Book Company, New York). At an airflow rates of 5-cfm, ~7,500 gallons of water per year would be exhausted from SST C-111. If we assume the air exhausting from SST C-111 was only at 190^{o}F and 70% relative humidity, then the air would contain ~0.52 lbs of water per lb of dry air, at a density of ~0.033 lbs dry air/ft^3, and 5-cfm would exhaust ~5,460 gallons of water per year. Therefore, the 8.5-inch loss of liquid level in SST C-111 can be adequately explained by an exhaust airflow rate of 5-cfm of air at 190^{o}F and a relative humidity of 70% to 100%, which are conditions estimated to have existed within this SST at the time of the liquid level decline.

As noted in RHO-CD-1193 (p. 28), following the 8.5-in. level decrease, there was a period of 231 days (about 7 months) that the waste level remained stable. The waste level in SST C-111 stayed at 176 in. (~497,000 gallons) between May 9, 1969 and December 26, 1969, before 349,000 gallons of waste was transferred to SST C-104. This serves as a reasonable static leak test after the period of evaporation. After transferring ~349,000 gallons of waste to SST C-104, the waste level in SST C-111 was ~49 in. (~109,400 gallons). The waste level in SST C-111 remained unchanged at 49 in. until June 1972 when approximately 24,700 gallons of waste was transferred from catch tank C-301 into SST C-111 (RHO-CD-1193, pg. 27), increasing the waste level to ~58-in. (~134,100 gallons). From June 1972 to 1974, the waste level remained at a level of 58 in. (~134,000 gallons). No waste losses were observed below this level.

Figure 4-19. Tank C-111 Liquid Level and Estimated Radiolytic Heat Generation July 1964 – September 69

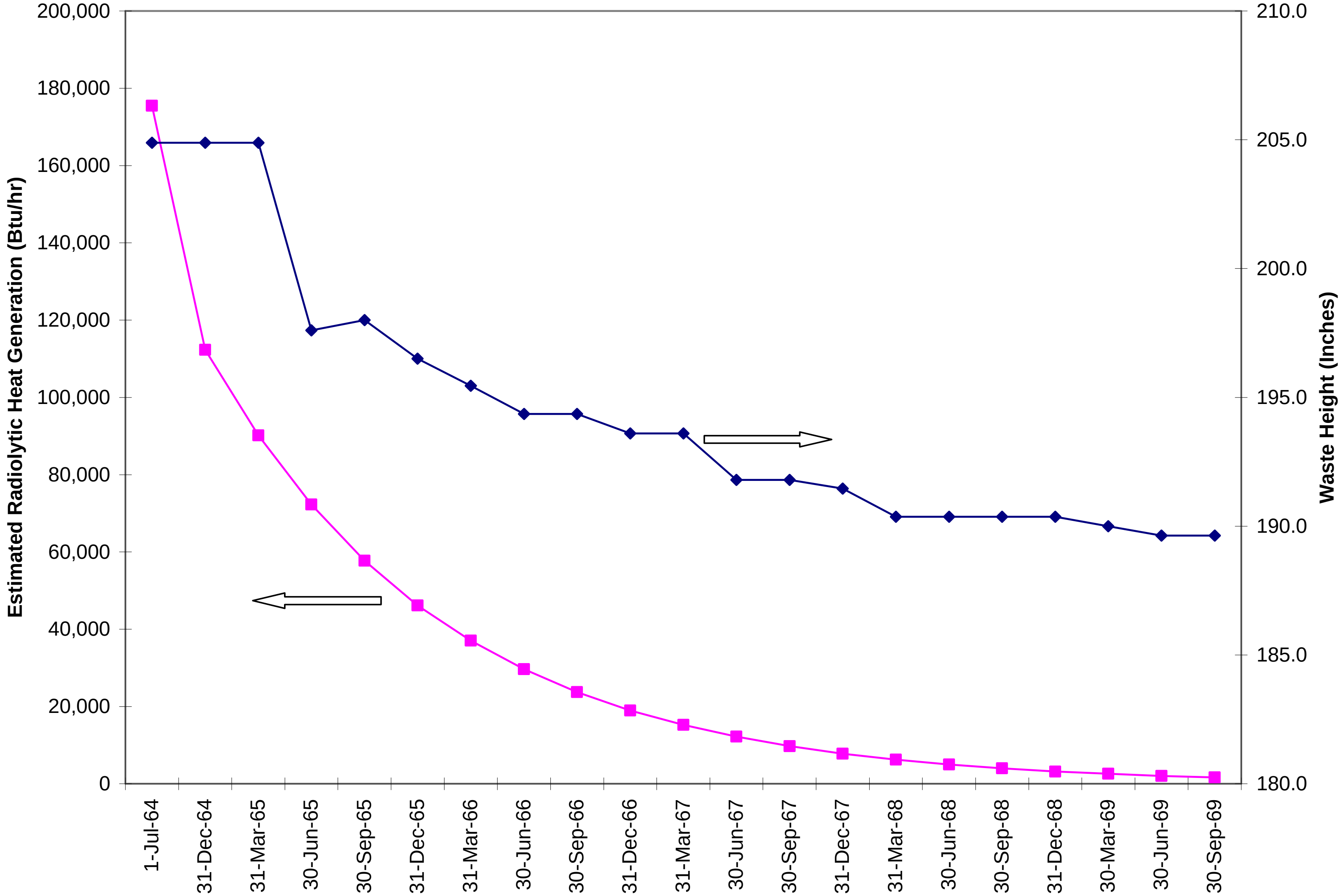


Table 4-10. Strontium Semiworks Cask Station Fission Products Shipment Information

Date	Inventory in Shipment (kilocuries)				Destination	Reference
	Sr-90	Cs-137	Ce-144	Pm-147		
August 1969	699				To B Plant	The 699kCi of purified Sr-90 were transferred from tank E-4 in the Strontium Semiworks to B Plant tank 35-1 for temporary storage. The Strontium Semiworks was placed in layaway status [PR-REPORT-AUG69-DEL, page AIV-3].
February 27, 1969	28				To PNNL	Shipped cask containing 40-liters of strontium product to PNNL [PR-REPORT-FEB69-DEL, page AIII-3 and ARH-1023-DEL, page 93].
January 1968	60				To PNNL	Shipment to PNNL [HAN-99604-DEL, page AIII-3].
October 1967	None	None	None	None		Strontium Semiworks shutdown. Washed solvent was transferred to tank 14-2 at REDOX using a PNNL trailer [ISO-651 RD, page 256].
September 18, 1967			150	200	To PNNL	Shippingport Am/Cm/Rare Earth material recovered at REDOX and semi-purified at Semiworks was transferred in a cask to PNNL. Approximately 2,820 curies Am-241, 4,830 curies Cm-244, 1,000 curies Eu-154 recovered along with Ce-144 and Pm-147 [ISO-651 RD, page 245 – 247].
July 1967			~1,200		To PNNL	Loaded two 200-gallon bowling ball casks with cerium product for delivery to PNNL [ISO-651 RD, page 180 and HAN-98343-DEL, page AIII-3].
June 1967	~35				To PNNL	About 35kCi of Sr-90 sent to PNNL in a 40-gallon sample cask [ISO-651 RD, page 141 and HAN-98163-DEL, page AIII-4].
May 1967			324		To PNNL	Loaded three 40-gallon PNNL casks with cerium and rare earth product [ISO-651 RD, page 113 and HAN-97845-DEL, page AIII-4].
November 1966			300		From PNNL	Received 6 casks, each containing 200-gallons of Ce waste and unloaded to tank 011 in 244-CR Vault [HAN-96143-DEL, page AIII-4].
October 1966	2.65				To PNNL	3.5-gallons of strontium-90 solution at approximately 200 Ci/l were loaded into a 11-gallon PNNL sample cask [ISO-75 RD, page 163].
June 10, 1966	390				To ORNL	Shipped HAPO-IB-3 cask [HAN-95105-DEL, page 15].
May 2, 1966	490				To ORNL	Shipped HAPO-II-2 and HAPO-IB-1 casks [HAN-94842-DEL, page 18].
May 1966				1,080	To PNNL	Two Pm-147 shipments to PNNL [HAN-94842-DEL, page 18].
April 1966				1,800	To PNNL	Two casks loaded and shipped [HAN-94591-DEL, page 14].
March 18, 1966	180				To Quehanna, PA	Shipped HAPO-II-1 cask [HAN-94330-DEL, page 15].
March 18, 1966				730	To PNNL	Shipped 200-gallon bowling ball cask [HAN-94330-DEL, page 15].
February 21, 1966	330				To ORNL	Sipped HAPO-IB-3 cask [HAN-94040-DEL, page 15].
February 4, 1966	160				To Quehanna, PA	Shipped HAPO-II-2 cask [HAN-94040-DEL, page 15].
January 3, 1966	170				To Quehanna, PA	Shipped HAPO-II-1 cask [HAN-93802-DEL, page 13].
December 13, 1965	430				To ORNL	Shipped HAPO-IB-1 cask [HAN-93551-DEL, page 13].
December 10, 1965				195	To PNNL	Shipped 200-gallon cask [HAN-93551-DEL, page 13].
November 29, 1965			420		To ORNL	Shipped HAPO-IB-2 cask [HAN-93300-DEL, page 13].

Table 4-10. Strontium Semiworks Cask Station Fission Products Shipment Information

Date	Inventory in Shipment (kilocuries)				Destination	Reference
	Sr-90	Cs-137	Ce-144	Pm-147		
November 18, 1965	150				To Quehanna, PA	Shipped HAPO-II-2 cask [HAN-93300-DEL, page 13].
October 1965	430				To ORNL	Shipped HAPO-IB-1 cask [HAN-92954-DEL, page 14].
September 10, 1965	100				To Quehanna, PA	Shipped HAPO-II-1 cask [HAN-92750-DEL, page 14].
September 1965				14	To PNNL	Shipped 40-gallon cask to PNNL. Pm-147 was from promethium ion exchange column run conducted at 222-S laboratory [HAN-92750-DEL, page 14].
June 18, 1965				120	To PNNL	[HAN-92077-DEL, page 14].
May 14, 1965				45	To PNNL	[HAN-91791-DEL, page 18].
April 1965				125	To PNNL	Loaded out 125kCi of Pm-147 from Strontium Semiworks [HAN-91499-DEL, page 14].
March 19, 1965	340				To ORNL	Shipped HAPO-IB-1 cask [HAN-91198-DEL, page 16].
September 11, 1964	350				To ORNL	Shipped HAPO-IB-1 cask [HW-84354, page A-3 and B-1].
July 6, 1964	420				To ORNL	Shipped HAPO-IB-2 cask [HW-83508, page B-2].
May 18, 1964	120				To ORNL	Shipped HAPO II-1 cask [HW-82526, page B-1].
March 23, 1964	410				To ORNL	Shipped HAPO-IB-2 cask [HW-81620, page A-3].
March 2, 1964			500		To ORNL	Shipped HAPO-IB-2 cask [HW-81620, page A-3].
February 1964			30		To HLO	Shipped 40-gallons cask to HLO [HW-81078, page B-1].
January 1964	110				To Quehanna, PA	Cask shipped [HW-80672, page A-3].
November 29, 1963				49	To ORNL	ORNL Pm cask shipped [HW-79768, page B-1].
November 22, 1963	140				To ORNL	HAPO-II-1 shipped [HW-79768, page B-1].
October 18, 1963	340				To ORNL	HAPO-IB-1 cask shipped [HW-79480, page A-3].
October 7, 1963	170				To ORNL	HAPO-II-2 cask shipped [HW-79480, page A-3].
August 12, 1963	470				To ORNL	HAPO-IB-1 cask shipped [HW-78817, page 5 and A-3].
August 5, 1963	140				To Quehanna, PA	HAPO-II-1 cask shipped [HW-78817, page 5 and A-3].
July 19, 1963	170				To Quehanna, PA	HAPO-II-2 cask shipped [HAN-83805-PT7, page 32].
June 14, 1963	160				To ORNL	HAPO-II-1 cask shipped [HAN-85578-DEL, page 11].
May 31, 1963	155				To Quehanna, PA	HAPO-II-2 cask shipped [HW-77795, page 5 and A-3].
April 15, 1963	170					ARH-N-82 page 2 reports 170kCi of Sr-90 shipped to ORNL on April 15, 1963. Monthly report for April 1963 (HAN-85001) does not report this shipment.
March 1963			100		To ORNL	HAPO-I cask shipped [HAN-84757-DEL, page 11].
March 22, 1963	145				To Quehanna, PA	HAPO-II-2 cask shipped [HAN-84757-DEL, page 11].
February 1963	50				To HLO	A HLO cask was loaded in the strontium nitrate form [HW-76848, page B-1].
February 22, 1963	170				To ORNL	Shipped HAPO-II-2 cask [HW-76848, page 5].
December 31, 1962	165				To Quehanna, PA	Shipped HAPO-II-2 cask [HW-76054, page 5].

Table 4-10. Strontium Semiworks Cask Station Fission Products Shipment Information

Date	Inventory in Shipment (kilocuries)				Destination	Reference
	Sr-90	Cs-137	Ce-144	Pm-147		
November 1962	170				To Quehanna, PA	Two HAPO-II casks were loaded with approximately 335kCi of Sr-90 in November 1962. The monthly report does not mention shipment of either cask [HW-75702, page B-1]. Only one of the HAPO-II casks containing 165kCi of Sr-90 is reported as being shipped in December 1962 [HW-76054, page 5]. Therefore, it is assumed that the other cask was shipped in November 1962.
September 29, 1962	94				To Quehanna, PA	Shipped HAPO-II-2 cask [HW-75145, page 5].
November 3, 1962	170				To Quehanna, PA	HAPO-II-1 cask loaded with 170kCi of Sr-90 for shipment on August 3, 1962 [HAN-80582-DEL, page 24].
July 6, 1962	130				To Quehanna, PA	Shipped HAPO-II-2 cask [HW-74505, page 5].
March 26, 1962	140				To ORNL	Shipped HAPO-II-2 cask [HW-73193, page 5].
March 2, 1962	110				To ORNL	Shipped HAPO-II-1 cask [HW-73193, page 5].
July 1961	120				To ORNL	Shipped HAPO-II-1 cask loaded at Hot Semiworks [HW-70588, page B-1].

Table 4-11. Estimated ^{144}Ce Inventory in Hot Semiworks Waste Transferred to SST C-111			
Date	**^{90}Sr kCi Shipped Offsite**	**Estimated ^{144}Ce kCi in waste**	**Decay Corrected to July 64 ^{144}Ce kCi**
6-Jul-64	420	1312.5	1,328.6
18-May-64	120	375.0	336.9
23-Mar-64	410	1281.3	1,004.1
Jan-64	110	343.8	220.6
22-Nov-63	140	437.5	254.7
18-Oct-63	340	1062.5	567.9
7-Oct-63	170	531.3	276.4
12-Aug-63	470	1468.8	666.7
5-Aug-63	140	437.5	195.2
19-Jul-63	170	531.3	227.5
14-Jun-63	160	500.0	196.6
31-May-63	155	484.4	184.0
15-Apr-63	170	531.3	180.4
22-Mar-63	145	453.1	145.2
Feb-63	50	156.3	44.4
22-Feb-63	170	531.3	159.0
31-Dec-62	165	515.6	135.6
Nov-62	170	531.3	120.7
29-Sep-62	94	293.8	61.6
3-Nov-62	170	531.3	121.3
Total	3939	12,309.4	6,427.3

Table 4-12. Radiolytic Heat Generation Rate for Hot Semiworks Waste Transferred to SST C-111		
Date	**Radiolytic Heat Generation Btu/hr**	**Decay Corrected Ce^{144} kCi**
1-Jul-64	175,464	6,427
31-Dec-64	112,321	4,114
31-Mar-65	90,195	3,304
30-Jun-65	72,252	2,647
30-Sep-65	57,737	2,115
31-Dec-65	46,138	1,690
31-Mar-66	37,050	1,357
30-Jun-66	29,679	1,087
30-Sep-66	23,717	869
31-Dec-66	18,952	694
31-Mar-67	15,219	557
30-Jun-67	12,191	447
30-Sep-67	9,742	357
31-Dec-67	7,785	285
31-Mar-68	6,236	228
30-Jun-68	4,996	183
30-Sep-68	3,992	146
31-Dec-68	3,190	117
30-Mar-69	2,568	94
30-Jun-69	2,052	75
30-Sep-69	1,640	60

Further evidence supporting evaporation is the seasonal pattern of waste level decrease, after July of 1967. The heat load from the waste would have significantly decayed by this point, leaving a warm tank to gradually cool by sensible heat. In the summer months, when the outside conditions were similar to the temperature in the tank, no change was observed. However, in the winter months, when the air inside the tank was warmer than the outside air, slight decreases in waste levels were observed. This is interpreted as evidence of increasing airflow in the winter due to thermal effects, which removed between 1,000 and 3,000 gallons of waste per quarter (see Table 4-9).

In the absence of any documentation, it is unclear why an 8.5-in. level drop was of little concern to the engineers and operators from 1964 through 1969. Compared to other tank leak events (e.g. SST T-106), a considerable span of time elapsed before most of the supernatant was pumped from this tank. It was almost a year after the observed waste level decreases that the supernatant was pumped, leaving approximately 147,000 gallons of waste in SST C-111. A period of about 5 years passed between the liquid level decrease and the declaration of SST C-111 as a “suspected leaker” in late 1973.

4.3.4 Tank C-111 Assessment

The summary information shown in Table 4-13 for tank C-111 was discussed with evaluation team members.

Drywell Activity

Minor surface level contamination and less than 1-picocuries of ^{137}Cs per gram of soil was detected at depth in these drywells when gamma spectral logging was conducted between 1997 and 2000 (GJPO-HAN-18, 1998 and GJO-98-39-TARA, 2000).

Evaporation

The waste volume in SST C-111 decreased by ~20,000-gallons from January 1, 1965 through June 30, 1965. This waste volume decline was described as due to the installation of a new electrode for determining liquid level. The decrease in liquid level measurements observed after installing a new manual tape electrode is attributed to instrument error. This discrepancy was not uncommon when a new electrode was installed. It is believed that the old electrode may have decayed or been damaged, resulting in the erroneous readings. Three electrode level adjustments are noted in the transfer record between 1957 and 1961. The fact that the SST C-111 waste surface level measurements remained steady at 519,000 to 520,000-gallons for three months (July thru September 1965) following installation of the new electrode is further evidence that there was likely no instantaneous liquid level decrease when the new electrode was installed.

SST C-111 also showed a decrease in waste volume from October 1965 through June 1969, losing 1,000 to 5,000-gallons per quarter for a total level decline of 22,000 gallons. High temperature conditions in SSTs typically create airflow mixing and airflow rates of 3 to 6-cfm are considered plausible under these conditions. The psychometric chart indicates at 190^{o}F and 100% relative humidity, air contains ~1.0 lbs of water per lb of dry air and has a density of ~0.024 lbs dry air/ft^3 (*Chemical Engineering Handbook*, 1973, pg. 20-6). At an airflow rate of 5-cfm, ~7,500 gallons of water per year would be exhausted from SST C-111. Assuming the air exhausting from SST C-111 was at 190^{o}F and 70% relative humidity, then the air would contain ~0.52 lbs of water per lb of dry air, at a density of ~0.033 lbs dry air/ft^{3}, and 5-cfm would exhaust ~5,460 gallons of water per year. Therefore, the loss of liquid level in SST C-111 can be adequately explained by an exhaust airflow rate of 5-cfm of air at 190^{o}F and a relative humidity of 70% to 100%. Measured liquid level decrease rates compared with calculated evaporation rates showed similar trends, further confirming that liquid level decreases from October 1965 through June 1969 can reasonably be attributed to evaporation losses.

A key difference in current evaporation calculations and previous estimate (RHO-CD-1193) is that previous report estimated evaporation for a 100^{o}F temperature. The authors of RHO-CD-1193 did not appear to be aware of and did not consider information (RHO-CD-1172, pages B-61 and B-62) found during the current assessment showing the tank waste temperature was 190^{o}F or higher.

4.3.5 Conclusions

Evaporation calculations and plotted liquid level and evaporation rates clearly indicate that the liquid level decrease can be attributed to evaporation and suggest that high tank waste temperature information was apparently not available for previous assessments. The assessment team believes that the data supports the potential to reclassify tank C-111 as sound. Therefore, no leak volume or inventory is assigned for tank C-111.

Table 4-13. Tank C-111 Leak Information Summary

Item	When	Estimated Leak Volume (gallons)	Range of Leak Volume (gallons)	Possible Sources	Comments
Declared "suspect leaker" in 1968 and "questionable integrity" in 1974	1968; 1974	No estimate	No estimate	No source identified	Tank was identified as questionable integrity based on RHO-CD-1193, 1981, *Review of the Classification of Hanford Single-Shell Tanks 110-B, 111-C, 103-T, 107-TX, 104-TY, and 106-U*. No primary source could be located corroborating the "Suspect Leaker" date of 1968, which is listed in LET-013074 and HNF-EP-0182 rev. 219. The first documented date for classification of SST C-111 as a "Suspect Leaker" is reported on March 25, 1974 in ARH-2794-D, 1974, Manufacturing and Waste Management Division Waste Status Summary October 1, 1973 Through December 31, 1973, Atlantic Richfield Hanford Company, Richland WA.
Current HNF-EP-0182 rev. 219 (June 2006) leak volume estimate	1968	5,500	No range provided	No source identified	"There were 27 tanks for which leak volumes have not previously been reported. Of these 27 tanks, the leak volume of 6 tanks could be determined using liquid level data, and 2 additional tank leaks were estimated as 2,000 gallons each." Table 2B lists the estimated leak volumes for the 27 tanks, including SST C-111 (Baumhardt, R. J. 1989). Note: The reference does not provide a basis for SST C-111 leak estimated of 5,500 gallon.
Liquid Level Decrease	1965-1969	~23,000	None	N/A	Unexplained liquid level decreases from ~520,000 to 497,000 gallons observed 1965 - 1969. Liquid level data indicates spare inlet nozzles were **not** submerged at this time. **Steady waste level at ~176 in. (~497,000 gallons) reported for May 9 1969 – December 26, 1969 (RHO-CD-1193, page 28).** **After transferring ~349,000 gallons of waste to SST C-104, the waste level in SST C-111 was steady at ~49 in. (~109,400 gallons) from 1970 through June 1972.** **In June 1972, ~24,700 gallons of waste was transferred from catch tank C-301 into SST C-111 (RHO-CD-1193, pg. 27), increasing the waste level to ~58-in. (~134,100 gallons). From June 1972 to 1974 the surface level remained at a level of 58 in. (~134,000 gallons).**

Table 4-13. Tank C-111 Leak Information Summary

Item	When	Estimated Leak Volume (gallons)	Range of Leak Volume (gallons)	Possible Sources	Comments
1974 Leak Estimate	1968	22,000	None	7,000 Ci Cs-137 (1968)	Accession # D196207372, LET-013074, "Radionuclide Inventories in Leaks from Transfer Lines and Tanks", letter dated January 30, 1974 from M. C. Fraser and D. J. Larkin to H. P. Shaw, Atlantic Richfield Hanford Company, Richland WA
Drywell data	1970 – 1986	No estimate	No estimate	No source identified	Monitoring of drywells 30-11-01 (1979), 30-11-05 (1975), 30-11-06 (1970), 30-11-09 (1970), and 30-11-11 (1975) all have shown less than the background radioactivity level of 50 cps gross gamma (RHO-CD-1193, page 27 and WHC-SD-WM-TI-356).
SGE data	October 2006	No estimate	No estimate	No source identified	No areas of low resistivity are found around SST C-111
1981 Prior leak investigations		No estimate	No estimate		SST C-111 was evaluated in the 1981 report (RHO-CD-1193). Four teams reviewed the classification status of SST C-111 with the teams comprised of: (1) Tank Farm & Evaporator Process Control Group, (2) Tank Farm Surveillance Analysis Group, (3) Process Engineering, 200 East Area Maintenance and Earth Sciences, and (4) Process Engineering. Teams 1, 2 and 4 concluded SST C-111 should be classified as a "Confirmed Leaker". However, team 3 concluded that "… without confirmatory drywell evidence Tank C-111 could not, at the 95% Confidence Level, be declared a Confirmed Leaker. Therefore, following the established Ground Rules for reclassification of single-shell tanks, Tank C-111 must continue to be classified as of Questionable Integrity." (RHO-CD-1193, pg. 13)
SIM Estimate		5,500			
SIM Mean Inventory	^{137}Cs	~195 Ci			Assumes leak date of 1968 and uses the following waste types and maximum leak volume estimate: 1C1 (BT1): 8.01E-03 liter TBP-UR (BT2): 5.86E-01 liter TFeCN (BT2): 1.50E+03 liters CWP1 (CWP1): 9.37E+03 PUREX (P2) OWW1: 3.01E+00 liter Sr-Cs Rec Wst (P1)_HS: 8.56E+03 liter PUREX (P2) Cool Wtr-Stm Cond: 1.39E+03 liter
	^{99}Tc	0.054 Ci			
	^{90}Sr	841.8 Ci			
	Cr	5.3 kg			

4.4 Reassessment of Tank 241-C-105 Waste Loss Event

4.4.1 Background

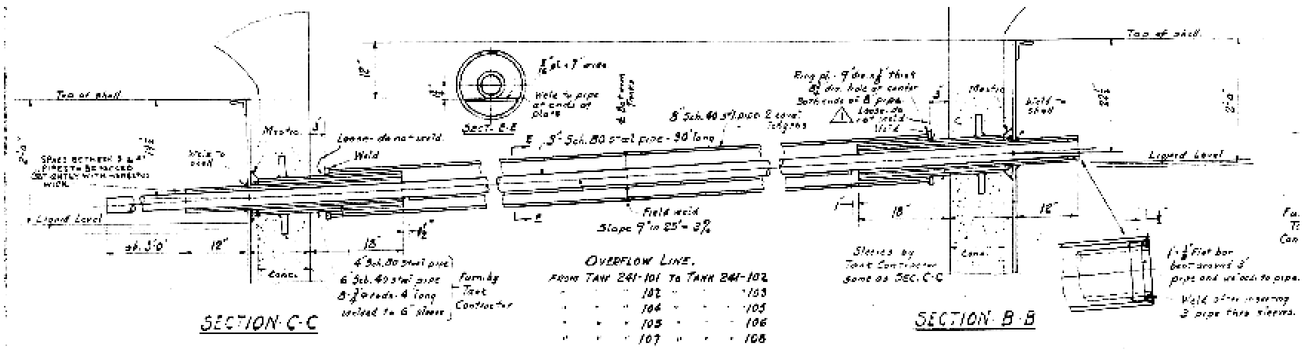
Tank C-105 is a single-shell tank (SST), which was constructed in 1944 through early 1945. SST C-105 has a capacity of 530,000 gallons and a diameter of 75-ft, as depicted in Figure 4-1 (W-72743). A cascade overflow line connects SST C-105 as second in a cascade series of three tanks continuing through SSTs C-104 and C-106. The cascade overflow line, as shown in Figure 4-20, consists of a 3-inch diameter schedule 80 steel pipe contained within an 8-inch diameter schedule 40 steel pipe (W-72743). The 3-inch diameter cascade pipeline extends into the pipe sleeves on both SSTs. The pipe sleeves consist of an outer 6-inch diameter schedule 40 steel pipe and an inner 4-inch diameter schedule 40 steel pipe. The pipe sleeves protrude from the SST and the ends of the outer 8-inch diameter pipe are welded to the pipe sleeve, external to the SST. SST C-105 is categorized as a sound tank (HNF-EP-0182, rev. 221, page 16). The operational history for SST C-105 for 1947 through 1980 is presented in WHC-MR-0132 and summarized in the following discussion.

Figure 4-21 provides the surface waste level history for SST C-105, which is described in more detail below. Figure 4-22 provides available temperature data for the waste stored in SST C-105 from 1973 through 1996 (WHC-SD-WM-ER-313, Appendix D).

SST C-105 began receiving Metal Waste (MW) in February 1947 from the 221-B Plant Bismuth Phosphate Process. The MW was received into SST 241-C-104 and then cascaded to SST C-105. After filling SST C-105 to normal operating capacity of 530,000-gallons in June 1947, MW cascaded through both SSTs C-104 and C-105 into SST C-106. The cascade was filled with MW in November 1947. The MW remained in SST C-105 until it was sluiced out in 1953 and 1954; after the last transfer of the MW slurry, virtually no solids remained in the tank.

During July and August of 1954, SST C-105 was filled with Tri-Butyl Phosphate (TBP) Plant waste (HW-32697, page 4 and HW-33002, page 4). SST C-105 contained a total volume of 546,000-gallons after receiving this TBP Plant waste, which corresponds to a waste height of 17-ft 4-in. above the center of the tank bottom. The spare inlet nozzles on the SSTs are at a height of 17-ft 4-in. (referenced from the center of the tank bottom) and it is known from the SST BX-102 waste loss event investigation (HW-20742, page 5) that some of the spare nozzles on SSTs are poorly sealed. It is possible that some TBP Plant waste was lost in August 1954 through the spare inlet nozzles to the soil nearby SST C-105.

Figure 4-20. Cascade Overflow Pipeline for 241-B, C, T, and U Single-Shell Tanks



SST C-105 remained filled at 546,000-gallons from August 1954 through February 1956 (HW-41812, page 4). In March 1956, approximately 294,000-gallons of TBP Plant waste was transferred from SST C-105 to 244-CR Vault for ferrocyanide scavenging of ^{137}Cs and ^{90}Sr, leaving 252,000-gallons of waste in SST C-105 (HW-42394, page 4). An additional 173,000-gallons of the TBP Plant waste was transferred in April 1956 from SST C-105 to 244-CR Vault for ferrocyanide scavenging of ^{137}Cs and ^{90}Sr, leaving a total of 79,000-gallons (including 15,000-gallons of sludge) of waste in SST C-105 (HW-42993, page 4). No waste was added or removed from SST C-105 from May 1956 through July 1956.

In August of 1956, the tank was utilized as a receiver for PUREX coating removal waste (CW). Approximately 451,000-gallons of PUREX CW was pumped from SST C-104 into SST C-105, filling the tank to 530,000-gallons (HW-45140, page 4). No waste was added or removed from SST C-105 through March 1957, but the total waste volume was adjusted to 535,000-gallons based on a new electrode measurement in February 1957 (HW-48846, page 4). Beginning in April 1957, SST C-105 was used to receive PUREX CW that was then transferred to other SSTs within 241-C Farm and to 241-BY Farm. SST C-105 was filled and emptied several time from April 1957 through April 1960 with PUREX CW (HW-65272, page 4). The monthly waste status summary reports for April 1957 through April 1960 do not indicate the total waste volume in SST C-105 exceeded the height of the spare inlet nozzles.

As of April 30, 1960, the waste total volume reported in SST C-105 was 527,000-gallons (HW-65272, page 4). From May 1960 (HW-65643, page 4) through December 1960 (HW-68292, page 4) , the total waste volume in SST C-105 was reported as 529,000-gallons, based on a new waste level electrode reading taken in May 1960. The SST C-105 waste volume was next reported in June 1961 (HW-71610, page 4). The total waste volume in SST C-105 was reported as 521,000-gallons on June 30, 1961; an unexplained 8,000-gallons decrease during the 6-months from the previously reported waste volume of 529,000-gallons in December 1960. The SST C-105 waste volume was reported as 521,000-gallons in December 1961 (HW-72625, page 4), 519,000-gallons in June 1962 (HW-74647, page 4), and 519,000-gallons in December 1962 (HW-76223, page 4).

Figure 4-21. SST C-105 Waste Level History Summary

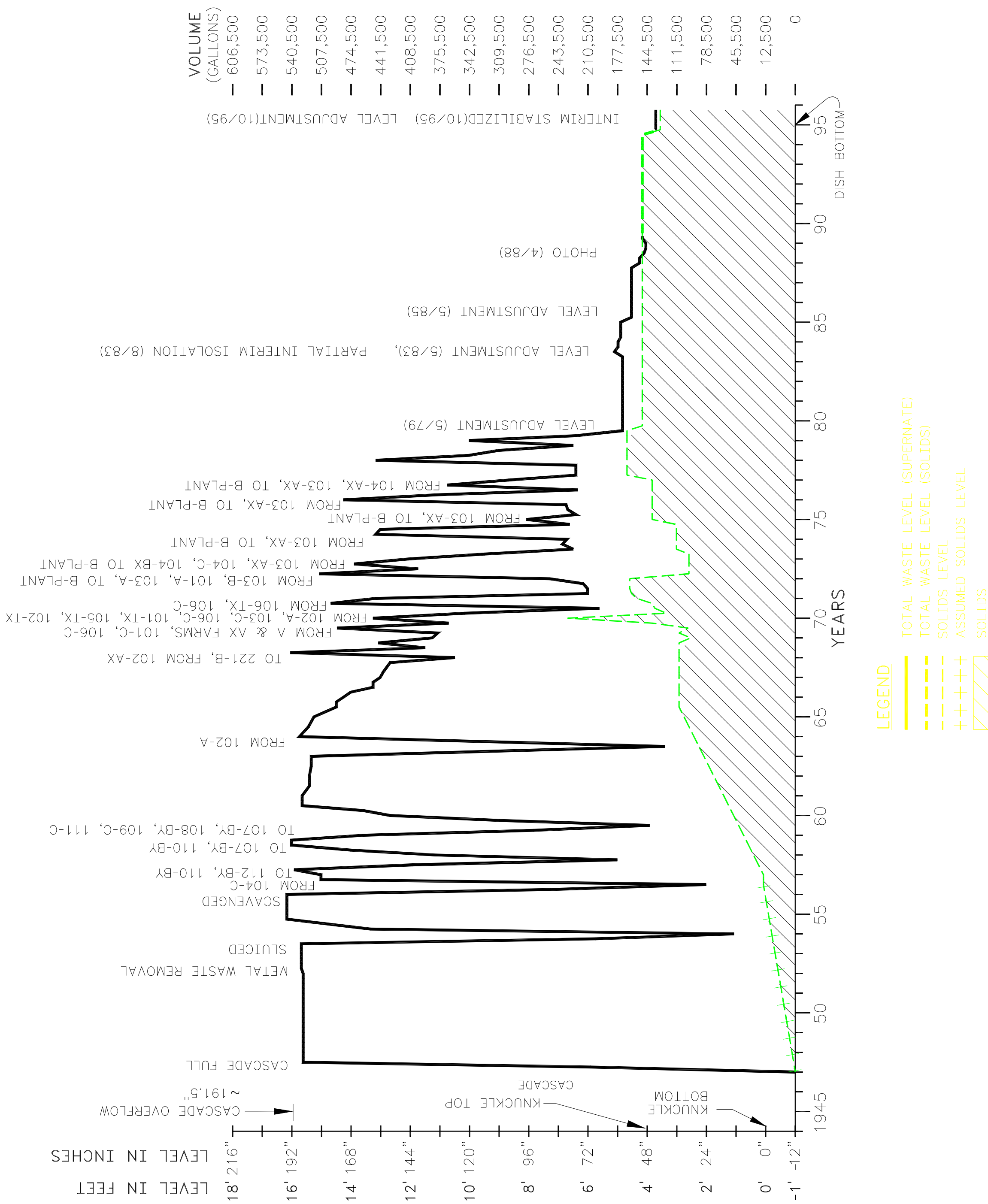
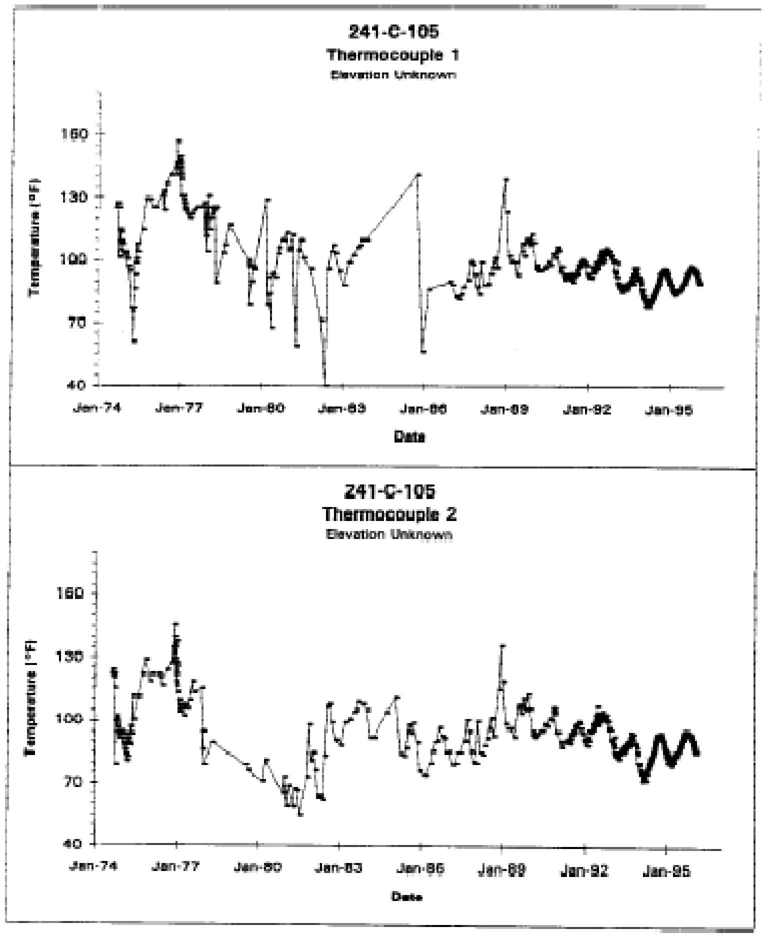
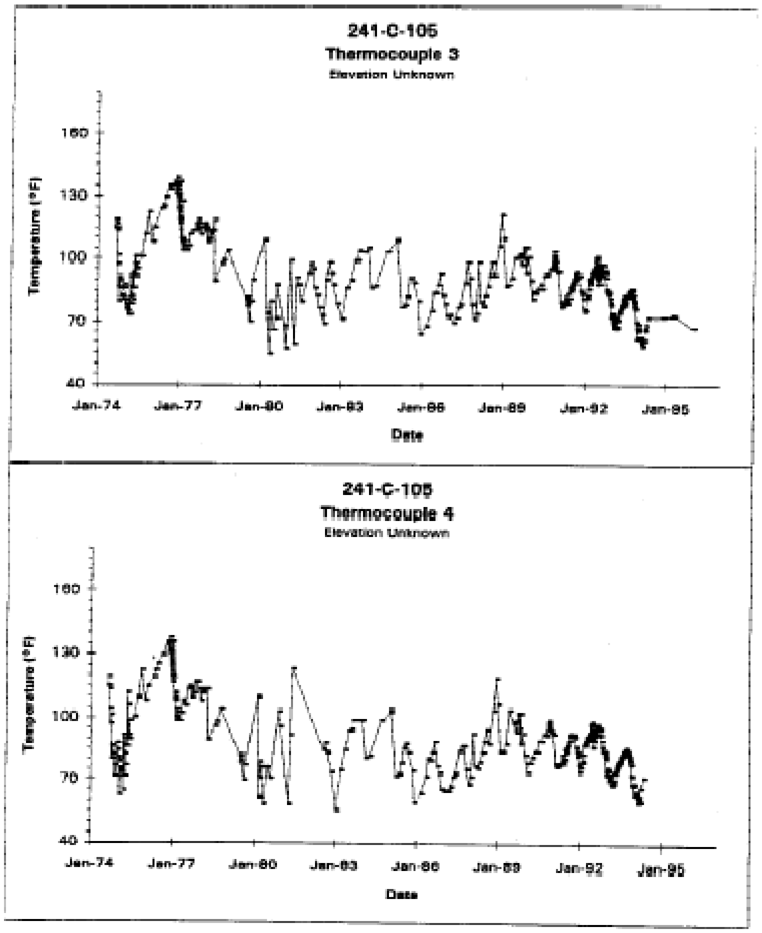


Figure 4-22. SST C-105 Historical Temperature Measurements



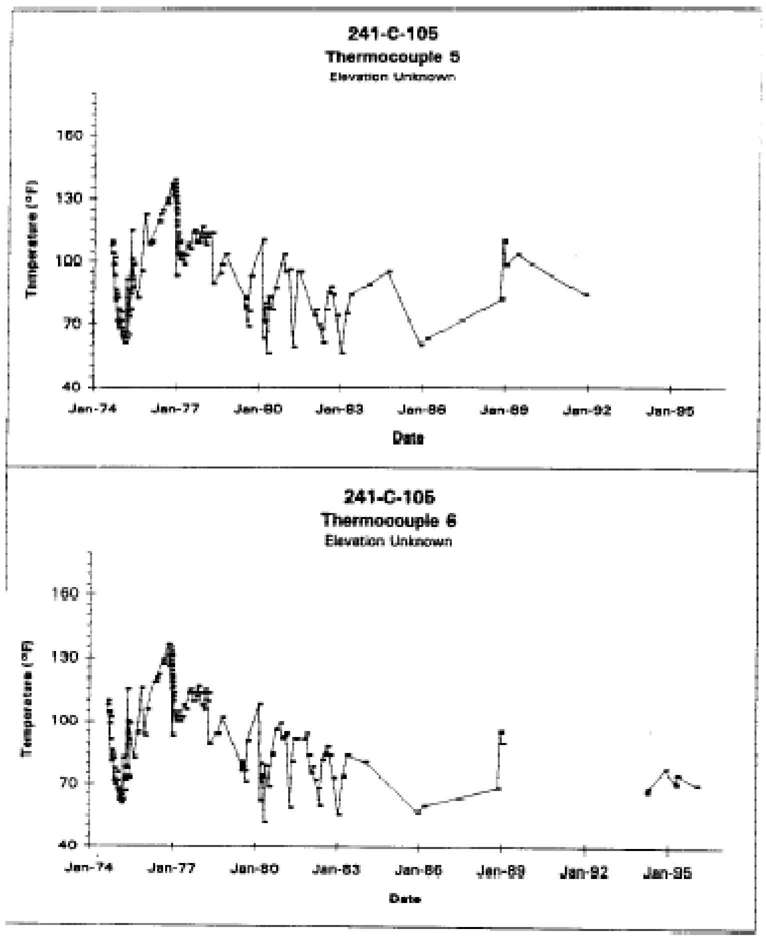
Data obtained from WHC Surveillance Analysis Computer System (SACS), Jan 9, 1996.

Figure 4-22. SST C-105 Historical Temperature Measurements (continued)



Data obtained from WHC Surveillance Analysis Computer System (SACS), Jan 9, 1996.

Figure 4-22. SST C-105 Historical Temperature Measurements (continued)



Data obtained from WHC Surveillance Analysis Computer System (SACS), Jan 9, 1996.

In May 1963, 394,000-gallons of waste was transferred from SST C-105 to SST C-102, leaving 125,000-gallons (HW-78279, page 4), in order to use SST C-105 as an emergency spare for waste from 241-A Farm (HW-77795, page B-1). In the last quarter of 1963, 407,000 gallons of neutralized PUREX supernatant (P1) waste were transferred from SST A-102 to SST C-105 to support sluicing operation testing that was conducted in SSTs A-102 and A-103 (HW-80379, page 4 and HW-78076, page B-1). The process records examined did not indicate the underground transfer lines that were used to transfer the P1 waste from SST A-102 into SST C-105. Since none of the records indicate SST A-102 waste was transferred into SST C-104, it is assumed that the cascade line was not used for this transfer. SST C-105 contained a total of 532,000 gallons following this transfer.

A 36-inch (101,000 gallons) liquid level decrease occurred in SST C-105 between May 1963, when it was filled with P1 waste, and the fourth quarter of 1967 (ARH-95, page 5). Records state the loss was due to “steaming” or “evaporation”, without further elaboration. Supporting temperature data for 1963 could not be located to verify evaporation (i.e. steaming) of waste from SST C-105 (ARH-CD-948).

The P1 waste transferred into SST C-105 during May 1963 originated from SST A-102. The temperature of the P1 waste stored in SST A-102 was measured to be range between 94^{o}C to 170^{o}C from January 1963 through May 11, 1963 prior to the transfer to SST C-105. The higher temperature readings in SST A-102 were experienced when the waste liquid level decreased from ~350-in. to ~300-in.. On May 15, 1963, the liquid level in SST A-102 was increased to 345-in. and the waste temperature was reported to be 105^{o}C (IDMS # D197260431). SST A-102 was equipped with air-lift circulators which aided in cooling the waste temperature. Clearly the waste stored in SST A-102 was capable of generating sufficient heat to cause liquid evaporation. After transferring 407,000 gallons of P1 waste from SST A-102 to SST C-105, evaporation of this waste would still be expected to occur in SST C-105. The waste volume in SST C-105 had reduced to 431,000 gallons by September 30, 1967 (ARH-95, page 5).

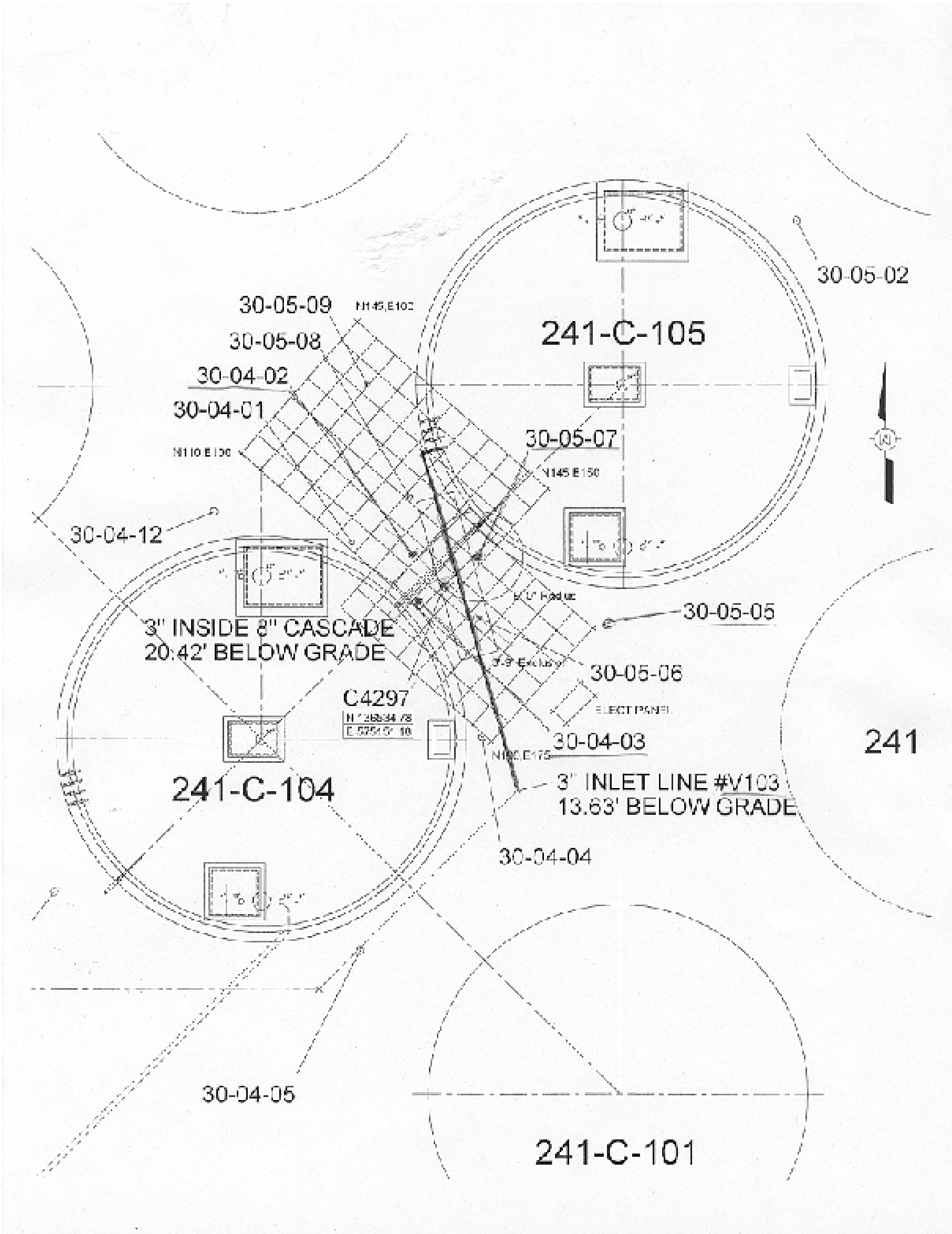
Beginning on December 27, 1967, the P1 supernatant was transferred from SST C-105 to the 221-B Plant to separate ^{137}Cs by ion exchange (IX) processing (ARH-N-85, page 140). The concentration of ^{137}Cs in SST C-105 supernatant was reported as 8.7 Ci/gal in December 1967 (ARH-N-82, page 140). The ^{137}Cs concentration in SST C-105 supernatant would have been ~9.7 Ci/gal (total of 5,160,000 curies) in May 1963, accounting for radionuclide decay and the volume of waste (532,000 gallons) as of May 1963. Approximately 83,000 Btu/hr of radiolytic decay heat would be generated from the ^{137}Cs stored in SST C-105. SST C-105 was equipped with an atmospheric condenser at the time the P1 waste was stored which would have allowed discharge of some condensate to the atmosphere. Collectively, this information supports the P1 waste stored in SST C-105 was capable of evaporating liquid.

In 1966, a transfer line (V-103) from diversion box 241-C-151 was cut and rerouted to SST C-105 in order to make direct transfers to SST C-105 (drawing H-2-61962, revision 1b). As depicted in Figure 4-23, line V-103 wraps around the southeast side of SST C-104 and then transverses across the cascade line before connecting to the southernmost spare inlet line. Note the grids in Figure 4-23 are five foot apart. There is a gap of roughly seven feet between the cascade line and line V-103 where the two lines cross each other (drawing H-2-61981). It is customary to periodically pressure test transfer lines in order to confirm their integrity. However, line V-103 connects to SST C-105 through the spare inlet line, which is permanently open and precluded any ability to check this line for leaks.

From 1968 through 1978, SST C-105 received additional P1 waste, PUREX Sludge Supernatant (designated as PSS), REDOX neutralized supernate (RSN) and B Plant cesium ion exchange wastes for rework from 241-A, 241-AX, and 241-TX Farm, SSTs C-103 and C-106, and double-shell tank 241-AY-102. Some solids contained in the SSTs 241-A and 241-AX wastes are believed to have been transferred to SST C-105 along with the P1 and PSS wastes. The P1 and PSS wastes were pumped periodically to the 221-B Plant for cesium IX recovery processing. The total waste volume in SST C-105 was varied from a 198,000-gallons (including 136,000-gallons of sludge) to 542,000-gallons (including 109,000-gallons of sludge). New wastes were no longer transferred to B Plant for cesium ion exchange processing after 1978. After 1978, supernates were removed from SST C-105 and the tank was maintained at a minimum supernate heel.

Until the early 1990's, the sludge in this tank generated significant radiolytic decay heat to cause evaporation of water to occur. Water was periodically added to the tank to cool the sludge. Water addition was stopped in the mid 1990's after determining that the radiolytic decay heat generation had declined sufficiently. The tank waste surface was inspected in 1995 and the tank determined to comply with interim stabilization criteria in October 1995 (HNF-SD-RE-TI-178, page 115). SST C-105 contains approximately 132,000 gallons of sludge as of August 2006 (HNF-EP-0182, rev. 221 page 16).

Figure 4-23. Drywells and Transfer Piping Around Tank 241-C-105



4.4.3 Basis for Leak Declaration

SST C-105 is currently classified as “sound” (HNF-EP-0182). Previous occurrence reports and the basis for the current assessment are presented in Data Review and Observations section.

4.4.4 Data Review and Observations

The radioactivity detected in drywells around SST C-105 (see Figures 4-24 through 4-27) suggests there may be several waste loss events. The pipeline, C-104 to C-105 cascade line, and spare inlet nozzle waste loss events are thought to be responsible for the radioactivity detected at one or more depth intervals in drywells 30-04-02, 30-04-03, C4297, 30-04-04, 30-04-05, 30-04-08, 30-05-06, and 30-05-09. The peak radioactivity detected in drywell 30-05-07 is approximately at the same elevation as the base of tank SST C-105. Therefore, waste loss from SST C-105 may have occurred.

There are several potential pipeline, spare inlet nozzle, or cascade line waste loss events that occurred in the vicinity of SSTs C-104 and C-105, which are summarized in Table 4-14. Two potential waste loss events of significance are: (1) waste loss from SST C-105 spare inlet nozzles reported in October 1967 (drywell 30-05-08) and (2) waste loss from pipeline V103 reported in 1988 (drywells 30-04-02, 30-04-03 and C4297). Additionally, there is significant radionuclide activity detected in drywell 30-05-07, which is located nearby SST C-105. These events are discussed further below.

a) <u>Waste Loss from SST C-105 Spare Inlet Nozzles</u>: During October 1967, excavation was occurring around SSTs C-104 and C-105 to install pipeline V103 and connect this pipeline to a spare inlet nozzle on SST C-105, as shown on drawing H-2-61981. During this excavation, personnel encountered contaminated soil directly beneath the spare inlet nozzles for SST C-105. This contamination appears to have occurred before October 1967, since the isotopic ratio for ^{137}Cs to ^{134}Cs in the contaminated soil was reported to be different than the waste in SST C-105.

   The spare inlet nozzles are located between the 8 and 9-o’clock positions on SST C-105. Radioactivity has been detected in drywell 30-05-08, located nearby the spare inlet nozzles (see Figure 4-25), since this drywell was installed in early 1974. The radioactivity has steadily decayed, as indicated by the gross gamma scans reported in WHC-SD-WM-TI-356. As shown in Figure 4-25, ^{137}Cs is detected from the ground surface to the bottom of the borehole. ^{137}Cs, ^{60}Co, and ^{154}Eu were detected at approximately 16-ft (depth location of pipeline V103) and ^{137}Cs and ^{60}Co between 35-ft and the bottom of the borehole during the spectral gamma energy scans conducted in 1997 for drywell 30-05-08 (GJPO-HAN-18). The spare inlet nozzles are approximately 21-ft bgs and may be responsible for the contamination below this depth. Waste loss from the spare inlet nozzles on SST C-105 may have been spread downward in the soil, as seen in the 1997 spectral gamma scan for drywell 30-05-08 below approximately 21-ft. Therefore, a waste loss event occurring before October 1967 from the spare inlet nozzles on SST C-105 is a likely source of radioactivity detected in drywell 30-05-08. The contamination between 14-ft and18-ft is likely associated with pipeline V103. This contamination may reside inside the pipeline, since the gamma logging of the borehole does not differentiate between contamination in the soil and buried objects.

Table 4-14. Potentially New Unplanned Releases of Waste in Vicinity of Tanks C-104, C-105 and C-106

Date	Location	Event as Described in Reference	Reference	Comments
1-1959	Pipeline leak – overground line 241-C Tank Farm	"A leak in the overground coating waste transfer line at 241-CR tank farm resulted in contamination of the ground to 1.5 r/hr at 15 feet. The line was replaced at a maximum exposure of 4 r/hr."	HW-59079, page C-3	HW-60807, page 18 reports a leak of about 50 gallons occurred during the transfer of PUREX coating removal waste from SST C-105 to SST 241-C-108. The leak occurred in the vicinity of the pump pit which is located on the north side (12 o'clock position) of the tank. SSTs C-105 was actively receiving PUREX coating waste and transferring PUREX coating waste to SST BY-110 from September 1957 through January 1959. No other SST in C-104 was actively receiving or transferring PUREX coating waste during this period.
3-1965	Pipeline leak Diversion box 241-CR-152 Tank 241-C-102	"A liquid level rise in Tank 103-C, the cesium feed tank, was apparently caused by a failed line in the encasement between the 152-CR diversion box and Tank 102-C which permitted coating waste from the Purex Plant to leak into the encasement and drain to Tanks 101-C, 102-C, and 103-C via the tank pump pits. Coating waste has been routed through a spare line to Tank 102-C and no further leaks have been detected. The coating waste solution accumulated in Tank 103-C did not significantly affect cesium loading capability as a cask was loaded normally following the incident."	RL-SEP-405, page B-2	The failed pipeline is enclosed in a concrete encasement which traverses along the east side of tanks 241-C-104, C-105, and 241-C-106. The failed line may have been replaced by line V8107 per drawing H-2-33087, *LN 8107 (241-CR-152 TO 102C) V843 & V844 (241-CR-151 TO 102C) V050 & V051 (241-A-152 TO 104C)*.

Table 4-14. Potentially New Unplanned Releases of Waste in Vicinity of Tanks C-104, C-105 and C-106

Date	Location	Event as Described in Reference	Reference	Comments
10-1967	Tank C-105 Spare inlet nozzle	**"During excavation on the southwest side of 105-C, J. A. Jones personnel unearthed some contaminated soil. The spot is located directly beneath two blanked stubs**. The extent of spreading or volume of the source contamination is unknown at this time. Analysis of a sample shows cesium to be the only gamma producing isotope present. 3.71 μCi/ml Cs-137 and 0.0039 μCi/ml Cs-134 were the results of analysis. This cesium ratio will allow determination of source and time of deposition of the activity. A sample of 105-C supernate is now being analyzed at Redox Laboratory."	ISO-651 RD, page 288	The absence of other gamma emitting radionuclides indicates this leak is old and did not occur in 1967. The curie ratio of ^{134}Cs to ^{137}Cs is 0.00105.
11-1967	Tank C-105 Spare inlet nozzle	"Analysis of Soil Samples Near Tank 105-C Subject analyses showed that the solution that had leaked into the soil was not the same as that currently contained in the tank. This conclusion was made on the basis of the different Cs-137/Cs-134 ratios. See letter, HL Brandt – PW Smith to LW Roddy, November 9, 1967."	ISO-651 RD, page 298	Same event as above.

Table 4-14. Potentially New Unplanned Releases of Waste in Vicinity of Tanks C-104, C-105 and C-106

Date	Location	Event as Described in Reference	Reference	Comments
Unknown (Pre-1988)	Pipeline V-103	"Earlier investigations of the extremely high levels of contamination found between Tanks 104-C and 105-C are described in reference (10). The following observations were documented at the time and were the bases for the conclusion that both tanks were sound: **The fill line V-103 was stated to have been abandoned at an earlier date due to pipeline leakage**, and the activity noted in DW 30-03-02 could have been due to migration of pre-existing contamination that was first seen in the exploratory scans. This line was part of the old PUREX supernate (PSN) transfer route from Tank 241-AX-101. The material was thermally hot, and water injection was required to maintain a temperature below 60^{o}C. **The cause of failure was believed to have been due to thermal shock induced by the intermittent transfers.** In-tank photographs failed to show any evidence that either tank was unsound. However, the Tank C-105 photos indicated that the tank had been filled to a level above that of the cascade and sidefill pipelines. The possibility of leakage through the wall penetration seals was discussed. The liquid levels in Tank C-105 and -104 remained at a high level for almost six months after the first exploratory well scans, and the observed activities, including that in DW 30-03-02, had remained stable throughout, whereas seepage from either tank would normally have been seen as steadily increasing radiation at the 35 to 41 feet farm excavation depth. The activity at this depth however has diminished in all wells since 1974."	Environmental Protection Deviation Report 87-10, Internal memo 13331-88-088 dated February 22, 1988, page 4	The reference to drywell (DW) 30-03-02 in the reference document seems to be a typographical error. The drywell should be 30-05-02

Waste loss from the spare inlet nozzles on SST C-105 could have occurred: (1) between July 1954 through February 1956 when this tank was filled to the height of the spare inlet nozzles with TBP Plant waste, (2) between August 1956 through April 1960, when this tank was used for PUREX CW storage and transfers, or (3) between May 1963 through September 1967 when P1 waste evaporation was occurring within this tank.

b) Waste Loss from Cascade Overflow Pipeline - Drywells 30-04-02, 30-04-03 and C4297: Radioactivity was found in drywell 30-04-02 in 1974, two years after this well had been drilled. This drywell (see Figures 4-3 and 4-23) is located between SSTs C-104 and C-105, near the cascade line and transfer pipeline V103. The contamination occurred just after two waste transfers from SST AX-103 through pipeline V103 into SST C-105 in March 1974. However, no increase in the radioactivity in drywell 30-04-02 was detected following a third transfer from SST AX-103 to SST C-105 in late March 1974. The total volume of waste in SST C-105 was approximately 443,500 gallons following this transfer. Waste in SST AX-103 was reported as hot, requiring dilution with water to maintain its temperature below 60°C (IDMS # 292-001798, LET-101574). It was suggested in October 1974 that as little as 400-gallons of condensate could have leaked at an elevation above the 158-inch level in SST C-105, resulting in the increased radioactivity detected in drywell 30-04-02.

A material balance for the three, March 1974 waste transfers to SST C-105 indicated less than 250-gallons difference in the volume of waste transferred and the volume received, which is within the tolerances for the liquid level measurement devices (IDMS # 292-001798, LET-101574). Therefore, a leak from pipeline V103 during the March 1974 waste transfers is unlikely to have occurred, but can't be discounted.

An occurrence report was written in 1974 (IDMS # D195005272; OR-74-120), indicating increased radioactivity in drywell 30-04-02 around C-104 and C-105. Radioactivity in drywell 30-04-02 increased in January 1974 from 400 c/s to 600 c/s at 40-ft bgs in March 1974. The activity in drywell 30-04-02 continued to increase reaching a maximum of 960 c/s at 41-ft bgs in June 1974 and then slowly decreasing in radioactivity to the present (RPP-8321, page 147). Occurrence report OR-74-120 also notes "the tank 105-C photos do indicate the tank liquid level was above the tank 104-C to tank 105-C cascade line for some period in the past (pre-June 1973) and highly contaminated dirt has been removed from the immediate area near both ends of this line during recent [1974] well drilling operation".

Occurrence report 74-120 was initiated because drywell 30-04-02 showed an increase in radiation at 40-ft depth. Additional boreholes were drilled to better define the source of contamination. It was concluded that both SST C-104 and C-105 were sound and the radioactivity detected in these drywells was due to an old leak associated with the cascade overflow pipeline between SSTs C-104 and C-105 and leakage from spare inlet nozzles in SST C-105. This is supported by the elevation of the peak radioactivity detected in drywells 30-04-03, which was ~ 21-ft bgs; the approximate location of the cascade overflow pipeline between SSTs C-104 and C-105. Also in 1975, Boeing used an electrical potential measurement technique to analyze the vadose zone between SSTs C-104 and C-105 for evidence of waste leakage (ARH-LD-120, page 31). Boeing used electric potential through the ground to detect moisture, salt, or other variances. Results from the 8 o-clock position on

SST C-105 indicated that the “area between 104-C and 105-C was flooded in the past from the overflow of the cascade line, and thus its salt content is quite high.” This Boeing report supports the postulated cascade overflow pipeline leak and leakage from spare inlet nozzles in SST C-105.

In 2004, drywell C4297 was installed adjacent to the cascade overflow pipeline between SSTs C-104 and C-10 and a few feet from pipeline V103. Sediments were obtained during installation of drywell C4297 and water extracted for analyses (RPP-23752), as shown in Figure 4-28 and 4-29. Spectral gamma analysis of drywell C4297 was conducted in 2004 and is shown in Figure 4-26 (PNNL-15503). The soil analyses from drywell C4297 and the spectral gamma scan also support a leak from the vicinity of the cascade overflow pipeline between SSTs C-104 and C-105, due to the elevated ^{60}Co concentrations and other contaminants between 40 and 60-ft and continued downward movement of contaminants such as ^{99}Tc, sodium, ^{60}Co, nitrate, and sulfate. The spectral gamma scan at approximately 15-ft where ^{60}Co, ^{137}Cs, and ^{154}Eu were detected suggest contaminants inside the cascade line. Soil samples acquired near this depth did not exhibit these contaminants, further suggesting the cascade line did not leak at this location. However, the soil between tanks C-104 and C-105 was excavated to a depth of at least 16-ft in 1967 when the V103 pipeline was installed.

c) Waste Loss from Pipeline V103: Drywell 30-04-02 was the only drywell located between SSTs 241-C-104 and C-105 prior to July 1974. Five additional drywells (30-04-01, 30-04-03, 30-05-06, 30-05-07 and 30-05-08) were installed in 1974 to better define the source of the contamination that was detected in drywell 30-04-02. These drywells are also depicted in Figure 4-23, with 1997 spectral gamma analyses shown in Figures 4-24 and 4-25. In 1974, the peak gross gamma radioactivity detected in drywells 30-04-01, 30-05-09, 30-05-10 were less than 100 cps, ~31,000, and 18,000 cps at 21-ft and 35-ft bgs, respectively in drywell 30-04-03, ~293-cps at 15-ft bgs in drywell 30-04-04, ~255, 120, and 110 cps at 15, 30, and 43-ft bgs, respectively in drywell 30-04-08, ~160 cps at 40-ft bgs (and ~100 cps at ~10-ft bgs) in drywell 30-05-06, 50,000 cps in drywell 30-05-07 at 37 to 58-ft bgs, and ~4,100 and 3,000 cps in drywell 30-05-08 at ~15 and 40-ft bgs, respectively (IDMS # D195005272, OR-74-120). The multiple depth intervals where gamma peaks are identified appear to coincide with pipelines (~15-ft), cascade lines and spare inlet lines (~21-ft), and potentially tank leaks (38-ft and below).

In 1974, the elevation that the peak radioactivity detected in drywells 30-04-04, 30-04-05, 30-05-08, 30-05-06, and more recently drilled C4297, which are nearby pipeline V103, was ~15-ft bgs. Pipeline V103 is ~13.6-ft bgs and the radioactivity detected in these five drywells may be due to the radioactivity internal, external, or both to the pipeline.

Additional waste transfers from tanks 241-AX-103, 241-AX-104 and 241-AY-101 to SST C-105 were conducted during 1974 through 1977, but is not clear whether pipeline V103 was used or an alternative pipeline was used.

1974: 103-AX waste – October

1975: All transfers were 103-AX waste -
April 5-9, May 4-5, May 30, June 14-15, June 27, July 6, July 23-25, August 10-11, August 30 – September 1, October 9, October 17-18, November 4-5, December 5, December 30-31 (all transfers were 103-AX waste)

1976: 103-AX waste - February 14,
104-AX waste - March 25-26, September 8-10

1977: 101-AY waste – November 4-8

1978: 101-AY waste – February 4-5, February 18, April 2-6, May 6-7

The total volume of waste in SST C-105 twice exceeded 443,500 gallons (volume as of March 31, 1974) during the period April 1974 thru May 1978. After the December 30-31, 1975 transfer of PSS waste, the total volume of waste in this SST was ~477,100 gallons. Condensate from a portable exhauster connected to SST C-105 was returned to this tank, thus causing the total waste volume to increase to ~491,100 gallons by February 3, 1976. The total waste volume in SST C-105 was subsequently decreased by transferring PSS waste to 221-B Plant for processing. On March 26, 1976 following the PSS waste transfer from SST 241-AX-104, the total volume of waste in SST C-105 was ~454,800 gallons. The total waste volume in SST C-105 was subsequently decreased to ~ 217,600 gallons by transferring PSS waste to 221-B Plant for processing from March 28, 1976 through April 16, 1976.

Radioactivity measurements in drywells 30-04-04, 30-04-05, 30-05-08, and 30-05-06 adjacent to pipeline V103 did not indicate an increase following any of these subsequent waste transfers conducted in 1975 – 1978. However, pipeline V103 was reported to have been abandoned due to pipeline leakage (Environmental Protection Deviation Report 87-10, page 4), but the date of the waste leak is not reported. The Environmental Protection Deviation Report 87-10 explanation for the leak in pipeline V103 is thermal shock due to the intermittent transfers. Waste transferred into SST C-105 was often hot enough that it needed do be diluted with water to limit its temperature to less than 60°C (140°F). Introducing this hot waste to pipes that had cooled to ground temperature (~60°F) could stress the pipe materials.

d) Potential Waste Loss from SST C-105: The largest measurements of ^{137}Cs contamination (>10^7pCi/g) have been found in drywell 30-05-07 between 36 and 40 feet bgs, as shown in Figure 4-25. Radioactivity was first detected in this drywell when it was installed in July 1974 (IDMS # D195005272; OR-74-120), measured at 50,000 cps at ~37-ft bgs. The peak gross gamma activity in drywell well 30-05-07 has steadily decreased after first being detected (RPP-8321, pg. 211). Peak radioactivity was detected in drywell 30-05-07 at the same elevation as the bottom of SST C-105.

e) Waste loss from C-104 Atmospheric Condenser: The single-shell tanks that contained high heat generating wastes were equipped with an atmospheric condenser. The atmospheric condenser sat on a concrete pit atop the tank. A gasket sealed the atmospheric condenser to the concrete pit. Tank vapors were drawn by natural convection into the condenser tubes. Cooler outside air contacted the condenser tubes causing condensation of the tank vapors. The condensate flowed down through the condenser tubes into the tank, while the vapors vented to the atmosphere through the open tubes.

Tank C-104 was equipped with an atmospheric condenser, which was at the 3-o'clock position on the tank, as shown Figure 4-23. The gasket sealing the atmospheric condenser to the pit atop tank C-104 was reported in July 1979 as being deteriorated and "… had condensate smearing 1 R/hr during an inspection in January" 1979. "The condenser problem is compounded by the deterioration of the concrete bases" (IDMS #D197225783). The leakage of radioactive condensate from the C-104 atmospheric condenser may have contributed to the radioactivity detected in the region between tanks C-104 and C-105.

4.4.5 Tank C-105 Assessment

The summary information shown in Table 4-15 for tank C-105 was discussed with evaluation team members. As shown in section 4.4.4, it is probable that the contamination around SST C-105 stems from different events. Pipeline V103, the cascade overflow pipeline from SST C-104, spare inlet nozzles on SST C-105, and a leak near the base of tank C-105 are all probable sources of waste loss events.

Based on new data and information presented in Section 4.4.4, this assessment concluded that a tank leak was a probable source of drywell 30-05-07 contamination. A formal tank leak assessment has not been conducted and therefore a definitive statement concerning the integrity of this tank can not be made at this time.

Evaporation

Previous documentation attributes a 100,000 gallon liquid level decrease in tank C-105 from 1963 to 1967 to evaporation. The actual tank temperature from 1963 to 1967 is unknown. The temperature of supernatant received from tank A-102 was 220^{o}F.

At a saturated air flow of 5-cfm (assumed as the natural air flow within the tank, prior to installation of an exhauster) and temperature of 220^{o}F, steam tables show ~ 40 gal/min would be exhausted or 18 million gallons/year. This would more than account for the liquid level decrease. However, the actual temperature of the waste at the time of the leak is somewhere between the waste temperature prior to receipt of A-102 waste and the temperature of the A-102 waste. A weighted average temperature of 192^{o}F can be calculated based on the relative amounts of A-102 supernatant added (407,000 gal) compared to the supernatant waste volume before receiving A-102 (125,000 gallon) and assuming the temperature of C-105 waste was only 100^{o}F before receiving supernate from tank A-102. Assuming saturated steam at 5-cfm this equates to ~ 8,000 gallons/year. Although more reasonable, this evaporation estimate does not take into account potential heat losses.

Lacking a known tank waste temperature at the time of the leak, evaporation estimates are highly uncertain such that liquid level decreases observed may be entirely or only partially due to evaporation. Consequently, leak volume and inventory estimates will be based only on vadose zone gamma logging measurements.

Tank Leak Estimate based on Dry Well Gamma Logging

As noted previously, only the contamination observed in drywell 30-05-07 is attributed to a potential leak from tank C-105. The ^{137}Cs activity levels were much lower and nearer to the waste surface or tank spare inlet ports for all other dry wells. Even in dry well C4297, only 9 ft away from drywell 30-05-07, significantly lower gamma activity was measured well above the tank bottom. Therefore only drywell 30-05-07 measurements were included in a a calculation to estimate a potential tank leak.

The concentration for ^{137}Cs in PSN-IX supernatant in tank C-105 in 1969 was 4.34 Ci/gal (ARH-1945, *B Plant Ion Exchange Feed Line Leak*). The same concentration is assumed at the time of the potential leak. Leak volumes based on a 4.34 Ci/gal ^{137}Cs concentration, soil density of 2.0 g/cm^3 and gamma logging measurements (see Figure 4-25) were calculated as follows:

1. For a minimum leak volume, a 30 ft long cylinder (10 ft with ^{137}Cs logged at about 10^7 pCi/g and 20 ft at about 10^5 pCi/g), with a point source leak and a 3 ft radius (distance from the tank to drywell 30-05-07) is assumed. The assumption that the potential leak may not have extended much beyond 30-05-07 is based on the observation that the potential leak concentration may be below ^{137}Cs sorption capacity and is based on the theory that ^{137}Cs sorption capacity is reached before a plume continues to migrate (See Appendix B). The resulting calculation, shown below, is a 165 Ci plume. For a 4.3 Ci/gal waste concentration this would be less than a 40 gal leak.

Volume of 3 ft radius and 10 ft long cylinder = 8.1 m^3 @ 10^7 pCi/g
Volume of 3 ft radius and 20 ft long cylinder = 16.2 m^3 @ 10^5 pCi/g

*8.1 m^3 * 2 g/cm^3 * 10^7 pCi/g = 162 Ci*
*16.2 m^3 *2 g/cm^3 * 10^5 pCi/g = 3 Ci*

165 Ci / 4.3 Ci/gal = 38 gal

2. A maximum potential leak volume was calculated assuming a potential leak could extend along as much as a quarter of the tank perimeter without being detected. For simplicity of geometry, the leak was assumed to spread horizontally 24 ft, 12 ft outside the tank perimeter and 12 ft under the tank from 35 to 65 ft bgs (12 ft is the distance between the tank and the closest dry well to 30-05-07 (vadose zone borehole C4297) showing no indication of contamination comparable to that found in 30-05-07). This forms a plume 30 feet below the base of the tank with an inner and an outer ring (like a rind) with radiuses of 25.5 feet and 49.5 ft respectively. The upper 10 feet of the plume has a concentration of 10^7 pCi/g ^{137}Cs and the concentration of the lower 20 ft is 10^5 pCi/g ^{137}Cs.

For a tank diameter of 75 ft, ¼ circumference = $2\pi r/4 = 2\pi(37.5)/4 = 59$ ft
*Upper Plume Volume = 10*24*59 = 14,140 ft^3 = 400 m^3 @ 10^7 pCi/g*
*400 m^3 * 2 g/cm^3 * 10^7 pCi/g = 8,000 Ci*

*Lower Plume Volume = 20*24*59 = 28,280* ft^3 *= 800* m^3 *@* 10^5 *pCi/g*
800 m^3 ** 2* g/cm^3 *** 10^5 *pCi/g =160 Ci*

(8,000 + 160)Ci / 4.3 Ci/gal = 1,900 gal or ~ 2,000 gal

4.4.6 Conclusions

There are potentially multiple waste loss events nearby SST C-105, with the potential sources of the waste losses the tank, nearby transfer pipelines, the cascade line from SST C-104, leakage from the C-104 atmospheric condenser, and/or the spare inlet lines to SST C-105. The radioactivity in drywell 30-05-07 indicates a potential tank leak. However, no increase in gamma activity has occurred in drywells since 1974, during which 2.8 million gallons of supernatant was cycled through SST C-105. A formal tank leak assessment has not been conducted and therefore a definitive statement concerning the integrity of this tank can not be made at this time.

Based on drywell calculations scenarios presented, and the absence of contamination in drywell C4297 (within 9 ft of 30-05-07), contamination below the tank base was estimated to range from 40 gallons to 2,000 gallons. The waste type for the leak is assumed to be PUREX (PSN-IX or P1) supernatant with a measured ^{137}Cs concentration of 4.34 Ci/gal (ARH-1945) for these calculations.

Table 4-15. Tank C-105 Leak Assessment Summary

Item	When	Estimated Leak Volume (gallons)	Range of Leak Volume (gallons)	Possible Sources	Comments
Current HNF-EP-0182 rev. 219 (June 2006)	NA	0	NA	Contamination in borehole 30-05-07 attributed to a pipe leak	The contamination around SST C-105 likely stems from different events. Pipeline V103, the cascade overflow pipeline from SST 241-C-104, spare inlet nozzles on SST C-105, and a leak near the base of tank C-105 are all probable sources of waste loss events.
Liquid Level Decrease	1963 to 1967	100,000 gallons 36 in.	NA	Tank liquid level measurements	The actual tank temperature from 1963 to 1967 is unknown. The temperature of supernatant received from tank A-102 prior to the leak was 220 F. Lacking a tank waste temperature evaporation estimates are highly uncertain. All or only a portion of the liquid level decrease could be attributed to evaporation.
Potential Leak volume based on Drywell 30-05-07 log	Well logged in 1974	Minimum 40 gal Maximum 1,000 gal	40 to 2,000 gal.	Tank, point or line source leak	Use 4.34 Ci/gal for ^{137}Cs concentration from supernatant analysis. Contamination measured at 10^7 pCi/g from 35 to 45 ft bgs (10 ft) and 10^5 pCi/g from 45 to 65 ft bgs (20 ft). Min volume: Assumes point source, cylindrical plume, 3 ft radius, 30 ft deep. Max. volume: a plume 30 feet below the base of the tank with an inner and an outer ring (like a rind) with radiuses of 25.5 feet and 49.5 ft respectively. The upper 10 feet of the plume has a concentration of 10^7 pCi/g ^{137}Cs and the concentration of the lower 20 ft is 10^5 pCi/g ^{137}Cs.
SGE data	October 2006	No estimate	No estimate	No source identified	Areas of low resistivity were found on the south side of SST C-105.
SIM Estimate		1,000			Assumes a 1,000 gallon leak loss.
SIM Mean Inventory	^{137}Cs	620 Ci			Assumes leak date of 1972 and uses predominantly a PUREX (PSN-IX or P1) waste type. SIM range for ^{137}Cs is 26 to 3,100 Ci back decayed to 1972 = 50 to 6,100 Ci or 0.05 to 6.1 Ci/gal. This bounds a measured ^{137}Cs conc. Of 4.3 Ci/gal.
Decayed to 1/1/2001	^{99}Tc	.23 Ci			
	^{90}Sr	9.0 Ci			
	Cr	1.4 kg			

Figure 4-24. Drywells 30-04-01 thru 30-05-04 Spectral Gamma Logs

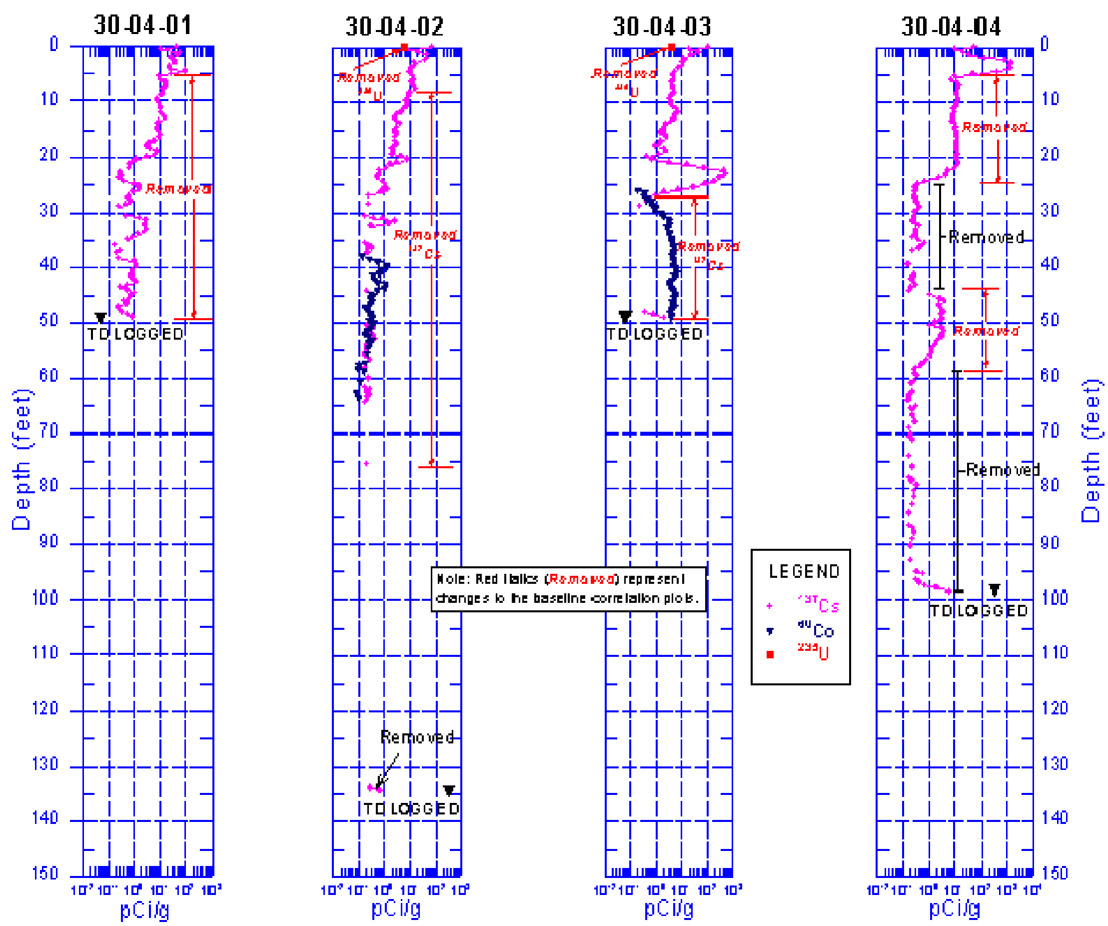


Figure C-3. Summary of Interpreted Data Set for the C Tank Farm

Figure 4-25. Drywells 30-05-07 thru 30-05-10 Spectral Gamma Logs

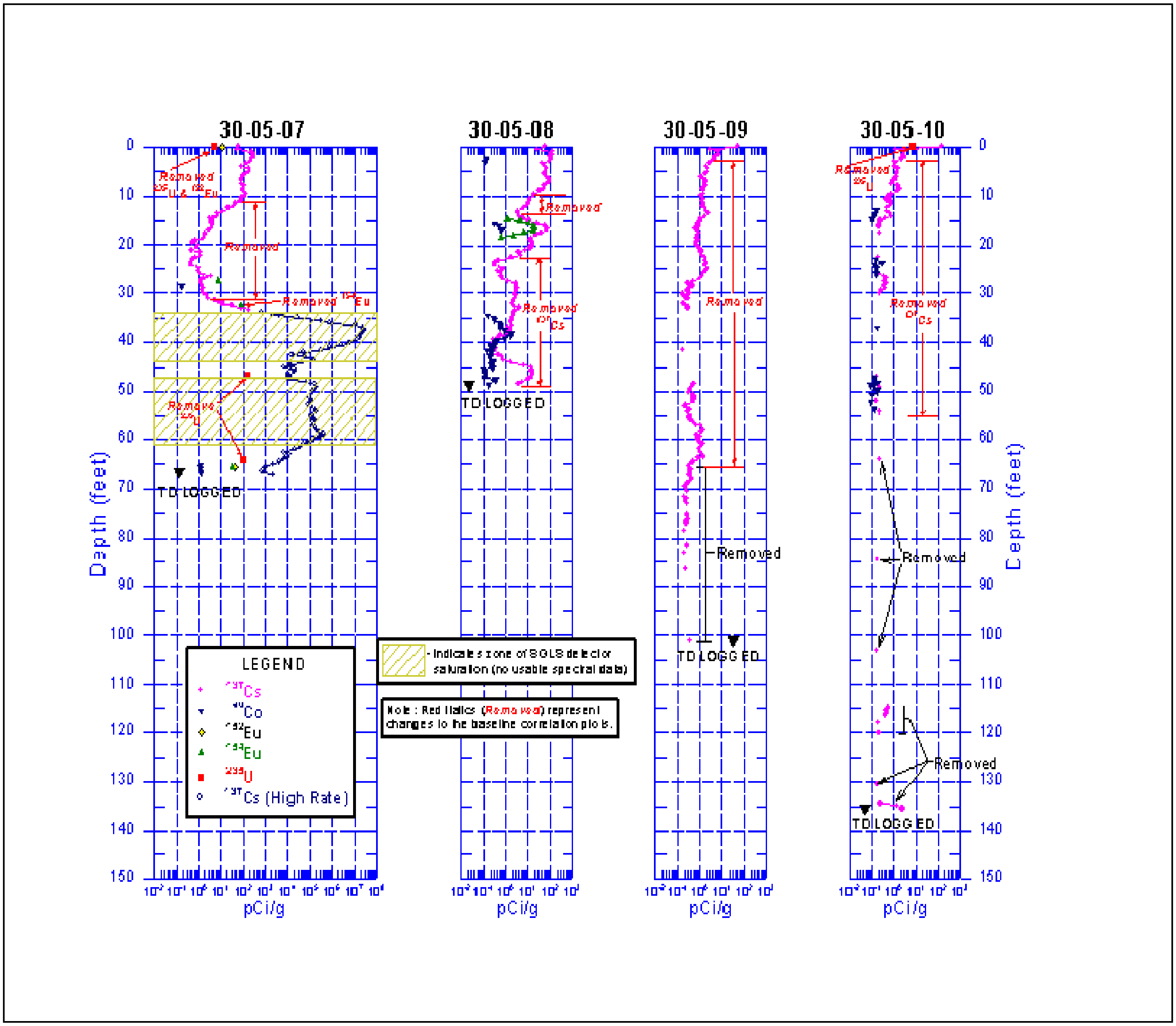


Figure 4-26. Drywell C4297 Spectral Gamma Log

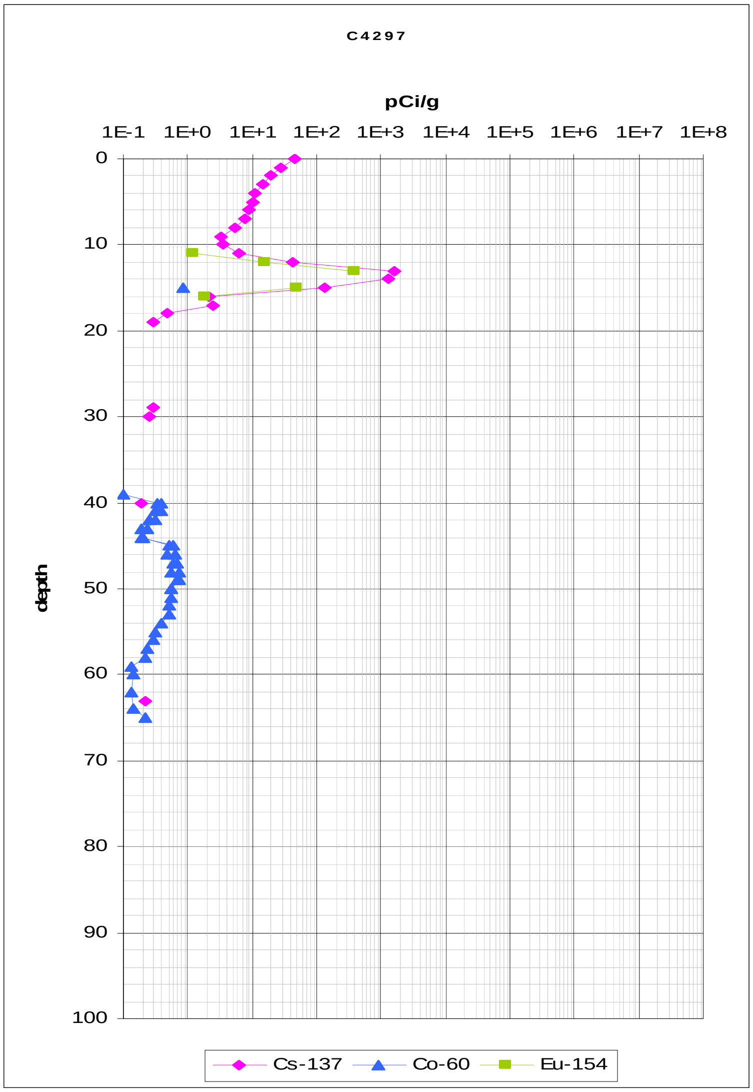


Figure 4-27. Drywell 30-05-07 Historical Gross Gamma Peak Values

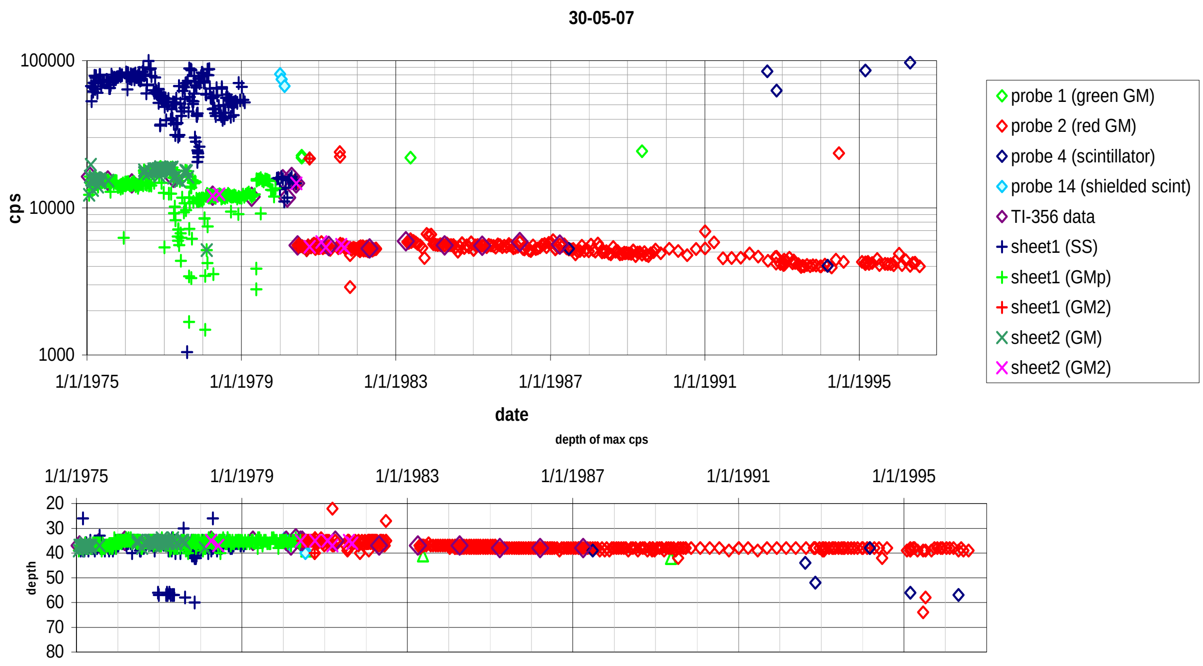


Figure 4-28. C4297 Well Sediment Sample Chemical Analyses

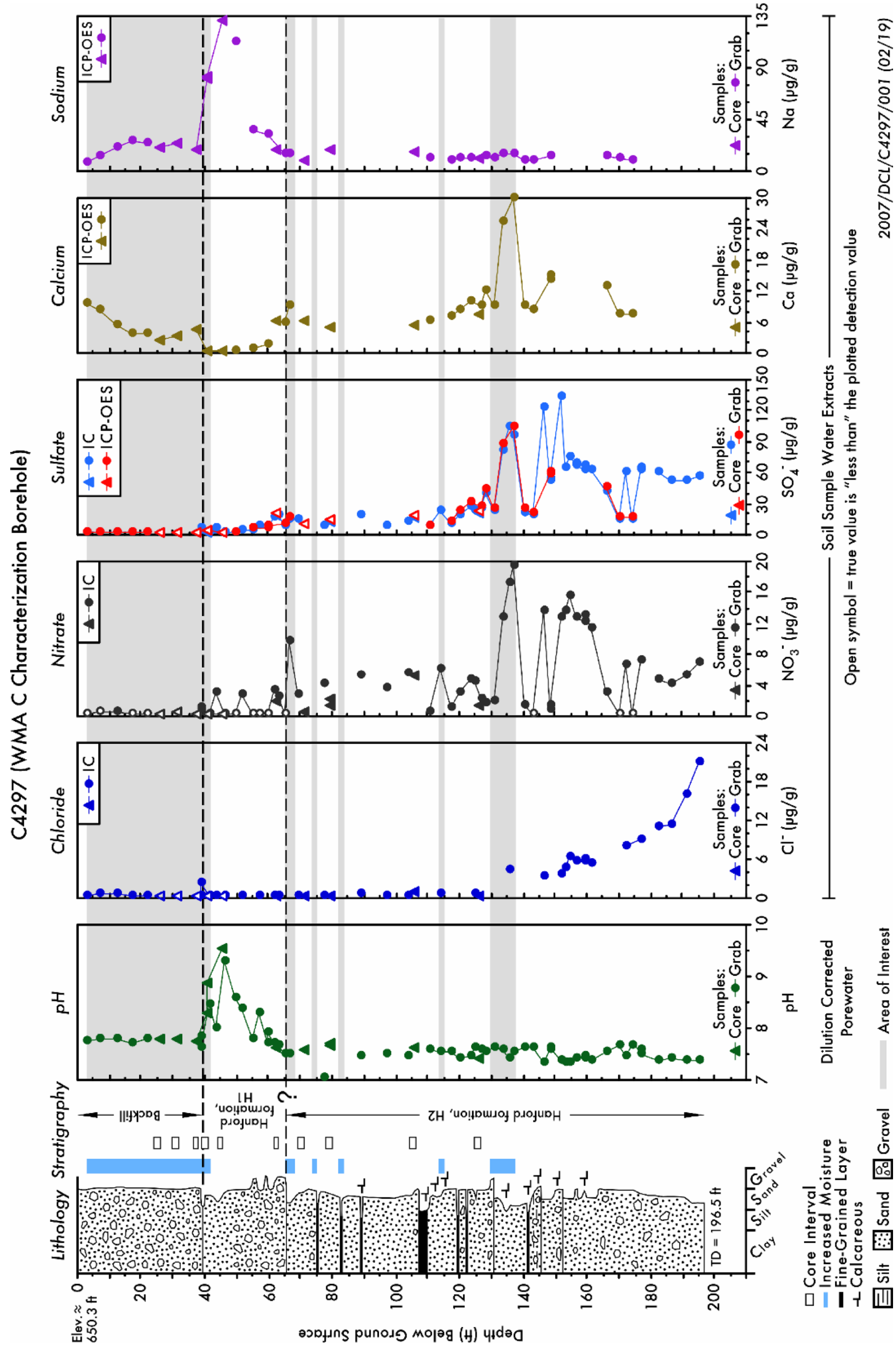
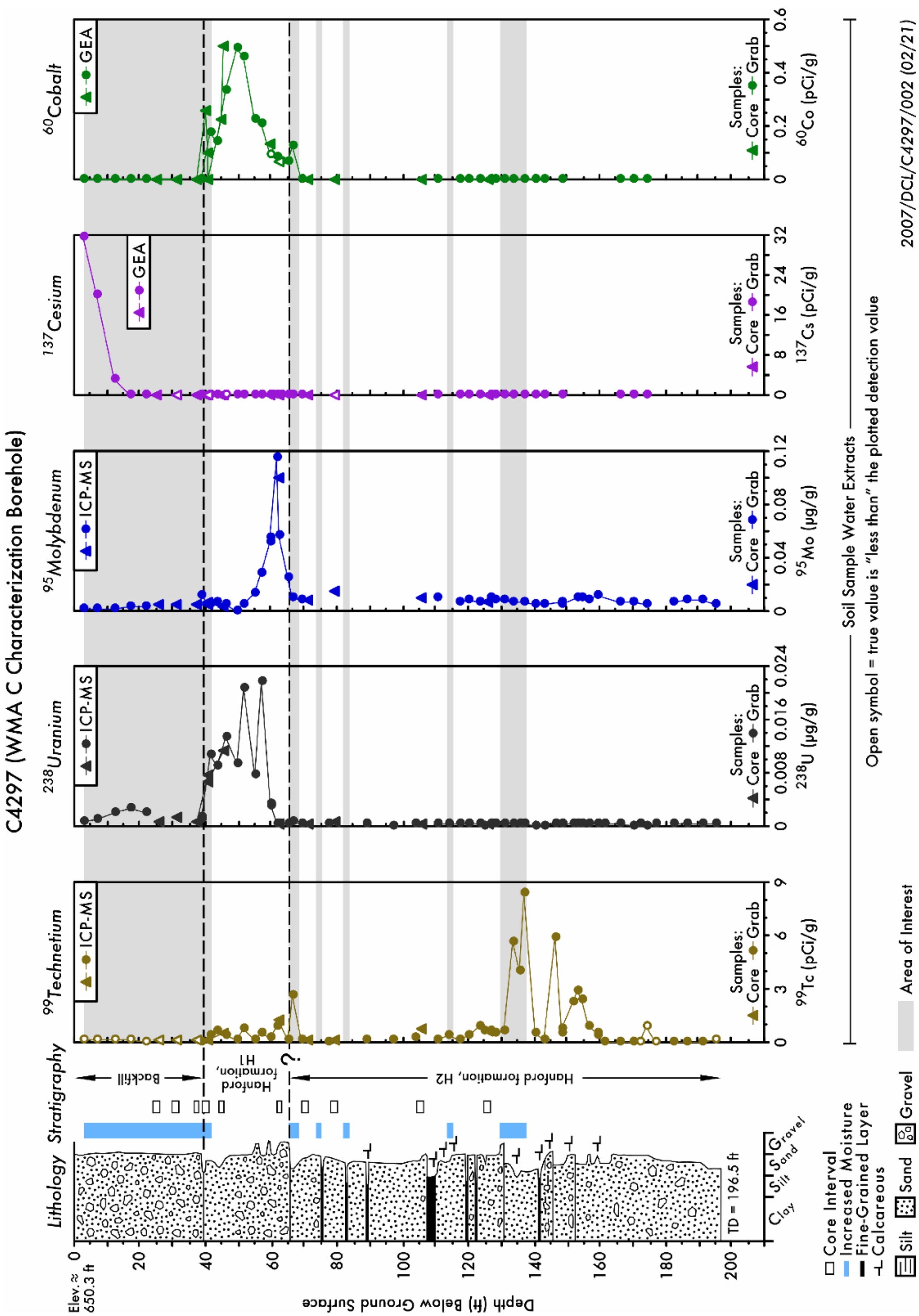


Figure 4-29. C4297 Well Sediment Sample Radionuclide Analyses



5.0 SUMMARY OF TANKS ASSESSED

Tank C-101 data appears to be inconsistent and high uncertainty remains. Until better supporting evidence is obtained, a 20,000 gallon leak volume (HNF-EP-0182) is assumed with a P1 waste type. Assessment attendees accept the sensitivity assumptions and modeling in the Initial SST System Performance Assessment (2006) as a starting point for risk estimates for this tank.

The tank C-110 leak appears to be the result of a tank overflow, the assumed volume of the leak is less than 2,000 gallons of CSR waste type. Supernatant samples of this waste obtained in 1975 provide waste composition measurements.

Evaporation calculations, plotted liquid level data, and evaporation rates clearly indicate that the liquid level decrease for tank C-111 can be attributed to evaporation. Therefore, no leak volume or inventory is assigned for tank C-111.

Data indicates leaks from multiple sources near tank C-105 including a potential leak at the base of the tank near drywell 30-05-07. The leak volume calculations based on dry well logging data range from 40 to 2,000 gallons. The waste type of the leak is assumed to be PUREX (PSN-IX or P1) supernatant for these calculations. A formal tank leak assessment has not been conducted and therefore a definitive statement concerning the integrity of this tank can not be made at this time.

6.0 Waste Management Area C Unplanned Releases

Information is provided on unplanned releases (UPRs) of tank wastes from pipelines, diversion boxes, and other structures within the Waste Management Area (WMA) C at the Hanford Site. The WMA C encompasses the 241-C Tank Farm, which includes the twelve 530,000 gallon capacity and four 55,000 gallon capacity single-shell tanks (SSTs); catch tank 241-C-301, diversion boxes 241-C-151, 241-C-152, 241-C-153, 241-C-252, 241-CR-151, 241-CR-152, 241-CR-153; buildings 241-C-801 Cesium Load-Out Facility and 271-CR Control Room, and 244-CR Vault.

Section 6.1 discusses known UPRs and discusses available documentation. Section 6.2 provides information on potential tank waste losses from the inlet nozzles on the SSTs. Section 6.3 discusses known waste loss events from pipelines, while section 6.4 discusses potential waste discharges from the 241-C-801 building to a drywell. In Section 6.5, drywell monitoring data is reviewed to identify other potentially contaminated areas in WMA C.

Information on unplanned releases (UPRs) in the WMA C was collected from the following sources:

- DOE/RL-88-30, rev. 16, 2007, *Hanford Site Waste Management Units Report*, Fluor, Richland WA
- RPP-7494, 2001, *Historical Vadose Zone Contamination from A, AX, and C Tank Farm Operations*, Fluor Federal Services, Richland WA
- RPP-25113, 2005, *Residual Waste Inventories in the Plugged and Abandoned Pipelines at the Hanford Site*, CH2MHILL Hanford Company, Richland WA
- RPP-RPT-29191, 2006, *Supplemental Information Hanford Tank Waste Leaks*, CH2MHILL Hanford Company, Richland WA
- Waste status summary and monthly report for the Hanford site from January 1945 through December 1980 (various reports)
- RHO-CD-673, 1979, *Handbook 200 Areas Waste Sites*, Rockwell Hanford Operations, Richland WA

The information provided on each UPR consists of the date when the waste loss event occurred, the waste type and estimate of the volume of waste discharged, if known.

6.1 Identified UPRs

DOE/RL-88-30, rev. 16, 2007, *Hanford Site Waste Management Units Report*, contains the official listing of unplanned releases identified at the Hanford site. The UPRs associated with WMA C are:

- 200-E-153-PL
  Description: Tank Farm Transfer Line V108/812 are 3 inch diameter, direct buried, Tank Farm process waste pipes. Line V108 is a stainless steel pipe. Line 812 is a carbon steel pipe. The site is radiologically posted as an Underground Radioactive Material Area

  Incorporates UPR-200-E-86,

- 200-E-133
  Description: The site is the soil inside and adjacent to the chain link fence that surrounds the 241-C Tank Farm. Various radiological postings and warning signs are attached to the chain link fence. The interior of the tank farm complex is covered with gravel. Many risers and monitoring devises for the underground structures are visible on the surface. The individual unplanned release associated with the 241-C Tank Farms are not separately marked or posted. Occasionally, radioactive contamination is found adjacent to the outside of the tank farm fence, resulting in a contamination zone extension around the tank farm perimeter. These areas are also part of this site.

  Incorporates UPR-200-E-16 (241-C Overground Transfer Line Leak), UPR-200-E-27 (244-CR Contamination Spread), UPR-200-E-68 (Radioactive Contamination Spread), UPR-200-E-81 (241-CR-151 Line Break), UPR-200-E-82 (241-C-152 Line Break), UPR-200-E-107 (Contamination Spread in 241-C Tank Farm), UPR-200-E-118 (Airborne

Release from 241-C-107); UPR-200-E-136 (241-C-101 Tank Leak), and UPR-200-E-137 (241-C-203 Leak) are treated as potential tank waste loss events and are not included in this section.

- UPR-200-E-72
  Description: The contamination consisted of beta/gamma particulates with dose rates up to 7 rad per hour on the uncovered material and the surrounding area. Site added in 1985; located northeast of 271-CR building.

Available record documentation was reviewed to identify additional information on the extent of contamination associated with each of the UPRs. Table 6-1 summarizes information on each of UPRs located in the various record documents.

Table 6-1. Additional Information on Identified UPRs

UPR	Date	Waste Type	Waste Discharged (Gallons)	Event Description	References
UPR-200-E-16	1-1959	PUREX CWP1	~50	"A leak in the overground coating waste transfer line at 241-CR tank farm resulted in contamination of the ground to 1.5 r/hr at 15 feet. The line was replaced at a maximum exposure of 4 r/hr". HW-60807, page 18 reports a leak of about 50 gallons occurred during the transfer of PUREX coating removal waste from SST 241-C-105 to SST 241-C-108. The leak occurred in the vicinity of the pump pit which is located on the north side (12 o'clock position) of the tank. SSTs C-105 was actively receiving PUREX coating waste and transferring PUREX coating waste to SST BY-110 from September 1957 through January 1959. No other SST in 241-C Farm was actively receiving or transferring PUREX coating waste during this period.	RPP-RPT-29191, page 113
UPR-200-E-27	11-1960	Particulate	no estimate	"A heavy schedule of diversion box work was experienced during the month. This work included unplugging of the drain line in the 001 vault; unplugging of the 001-CR sump weight factor dip tube with reactivation of the sump jet; installation of jumpers to route the contents of the 011-CR tank to 101-C; installation of special jumpers in the 002-003 CR vault to permit new strontium-90 routings and installation of a new jumper in the 151-A diversion box to permit pumping strontium-90 solutions from the CR vault to 202-A." "A small amount of fission product contamination was spread during work in a diversion box in the 241-CR tank farm. Levels varied from 50 to 100mrads/hr at the edge of the box."	HW-67459, B-2 and B-3
UPR-200-E-27				"241-CR Vault On November 1, 1960 during work in the 241-CR vault, winds spread contaminated particles from the vault generally east and out to several hundred feet beyond the limited area fence. Contamination levels around the vault were on the order of 50 to 100mrad/hr. Particles outside the fence road read as high as 40,000 c/m on a GM meter. No private vehicles were involved."	HW-84619, page 7

Table 6-1. Additional Information on Identified UPRs					
UPR	**Date**	**Waste Type**	**Waste Discharged (Gallons)**	**Event Description**	**References**
UPR-200-E-27				Radiological survey W304943 dated 1-10-1997 includes field surveys of the contaminated areas encompassing UPR-200-E-27. Also included in a work plan for "244-CR Vault Outside Areas Down Posting Plan", which specified the application of a sealant and a minimum of 6-inches of gravel added to stabilize the area.	IDMS # D199138781
UPR-200-E-68	1985	Particulate	no estimate	The contamination consisted of beta/gamma particulates, with readings ranging from 2,000 counts per minute to 5 rad per hour on the diversion box cover blocks and other surfaces in 200 East Area.	DOE/RL-88-30, rev. 16, page 670
UPR-200-E-72	1985	Particulate	no estimate	The contamination consisted of beta/gamma particulates with dose rates up to 7 rad per hour on the uncovered material and the surrounding area.	DOE/RL-88-30, rev. 16, page 671
UPR-200-E-81	10-1969	PUREX CWP2	~36,000	"On October 15, a leak developed in the PUREX to 102-C coating waste tank line (F-18 cell drainage transfer line) just outside the 151-CR diversion box. Purex has been able to merge all their low-level waste flows into the remaining line available which has carried organic wash and special run coating waste. Work is underway for a bypass line around the tank. (11/1969) "Final work has been completed on installation of the bypass lines around the leak in the Purex nonboiling waste line near 151-CR diversion box. The two lines are now stainless steel all the way. The original lines had a carbon steel segment from the 151-CR diversion box to TK-102-C. The leak occurred at the weld connection between carbon steel and stainless steel on one of the lines."	RPP-RPT-29191, page 127-128
UPR-200-E-81	10-1969			Provides radiation occurrence report for pipeline leak and estimated volume and radionuclides content of leak (720 Ci Cs-137 and 36- Ci Sr-90in 10/1969).	RHO-CD-673
UPR-200-E-82	12-1969	PUREX P2 supernate	~2,600	**"**Leak in cesium line from 105-C to B Plant was discovered about 35 feet south of 152-C diversion box. Contamination was covered with 2 feet of dirt for control and shielding." Identified as **pipeline V122**.	RPP-RPT-29191, page 128-129
UPR-200-E-82				Provides ARH-1945 report for pipeline leak and estimated volume and radionuclides content of leak (11,300 Ci Cs-137 in 12/1969).	RHO-CD-673

Table 6-1. Additional Information on Identified UPRs					
UPR	**Date**	**Waste Type**	**Waste Discharged (Gallons)**	**Event Description**	**References**
UPR-200-E-82				Radiological survey E300311 dated 4-15-1997 includes field surveys of the contaminated areas encompassing UPR-200-E-82, which is described as a “Cs Mound”. The radiological survey states “Notified HPT management that the **foam over the Cs mound** is cracking in several places.”	IDMS # D197254753
UPR-200-E-86	2-1971	PUREX PSS [(3)]	17,385	**“**Waste Transfer Line Leak – Evidence of leakage from the 244-AR Vault to the 151-C diversion box portion of the PSS line to the 106-C tank was discovered on February 25 by the Radiation Monitoring (RM) routine patrol inaugurated previously for the purpose of finding such leakage from direct buried lines. The damaged portion of the line will be blanked off and by-passed. The leak appeared to be at a carbon steel – stainless steel weld.” Identified as **pipeline V108/812**.	RPP-RPT-29191, page 134
UPR-200-E-86				3-1-1971, page 91: “Pressure tested route between 106-C and 244-AR Vault. Appears to be a leak above 151-C diversion box at 10 gal/per minute.” 3-2-1971, page 106: “Line from 151-C to 151-CR diversion box was hydrostatically tested. No leak detected. Design is underway to bypass leak in portion of PSS line between 244-AR Vault and 151-C diversion box. Leak detected on 2-25-71 and confirmed on 2-26-71.” 3-8-1971, page 114: “No actual work as yet on leaking line between 244AR Vault and 151C Diversion Box. About 80 ft. of line must be replaced. Minor Construction will do work.” 3-12-1971, page 122: “Minor Construction has started excavating in preparation for repairing leaking line between 244 AR Vault and 151 C diversion box.” 3-16-1971, page 126: “Down pending replacement of the leaking segment of the PSS line between 244AR Vault and the 151-C diversion box. J. A. Jones has started line excavation.” 3-17-1971, page 128: “Down pending replacement of the leaking segment of the PSS line between 244AR and the 151-C diversion box. J. A. Jones	ARH-1895-1

Table 6-1. Additional Information on Identified UPRs					
UPR	**Date**	**Waste Type**	**Waste Discharged (Gallons)**	**Event Description**	**References**
				has started line excavation.” 3-18-1971, page 130: “Down pending replacement of the leaking segment of the PSS line between 244AR and the 151-C diversion box. J. A. Jones has started line excavation.” 3-19-1971, page 132: “Down pending replacement of leaking segment of PSS line between 244 and the 151-C diversion box.” 3-22-1971, page 134: “Down pending replacement of leaking segment of PSS line. Line has been excavated and J. A. Jones has prefabricated piping to bypass leaking section” 3-23-1971, page 136: “Down pending replacement of leaking segment of PSS line between 244 and the 151-C diversion box.” 3-24-1971, page 138: “Down pending replacement of leaking segment of PSS line between 244 and the 151-C diversion box.” 3-25-1971, page 140: “Down pending replacement of leaking segment of PSS line between 244 and the 151-C diversion box.” 3-26-1971, page 142: “Down pending replacement of leaking segment of PSS line between 244 and the 151-C diversion box.” 3-29-1971, page 144: “Down pending replacement of leaking segment of PSS line between 244 and the 151-C diversion box.” 3-30-1971, page 146: “Down pending replacement of leaking segment of PSS line between 244 and the 151-C diversion box. J. A. Jones plans to have line repaired by April 1.” 3-31-1971, page 148: “Down pending replacement of leaking segment of PSS line between 244 and the 151-C diversion box.” 4-1-1971, page 150: “Down pending replacement of leaking segment of	

Table 6-1. Additional Information on Identified UPRs

UPR	Date	Waste Type	Waste Discharged (Gallons)	Event Description	References
				PSS line between 244 and the 151-C diversion box." 4-13-1971, page 16: "J. A. Jones has completed piping to bypass the leak in PSS line between 244AR and the 151-C diversion box."	ARH-1895-2
UPR-200-E-86				Provides additional information on soil samples taken to characterize extent of pipeline leak and estimated volume and Cs-137 content of leak (~25,000 curies in 2/1971).	RHO-CD-673
UPR-200-E-107	11-1952	TBP Waste	~5	Contamination spread to ground and equipment during transfer pump installation in the 110-CR tank in the 241-CR tank farm on November 26, 1952. An estimated 5 gallons of **TBP waste was discharged** from a pump to the ground. A maximum dose rate of 4.2-rep/hr at surface including 200-mr/hr at two inches was observed on ground contamination. HW-26486 page 3 states: "Decontamination of the equipment and ground was initiated immediately. Due to the magnitude of the ground contamination it was decided to excavate a hole and blade the contamination earth into the hole."	RPP-RPT-29191, page 103
UPR-200-E-118	1957	Particulate	no estimate	The contaminated particles on the ground surface read up to 3,000 counts per minute	DOE/RL-88-30, rev. 16, page 675

6.2 Waste Losses from Spare Inlet Nozzles and Cascade Lines

The SSTs in WMA C are equipped with horizontal inlet nozzles. Process waste transfer pipelines were inserted through the inlet nozzle and protruded into the SST. As discussed in further detail in section 6.2.1, a loose seal was installed around the process waste transfer pipeline at the nozzle. The 100-series SSTs are also arranged in four cascades of three tanks each. After filing the first tank in the cascade, waste then flows to the second and once filled, the waste flows to the third and final tank in the cascade.

Tank waste may have been discharged from the SST inlet nozzles if the waste elevation in the tank exceeded the elevation of the inlet nozzles. Cascade lines which lie below the spare inlets in elevation are also submerged when the waste level exceeds the spare inlet level. When the waste exceeds the operating capacity of the tank, it would appear the waste must find an outlet over the top of the tank liner, breach a weak spot in the cascade (perhaps where it exits or enters the tank liner), or breach the spare inlet lines. Section 6.2.2 provides the waste volumes in each of the SSTs in WMA C, as reported by the Tank Farm operator. Events are identified when the inlet nozzles on a SST were submerged beneath tank waste. Although the inlet nozzles on several SSTs were submerged, there is no record of the waste volume potentially lost to the soil surrounding the SST.

6.2.1 Description of SST Inlet Nozzles

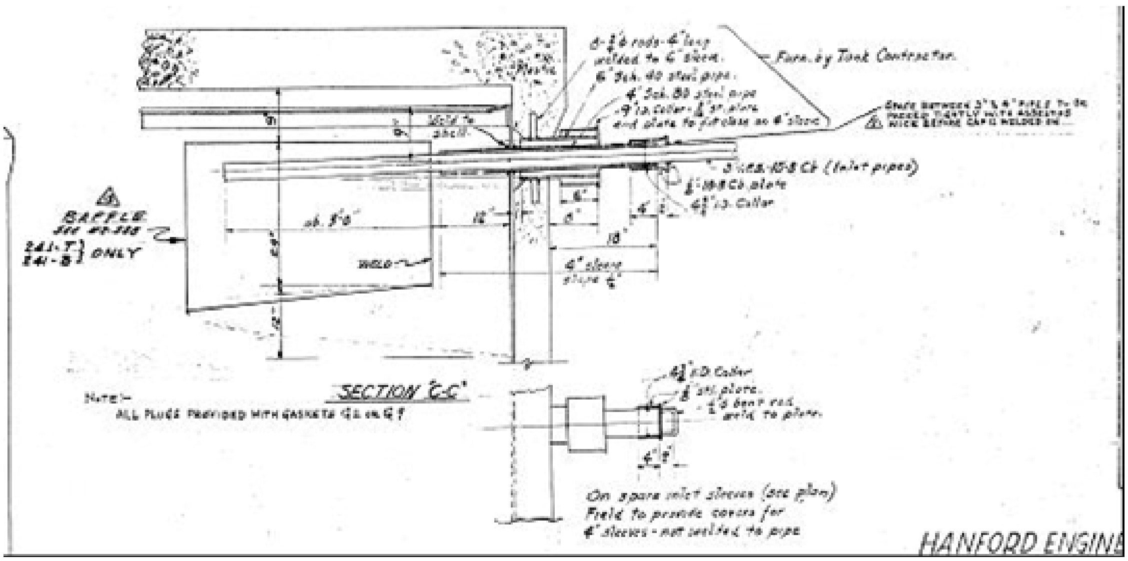
The SSTs in the 241-C Tank Farm are each equipped with four, horizontal inlet nozzles, as shown in Figure 6-1 (see drawings W-72742 and W-72743). While Figure 6-1 depicts a typical inlet nozzles for the 200-series SSTs, the inlet nozzles are the same for the 100-series SSTs. An inlet nozzle consists of an inner 4-inch diameter schedule 80 steel pipe with an outer 6-inch diameter schedule 40 steel pipe. The outer 6-inch diameter steel pipe is imbedded in the concrete sidewall of the SST, attached to the exterior of the carbon steel sidewall using mastic and protrudes ~8-inches from the exterior of the tank wall. The 4-inch diameter steel pipe is inserted through the 6-inch diameter steel pipe, protrudes ~12-inches inside the SST and ~18-inches beyond the exterior of the concrete sidewall of the SST. The 4-inch diameter steel pipe is welded to the sidewall of the carbon steel tank. An 8-inch diameter steel collar is tightly fitted around the 6-inch diameter steel pipe where the 4-inch diameter steel pipe exits this outer pipe. Process waste lines, which are 3-inch inner diameter, 11 gauge 18-8Cb (i.e. early form of stainless steel) tubing, are inserted through the 4-inch diameter steel pipe and extend ~4-ft inside the SST.

The elevation of the four inlet nozzles for the 100-series SSTs is 17-ft 4-inches from the center of the tank bottom (see drawing H-2-1744). The elevation of the four inlet nozzles for the 200-series SSTs is 24-ft 7-inches from the center of the tank bottom (see drawing H-2-1744). All inlet nozzles on the 100-series SSTs in 241-C Farm are located at approximately the 8 o’clock position relative to north being 12 o’clock. For the 200-series SSTs, two spare inlets are located approximately at the 12:30 o’clock position and two spare inlets are located approximately at the 9:30 o’clock relative to north being 12 o’clock.

The process waste lines connecting to the inlet nozzles on SSTs C-101, C-104, C-107, C-108, C-110, and C-111 are supported by concrete beams (see drawings W-74108, H-2-616, and

H-2-2929). The concrete support beams are 30-inches tall and 32-inches wide, except for C-101, which are only 26-inches wide. The concrete support beams have a 4-inch tall shoulder, resulting in a 24-inch (only 18-inches for C-101) wide trough running down the center of the beam.

Figure 6-1 20-Ft Diameter SST Detail Showing Inlet Nozzles



Process waste lines from diversion box 241-C-252 connect to two inlet nozzles on each of the C-200 series SSTs and are supported by concrete beams (see drawing W-74317). The other two inlet nozzles are spares on the C-200 series SSTs and do not have connecting concrete support beams. For the 200-series SSTs, the concrete support beams are 37-inches tall and 20-inches wide. The concrete support beams have a 4-inch tall shoulder, resulting in a 12-inch wide trough running down the center of the beam.

Some of the inlet nozzles on the SSTs are spares and do not have installed process waste lines. The design for the SSTs identified a 4.5-inch diameter cover was to be placed over the 4-inch diameter spare inlet nozzles (see Figure 6-1). It is known that some of the spare inlet nozzles are poorly sealed. SST BX-102 was overfilled in February 1951 and waste was lost to the ground through the spare inlet nozzles (HW-20742). As part of the investigation into the waste loss from SST BX-102, spare inlet nozzles on several SSTs (specific tanks were not identified) were examined. This investigation revealed "… that some have blanks which are welded tight, some have wooden plugs driven into the spare nozzle covered by a cap and sealed with waterproofing, and some have caps covered with waterproofing membrane and then sealed in cement" (see HW-20742, page 5).

Based on the SST BX-102 waste loss investigation, waste may have been similarly lost to the ground in the 241-C Farm if SSTs were filled above the height of the spare inlet nozzles; 17-ft 4-inches (~547,500 gallons) for 100-series and 24-ft 7-inches (~55,900 gallons) for the 200-series SSTs. If waste losses occurred, small waste losses from the spare inlet nozzles for SSTs C-101, C-104, C-107, C-108, C-110, and C-111 may have been contained and channeled along the concrete beams that support the process waste lines connecting to the inlet nozzles.

6.2.2 Potential Waste Loss through Inlet Nozzles of Cascade Lines

The waste volumes in all SSTs was reported monthly from January 1945 through December 1960 (except no data for August 1951 through March 1952), semi-annually from January 1961 through June 1965, quarterly from September 1965 through September 1976, and monthly thereafter. Frequent waste transfers into and waste removal from tanks occurred. Only the waste volume in each tank at the end of the reporting period was documented. The waste volumes reported in the sixteen SSTs in the 241-C Farm for January 1945 through December 1980 are tabulated in Table 6-2. SSTs were removed from service in January 1981 and no waste additions were allowed after this date. Dates when a SST was filled with waste above the elevation of the spare inlet nozzles and therefore also the cascade lines are high-lighted using pink in Table 6-2. Tanks may have been filled with waste above the spare inlets nozzles and cascade lines on more occasions than indicated in Table 6-2 due to transient conditions.

In addition to the information in Table 6-2, there are two additional events when SSTs in WMA C were potentially filled with waste above the spare inlet nozzles and cascade lines, as reported in RPP-RPT-29191.

- RPP-RPT-29191, page 143: "On 11-20-51, water inadvertently seeped into the 106-C Metal Waste Storage Tank from a hose which had been left running to prevent freezing of the water line. After extensive checking it was determined that the liquid level in the tank had raised approximately 8½ inches and had reached the level of the stubbed inlet lines. All survey work showed no indications of tank overflow and the level of the tank has remained constant for the past four weeks. Corrective measures have been instituted to prevent a similar occurrence".

- RPP-RPT-29191, page 158: (**October 1967) "During excavation on the southwest side of 105-C, J. A. Jones personnel unearthed some contaminated soil. The spot is located directly beneath two blanked stubs**. The extent of spreading or volume of the source contamination is unknown at this time. Analysis of a sample shows cesium to be the only gamma producing isotope present. 3.71 μCi/ml Cs-137 and 0.0039 μCi/ml Cs-134 were the results of analysis. This cesium ratio will allow determination of source and time of deposition of the activity. A sample of 105-C supernate is now being analyzed at Redox Laboratory".

  (November 1967) "Analysis of Soil Samples Near Tank 105-C: Subject analyses showed that the solution that had leaked into the soil was not the same as that currently contained in the tank. This conclusion was made on the basis of the different Cs-137/Cs-134 ratios".

Based on Table 6-2 and the additional information cited above, SSTs C-101, C-103, C-104, C-105, C-106, C-109, C-111, C-201, C-202, and C-204 were filled with waste above the elevation of the spare inlet nozzles and cascade lines on several occasions. As previously stated waste may have been lost to the ground from these SSTs as a result of overfilling these tanks. The date and waste type present in each SST when the tank was filled with waste above the elevation of the spare inlet nozzles are summarized in Table 6-3.

Table 6-2 Waste Volume Stored in 241-C Farm Single-Shell Tanks January 1945 – September 1950

		Percent Filled				
Reference	**Tank**	**C-101 thru C-103**	**C-104 thru C-106**	**C-107 thru C-109**	**C-110 thru C-112**	**C-201 - C-204**
HW-7-1293-DEL	Jan-45	0	0	0	0	0
HW-7-1388-DEL	Feb-45	0	0	0	0	0
HW-7-1544-DEL	Mar-45	0	0	0	0	0
HW-7-1649-DEL	Apr-45	0	0	0	0	0
HW-7-1793-DEL	May-45	0	0	0	0	0
HW-7-1981-DEL	Jun-45	0	0	0	0	0
HW-7-2177-DEL	Jul-45	0	0	0	0	0
HW-7-2361-DEL	Aug-45	0	0	0	0	0
HW-7-2548-DEL	Sep-45	0	0	0	0	0
HW-7-2706-DEL	Oct-45	0	0	0	0	0
HW-7-2957-DEL	Nov-45	0	0	0	0	0
HW-7-3171-DEL	Dec-45	0	0	0	0	0
HW-7-3378-DEL	Jan-46	0	0	0	0	0
HW-7-3566-DEL	Feb-46	0	0	0	0	0
HW-7-3751	Mar-46	7	0	0	0	0
HW-7-4001-DEL	Apr-46	19.1	0	0.1	0	0
HW-7-4193-DEL	May-46	34	0	0	12.1	0
HW-7-4343-DEL	Jun-46	45.6	0	0	21.3	0
HW-7-4542-DEL	Jul-46	59.2	0	0	31.7	0
HW-7-4739-DEL	Aug-46	77.3	0	0	46.4	0
HW-7-5194-DEL	Sep-46	87.6	0	0	54.2	0
HW-7-5362-DEL	Oct-46	100	0.3	0	64.1	0
HW-7-5505-DEL	Nov-46	100	10.4	0	71.6	0
HW-7-5630-DEL	Dec-46	100	22.5	0	80.8	0
HW-7-5802-DEL	Jan-47	100	29.5	0	86.6	0
HW-7-5944-DEL	Feb-47	100	34.6	0	90.6	0
HW-7-6048-DEL	Mar-47	100	46.4	0	98.9	0
HW-7-6184-DEL	Apr-47	100	52.6	8.5	100	0
HW-7-6391-DEL	May-47	100	59.3	11.6	100	0

Table 6-2 Waste Volume Stored in 241-C Farm Single-Shell Tanks January 1945 – September 1950						
		Percent Filled				
Reference	**Tank**	**C-101 thru C-103**	**C-104 thru C-106**	**C-107 thru C-109**	**C-110 thru C-112**	**C-201 - C-204**
HW-7096-DEL	Jun-47	100	67.1	17.3	100	0
HW-7283-DEL	Jul-47	100	75.8	23.7	100	0
HW-7504-DEL	Aug-47	100	82.8	28.3	100	0
HW-7795-DEL	Sep-47	100	91.1	34.3	100	0
HW-7997-DEL	Oct-47	100	96.5	38.7	100	0
HW-8267-DEL	Nov-47	100	100	43.3	100	25
HW-8438-DEL	Dec-47	100	100	49	100	68.6
HW-8931-DEL	Jan-48	100	100	53.4	100	100
HW-9191-DEL	Feb-48	100	100	59.2	100	100
HW-9595-DEL	Mar-48	100	100	65.7	100	100
HW-9922-DEL	Apr-48	100	100	70.7	100	100
HW-10166-DEL	May-48	100	100	77.5	100	100
HW-10378-DEL	Jun-48	100	100	84.8	100	100
HW-10714-DEL	Jul-48	100	100	92.4	100	100
HW-10993-DEL	Aug-48	100	100	98.2	100	100
HW-11226-DEL	Sep-48	100	100	100	100	100
HW-11499-DEL	Oct-48	100	100	100	100	100
HW-11835-DEL	Nov-48	100	100	100	100	100
HW-12086-DEL	Dec-48	100	100	100	100	100
HW-12391-DEL	Jan-49	100	100	100	100	100
HW-12666-DEL	Feb-49	100	100	100	100	100
HW-12937-DEL	Mar-49	100	100	100	100	100
HW-13190-DEL	Apr-49	100	100	100	100	100
HW-13561-DEL	May-49	100	100	100	100	100
HW-13793-DEL	Jun-49	100	100	100	100	100
HW-14043-DEL	Jul-49	100	100	100	100	100
HW-14338-DEL	Aug-49	100	100	100	100	100
HW-14596-DEL	Sep-49	100	100	100	100	100
HW-14916-DEL	Oct-49	100	100	100	100	100
HW-15267-DEL	Nov-49	100	100	100	100	100
HW-15550-DEL	Dec-49	100	100	100	100	100
HW-15843-DEL	Jan-50	100	100	100	100	100

Table 6-2 Waste Volume Stored in 241-C Farm Single-Shell Tanks January 1945 – September 1950						
		Percent Filled				
Reference	**Tank**	**C-101 thru C-103**	**C-104 thru C-106**	**C-107 thru C-109**	**C-110 thru C-112**	**C-201 - C-204**
HW-17056-DEL	Feb-50	100	100	100	100	100
HW-17410-DEL	Mar-50	100	100	100	100	100
HW-17660-DEL	Apr-50	100	100	100	100	100
HW-17971-DEL	May-50	100	100	100	100	100
HW-18221-DEL	Jun-50	100	100	100	100	100
HW-18473-DEL	Jul-50	100	100	100	100	100
HW-18740-DEL	Aug-50	100	100	100	100	100
HW-19021-DEL	Sep-50	100	100	100	100	100

Table 6-2 Waste Volume Stored in 241-C Farm Single-Shell Tanks October 1950 through March 1952						
		C-101 thru C-106 and C-200 Series Total Volume (Kgal)		**C-107 thru C-112 Total Volume (Kgal)**		
HW-19325-DEL	Oct-50	3374		3170		
HW-19622-DEL	Nov-50	3374		3170		
HW-19842-DEL	Dec-50	3374		3170		
HW-20161-DEL	Jan-51	3374		3170		
HW-20438-DEL	Feb-51	3374		3170		
HW-20671-DEL	Mar-51	3374		3170		
HW-20991-DEL	Apr-51	3374		3170		
HW-21260-DEL	May-51	3374		3170		
HW-21506-DEL	Jun-51	3374		3170		
HW-21802-DEL	Jul-51	3374		3170		
HW-22075-DEL	Aug-51	No data reported for August 1951 through March 1952				
HW-22304-DEL	Sep-51					
HW-226100-DEL	Oct-51					
HW-22875-DEL	Nov-51					
HW-23140-DEL	Dec-51					
HW-23437-DEL	Jan-52					
HW-23698-DEL	Feb-52					
HW-23982-DEL	Mar-52					

Table 6-2 Waste Volume Stored in 241-C Farm Single-Shell Tanks April 1952 through December 1980 (Kgal)							
Reference	**Tank**	**C-101**	**C-102**	**C-103**	**C-104**	**C-105**	**C-106**
HW-27838	Apr-52	530	530	519	530	530	519
	May-52	530	530	519	530	530	519
	Jun-52	530	530	519	530	530	519
HW-27839	Jul-52	530	530	519	530	530	519
	Aug-52	530	530	519	530	530	519
	Sep-52	530	530	519	530	530	519
HW-27840	Oct-52	530	530	519	530	530	519
	Nov-52	779 combined in C-101,102, and 103			530	530	519
	Dec-52	984 combined in C-101,102, and 103			530	530	519
HW-27841	Jan-53	543 combined in C-101,102, and 103			530	530	519
HW-27842	Feb-53	336 combined in C-101,102, and 103			530	530	519
HW-27775	Mar-53	1507 combined in C-101 thru C-106					
HW-28043	Apr-53	10	53	180	530	530	368
HW-28377	May-53	389	46	10	530	530	234
HW-28712	Jun-53	422		45	530	530	76
HW-29054	Jul-53	422		45	530	530	439
HW-29242	Aug-53	530	343	505	78	396	245
HW-29624	Sep-53	222	467	508	46	202	439
HW-29905	Oct-53	517	508	560	10	202	100
HW-30250	Nov-53	517	508	560	0	78	194
HW-30498	Dec-53	517	508	560	0	48	143
HW-30851	Jan-54	517	530	560	0	48	59
HW-31126	Feb-54	510	530	560	0	0	50
HW-31374	Mar-54	510	530	560	312	458	50
HW-31811	Apr-54	510	530	560	389	219	50
HW-32110	May-54	510	530	560	127	27	50
HW-32389	Jun-54	510	530	560	323	0	50
HW-32697	Jul-54	510	530	560	124	530	85
HW-33002	Aug-54	510	530	560	415	546	538
HW-33396	Sep-54	510	530	560	271	546	538

Table 6-2 Waste Volume Stored in 241-C Farm Single-Shell Tanks April 1952 through December 1980 (Kgal)

Reference	Tank	C-101	C-102	C-103	C-104	C-105	C-106
HW-33544	Oct-54	510	530	560	36	546	538
HW-33904	Nov-54	510	530	560	523	546	538
HW-34412	Dec-54	510	530	560	494	546	538
HW-35022	Jan-55	510	530	560	350	546	538
HW-35628	Feb-55	510	530	560	48	546	538
HW-36001	Mar-55	510	530	560	0	546	538
HW-36553	Apr-55	510	530	560	0	546	538
HW-37143	May-55	510	530	560	0	546	538
HW-38000	Jun-55	510	530	560	0	546	538
HW-38401	Jul-55	510	530	560	0	546	538
HW-38926	Aug-55	510	530	560	0	546	538
HW-39216	Sep-55	510	530	560	0	546	538
HW-39850	Oct-55	510	530	560	420	546	538
HW-40208	Nov-55	510	530	560	420	546	538
HW-40816	Dec-55	326	530	560	420	546	538
HW-41038	Jan-56	485	530	560	85	546	538
HW-41812	Feb-56	485	530	560	196	546	538
HW-42394	Mar-56	485	530	560	224	252	538
HW-42993	Apr-56	485	530	560	271	79	538
HW-43490	May-56	485	530	560	329	79	538
HW-43895	Jun-56	485	530	560	439	79	538
HW-44860	Jul-56	485	530	560	519	79	538
HW-45140	Aug-56	485	530	560	110	530	538
HW-45738	Sep-56	161	530	560	176	508	538
HW-46382	Oct-56	131	530	560	239	508	538
HW-47052	Nov-56	131	530	560	319	508	538
HW-47640	Dec-56	131	530	560	406	508	538
HW-48144	Jan-57	131	533	569	411	508	483
HW-48846	Feb-57	98	533	569	411	535	516
HW-49523	Mar-57	98	535	568	464	538	519
HW-50127	Apr-57	95	48	37	535	238	519
HW-50617	May-57	95	48	37	541	320	43
HW-51348	Jun-57	483	48	37	541	406	354
HW-51858	Jul-57	260	48	37	543	252	524
HW-52414	Aug-57	299	48	37	543	373	524

Table 6-2 Waste Volume Stored in 241-C Farm Single-Shell Tanks April 1952 through December 1980 (Kgal)							
Reference	**Tank**	**C-101**	**C-102**	**C-103**	**C-104**	**C-105**	**C-106**
HW-52932	Sep-57	178	48	329	543	178	524
HW-53573	Oct-57	205	48	348	541	318	524
HW-54067	Nov-57	411	48	348	541	266	68
HW-54519	Dec-57	131	48	348	535	381	111
HW-54916	Jan-58	131	48	62	541	224	106
HW-55264	Feb-58	134	51	62	538	367	106
HW-55630	Mar-58	150	51	62	538	475	106
HW-55997	Apr-58	125	37	62	535	541	123
HW-56357	May-58	125	37	62	535	541	197
HW-56761	Jun-58	125	37	62	535	541	232
HW-57122	Jul-58	125	37	62	541	541	343
HW-57550	Aug-58	125	37	46	557	541	392
HW-57711	Sep-58	125	37	46	541	541	519
HW-58201	Oct-58	125	37	46	541	191	521
HW-58579	Nov-58	125	37	46	541	332	535
HW-58831	Dec-58	125	37	46	541	461	535
HW-59204	Jan-59	125	37	46	541	381	535
HW-59586	Feb-59	125	37	46	541	137	535
HW-60065	Mar-59	128	37	45	524	271	510
HW-60419	Apr-59	128	37	62	519	353	510
HW-60738	May-59	128	37	48	524	425	510
HW-61095	Jun-59	128	37	48	517	142	510
HW-61582	Jul-59	128	37	48	524	207	510
HW-61952	Aug-59	128	37	48	524	362	510
HW-62421	Sep-59	131	34	45	524	309	510
HW-62723	Oct-59	131	34	45	524	199	510
HW-63083	Nov-59	131	34	45	524	309	510
HW-63559	Dec-59	131	34	45	524	431	510
HW-63896	Jan-60	131	34	45	524	276	510
HW-64373	Feb-60	131	34	45	524	362	510
HW-64810	Mar-60	131	34	45	538	461	510
Hw-65272	Apr-60	131	34	144	538	527	527
HW-65643	May-60	131	34	243	538	529	527
HW-66187	Jun-60	131	34	309	538	529	527
HW-66557	Jul-60	131	62	395	538	529	527

Table 6-2 Waste Volume Stored in 241-C Farm Single-Shell Tanks April 1952 through December 1980 (Kgal)							
Reference	**Tank**	**C-101**	**C-102**	**C-103**	**C-104**	**C-105**	**C-106**
HW-66827	Aug-60	131	250	408	538	529	527
HW-67696	Sep-60	131	378	416	538	529	527
HW-67705	Oct-60	131	378	416	538	529	527
HW-68291	Nov-60	141	518	424	538	529	527
HW-68292	Dec-60	150	491	524	538	529	527
HW-71610	Jun-61	510	521	557	538	521	527
HW-72625	Dec-61	510	519	563	541	521	527
HW-74647	Jun-62	524	356	227	538	519	527
HW-76223	Dec-62	524	370	57	538	519	527
HW-78279	Jun-63	524	334	530	543	125	530
HW-80379	Dec-63	370	450	469	541	532	538
HW-83308	Jun-64	542	407	442	539	522	522
RL-SEP-260	Dec-64	546	442	420	539	516	505
RL-SEP-659	Jun-65	574	326	458	554	491	541
RL-SEP-821	Sep-65	568	447	455	560	491	546
RL-SEP-923	Dec-65	565	461	222	560	483	549
ISO-226	Mar-66	563	472	527	560	475	549
ISO-404	Jun-66	571	472	497	532	450	519
ISO-538	Sep-66	565	464	494	532	450	519
ISO-674	Dec-66	563	453	475	532	442	527
ISO-806	Mar-67	557	499	450	532	439	527
ISO-967	Jun-67	555	486	439	532	435	527
ARH-95	Sep-67	555	486	433	532	431	527
ARH-326	Dec-67	549	444	433	532	359	527
ARH-534	Mar-68	545	476	436	531	542	66
ARH-721	Jun-68	545	466	435	531	392	72
ARH-871	Sep-68	545	455	433	530	444	70
ARH-1061	Dec-68	541	457	431	530	384	70
ARH-1200A	Mar-69	541	462	431	530	378	124
ARH-1200B	Jun-69	538	458	429	200	490	244
ARH1200C	Sep-69	538	501	103	200	366	293
ARH1-1200D	Dec-69	132	486	103	246	450	167
ARH-1666A	Mar-70	134	486	491	347	348	222
ARH-1666B	Jun-70	134	486	109	296	198	379
ARH-1666C	Sep-70	136	486	180	480	497	517

Table 6-2 Waste Volume Stored in 241-C Farm Single-Shell Tanks April 1952 through December 1980 (Kgal)							
Reference	**Tank**	**C-101**	**C-102**	**C-103**	**C-104**	**C-105**	**C-106**
ARH-1666D	Dec-70	138	486	279	453	447	530
ARH-2074A	Mar-71	131	480	92	481	211	212
ARH-2074B	Jun-71	131	480	92	507	211	212
ARH-2074C	Sep-71	128	480	90	466	216	239
ARH-2074D	Dec-71	127	479	102	437	253	235
ARH-2456A	Mar-72	125	475	102	351	510	233
ARH-2456B	Jun-72	125	477	102	366	400	235
ARH-2456C	Sep-72	124	474	539	384	471	244
ARH-2456D	Dec-72	120	475	92	334	411	248
ARH-2794A	Mar-73	121	484	94	517	326	255
ARH-2794B	Jun-73	120	483	239	332	227	249
ARH-2794C	Sep-73	120	465	390	483	239	241
ARH-2794D	Dec-73	131	466	392	436	234	238
ARH-CD-133A	Mar-74	129	467	508	439	447	237
ARH-CD-133B	Jun-74	128	467	343	337	442	250
ARH-CD-133C	Sep-74	81	467	107	340	231	324
ARH-CD-133D	Dec-74	92	466	224	351	279	420
ARH-CD-336A	Mar-75	92	466	516	296	224	373
ARH-CD-336B	Jun-75	92	466	164	417	233	345
ARH-CD-336C	Sep-75	92	466	109	299	235	469
ARH-CD-336D	Dec-75	92	431	106	513	483	288
ARH-CD-702A	Mar-76	92	431	274	362	381	329
ARH-CD-702B	Jun-76	73	431	288	505	222	499
ARH-CD-702I	Sep-76	73	431	321	420	367	422
ARH-CD-822-OCT	Oct-76	73	431	334	483	332	321
ARH-CD-822-NOV	Nov-76	73	431	343	488	329	439
ARH-CD-822-DEC	Dec-76	73	431	345	373	299	233
ARH-CD-822-JAN	Jan-77	73	431	348	376	252	373
ARH-CD-822-Feb	Feb-77	73	431	351	499	224	392
ARH-CD-822-MAR	Mar-77	73	431	384	406	224	373
ARH-CD-822-APR	Apr-77	73	431	216	312	224	343
ARH-CD-822-MAY	May-77	73	431	183	359	224	453
RHO-CD-14-JUN	Jun-77	73	431	387	453	224	480
RHO-CD-14-JUL	Jul-77	73	431	268	497	222	469
RHO-CD-14-AUG	Aug-77	73	431	233	315	224	277

Table 6-2 Waste Volume Stored in 241-C Farm Single-Shell Tanks April 1952 through December 1980 (Kgal)							
Reference	**Tank**	**C-101**	**C-102**	**C-103**	**C-104**	**C-105**	**C-106**
RHO-CD-14-SEP	Sep-77	73	431	274	334	224	398
RHO-CD-14-OCT	Oct-77	73	431	387	466	288	398
RHO-CD-14-NOV	Nov-77	73	431	268	301	447	249
RHO-CD-14-DEC	Dec-77	73	431	422	340	447	384
RHO-CD-14-JAN	Jan-78	73	431	450	326	343	312
RHO-CD-14-FEB	Feb-78	73	431	285	321	442	475
RHO-CD-14-MAR	Mar-78	73	431	235	409	343	255
RHO-CD-14-APR	Apr-78	73	431	241	464	425	373
RHO-CD-14-MAY	May-78	Report not located.					
RHO-CD-14-JUN	Jun-78	73	431	260	329	310	356
RHO-CD-14-JUL	Jul-78	73	431	274	347	233	414
RHO-CD-14-August 1978	Aug-78	73	431	279	378	233	417
RHO-CD-14-September 1978	Sep-78	73	431	288	378	227	444
RHO-CD-14-October 1978	Oct-78	73	431	290	455	227	433
RHO-CD-14-November 1978	Nov-78	73	431	293	458	227	428
RHO-CD-14-December 1978	Dec-78	73	431	296	464	343	422
RHO-CD-14-January 1979	Jan-79	73	431	296	477	224	422
RHO-CD-14-February 1979	Jan-79	73	431	299	499	224	414
RHO-CD-14-March 1979	Mar-79	73	431	301	315	224	202
RHO-CD-14-April 1979	Apr-79	73	431	307	315	224	222
RHO-CD-14-May 1979	May-79	73	431	307	329	224	219
RHO-CD-14-June 1979	Jun-79	73	431	307	345	172	219
RHO-CD-14-July 1979	Jul-79	73	431	200	464	172	219
RHO-CD-14-August 1979	Aug-79	73	431	200	464	172	219
RHO-CD-14-September 1979	Sep-79	73	431	200	365	172	219
RHO-CD-14-October 1979	Oct-79	73	431	200	400	172	219
RHO-CD-14-November 1979	Nov-79	73	431	200	417	172	219
RHO-CD-14-December 1979	Dec-79	73	431	200	450	172	219
WHC-MR-0132	Mar-80	73	431	200	315	172	219
WHC-MR-0132	Jun-80	73	431	200	315	172	219
WHC-MR-0132	Sep-80	73	431	200	315	172	219
WHC-MR-0132	Dec-80	73	431	200	315	172	219

Table 6-2 Waste Volume Stored in 241-C Farm Single-Shell Tanks April 1952 through December 1980 (Kgal)											
Reference	**Tank**	**C-107**	**C-108**	**C-109**	**C-110**	**C-111**	**C-112**	**C-201**	**C-202**	**C-203**	**C-204**
HW-27838	Apr-52	399	34	525	530	530	525	54.5	54.5	54.5	52.5
	May-52	399	34	525	530	530	99	54.5	54.5	54.5	52.5
	Jun-52	399	34	311	530	530	99	54.5	54.5	54.5	54.5
HW-27839	Jul-52	399	34	17	231	237	140	54.5	54.5	54.5	54.5
	Aug-52	399	34	10	231	36	17	54.5	54.5	54.5	54.5
	Sep-52	399	34	10	231	36	17	54.5	54.5	54.5	54.5
HW-27840	Oct-52	399	34	10	231	36	17	52.5	54.5	54.5	54.5
	Nov-52	399	34	496	490	139	17	52.5	54.5	54.5	54.5
	Dec-52	547	85	496	490	139	17	52.5	54.5	54.5	54.5
HW-27841	Jan-53	518	473	10	538	536	230	52.5	54.5	54.5	54.5
HW-27842	Feb-53	518	473	10	538	536	230	52.5	54.5	54.5	54.5
HW-27775	Mar-53	518	527	182	538	536	249	52.5	54.5	54.5	54.5
HW-28043	Apr-53	509	527	521	538	536	517	54.5	8	54.5	54.5
HW-28377	May-53	519	530	521	538	536	517	54.5	8	54.5	54.5
HW-28712	Jun-53	519	530	521	538	536	517	54.5	8	54.5	54.5
HW-29054	Jul-53	530	530	521	538	536	517	54.5	8	54.5	54.5
HW-29242	Aug-53	530	530	521	538	536	517	54.5	8	54.5	54.5
HW-29624	Sep-53	530	530	521	538	536	178	54.5	8	54.5	54.5
HW-29905	Oct-53	530	530	521	538	536	178	54.5	8	54.5	54.5
HW-30250	Nov-53	530	530	521	538	536	145	54.5	8	54.5	54.5
HW-30498	Dec-53	530	530	521	538	536	145	15.7	43.7	14.8	15.2
HW-30851	Jan-54	530	530	521	538	536	145	15.7	0	0	39.2
HW-31126	Feb-54	530	530	521	538	536	145	10	0	0	51
HW-31374	Mar-54	530	530	521	538	536	145	0	0	0	51
HW-31811	Apr-54	530	530	521	538	536	178	0	0	0	51
HW-32110	May-54	530	530	521	538	536	178	0	0	0	51
HW-32389	Jun-54	530	530	521	538	536	178	0	0	0	51
HW-32697	Jul-54	530	530	521	538	536	433	0	0	0	51
HW-33002	Aug-54	530	530	521	538	536	433	0	0	0	51
HW-33396	Sep-54	530	530	521	538	536	466	0	0	0	51

Table 6-2 Waste Volume Stored in 241-C Farm Single-Shell Tanks April 1952 through December 1980 (Kgal)											
Reference	**Tank**	**C-107**	**C-108**	**C-109**	**C-110**	**C-111**	**C-112**	**C-201**	**C-202**	**C-203**	**C-204**
HW-33544	Oct-54	530	530	521	538	536	466	0	0	0	51
HW-33904	Nov-54	530	530	521	538	536	466	0	0	0	47
HW-34412	Dec-54	530	530	521	538	536	466	0	0	0	47
HW-35022	Jan-55	530	530	521	538	536	466	0	0	0	0
HW-35628	Feb-55	530	530	521	538	536	466	0	0	0	0
HW-36001	Mar-55	530	530	521	538	536	466	0	0	0	0
HW-36553	Apr-55	530	530	521	538	536	466	0	0	0	0
HW-37143	May-55	530	530	521	538	536	466	2	0	0	0
HW-38000	Jun-55	530	530	521	538	536	466	13	0	0	0
HW-38401	Jul-55	530	530	521	538	536	466	24.5	0	0	0
HW-38926	Aug-55	530	530	521	538	536	466	25	0	0	0
HW-39216	Sep-55	530	530	521	538	536	466	30	0	0	0
HW-39850	Oct-55	530	530	521	538	536	46	43	0	0	0
HW-40208	Nov-55	530	530	474	538	536	46	54.5	5.5	51.5	45.5
HW-40816	Dec-55	530	530	204	538	536	524	57	6	5	5
HW-41038	Jan-56	530	530	109	538	53	530	57	9	5	5
HW-41812	Feb-56	530	123	530	265	383	530	54.5	23.5	5	5
HW-42394	Mar-56	530	80	530	265	530	340	54.5	23.5	5	5
HW-42993	Apr-56	530	530	530	265	530	530	54.5	42.5	5	5
HW-43490	May-56	530	530	530	265	530	530	54.5	54.5	5	34
HW-43895	Jun-56	530	530	530	436	530	530	54.5	54.5	5	34
HW-44860	Jul-56	530	530	530	483	530	456	54.5	54.5	5	34
HW-45140	Aug-56	530	270	530	507	56	127	54.5	54.5	20	34
HW-45738	Sep-56	530	115	530	491	56	417	54.5	54.5	22	34
HW-46382	Oct-56	375	78	241	491	64	39	54.5	54.5	39.5	9.5
HW-47052	Nov-56	375	78	241	491	64	39	54.5	54.5	34.5	34
HW-47640	Dec-56	375	78	241	491	70	39	54.5	54.5	34.5	34.5
HW-48144	Jan-57	383	78	239	484	116	138	54	56	36	34
HW-48846	Feb-57	378	78	239	510	213	138	54	56	36	34
HW-49523	Mar-57	376	78	238	513	332	156	54	56	36	54
HW-50127	Apr-57	381	78	541	508	532	329	54	55	35	33

Table 6-2 Waste Volume Stored in 241-C Farm Single-Shell Tanks
April 1952 through December 1980 (Kgal)

Reference	Tank	C-107	C-108	C-109	C-110	C-111	C-112	C-201	C-202	C-203	C-204
HW-50617	May-57	381	78	202	508	550	537	54	55	35	33
HW-51348	Jun-57	381	78	79	508	521	54	54	56	35	33
HW-51858	Jul-57	403	79	312	510	409	532	55	56	35	32
HW-52414	Aug-57	384	414	541	510	340	381	55	56	35	32
HW-52932	Sep-57	392	532	340	510	549	541	55	56	35	32
HW-53573	Oct-57	392	530	348	510	230	521	55	56	35	32
HW-54067	Nov-57	392	516	543	510	444	189	55	56	35	32
HW-54519	Dec-57	411	472	543	510	98	516	55	56	35	32
HW-54916	Jan-58	428	175	112	510	98	84	55	56	35	32
HW-55264	Feb-58	425	175	112	508	101	84	55	56	36	34
HW-55630	Mar-58	425	175	112	508	101	84	55	56	36	34
HW-55997	Apr-58	425	175	112	508	101	84	55	56	36	34
HW-56357	May-58	425	175	112	508	101	84	55	56	36	34
HW-56761	Jun-58	425	175	112	508	101	84	55	56	36	34
HW-57122	Jul-58	425	175	112	508	101	84	55	56	36	34
HW-57550	Aug-58	425	175	112	508	101	84	55	56	36	34
HW-57711	Sep-58	422	175	112	508	101	84	55	56	36	34
HW-58201	Oct-58	425	175	112	508	101	84	55	56	36	34
HW-58579	Nov-58	425	175	112	508	153	106	55	55	36	34
HW-58831	Dec-58	425	175	112	508	88	134	55	55	35	34
HW-59204	Jan-59	425	175	112	508	88	134	55	55	35	34
HW-59586	Feb-59	425	175	112	508	88	134	55	55	35	34
HW-60065	Mar-59	425	175	112	508	90	137	54	55	34	33
HW-60419	Apr-59	425	180	112	508	90	137	54	55	34	33
HW-60738	May-59	422	180	112	504	90	137	54	55	34	33
HW-61095	Jun-59	422	183	373	507	90	137	54	55	34	33
HW-61582	Jul-59	422	183	386	507	90	137	54	55	34	33
HW-61952	Aug-59	422	183	386	507	97	137	54	55	34	33
HW-62421	Sep-59	422	188	540	507	111	84	54	55	34	33
HW-62723	Oct-59	422	188	540	507	298	136	55	55	34	36
HW-63083	Nov-59	422	188	540	507	298	136	55	55	34	36

Table 6-2 Waste Volume Stored in 241-C Farm Single-Shell Tanks
April 1952 through December 1980 (Kgal)

Reference	Tank	C-107	C-108	C-109	C-110	C-111	C-112	C-201	C-202	C-203	C-204
HW-63559	Dec-59	422	188	540	507	298	136	55	55	34	36
HW-63896	Jan-60	422	494	540	507	298	137	55	55	34	36
HW-64373	Feb-60	422	494	540	507	298	137	55	55	34	36
HW-64810	Mar-60	422	494	540	507	337	137	55	55	34	36
Hw-65272	Apr-60	422	494	540	507	337	137	55	55	34	36
HW-65643	May-60	422	494	540	507	337	137	55	55	34	36
HW-66187	Jun-60	422	494	540	507	337	137	55	55	34	36
HW-66557	Jul-60	422	494	540	507	337	137	55	55	34	36
HW-66827	Aug-60	422	500	540	507	337	137	55	55	34	36
HW-67696	Sep-60	422	500	540	507	337	263	55	55	34	36
HW-67705	Oct-60	422	500	540	507	337	359	55	55	34	36
HW-68291	Nov-60	422	243	546	510	342	400	55	55	34	36
HW-68292	Dec-60	422	166	546	455	309	367	55	55	34	36
HW-71610	Jun-61	439	486	549	505	345	455	56	56	34	37
HW-72625	Dec-61	483	486	549	510	345	486	56	56	34	37
HW-74647	Jun-62	384	486	433	510	345	508	56	56	34	37
HW-76223	Dec-62	384	486	491	508	370	505	56	56	34	37
HW-78279	Jun-63	384	483	494	505	431	510	56	56	34	37
HW-80379	Dec-63	381	486	494	505	472	513	54	57	35	36
HW-83308	Jun-64	381	426	532	505	539	547	54	55	35	36
RL-SEP-260	Dec-64	383	426	535	513	539	547	54	55	35	36
RL-SEP-659	Jun-65	395	532	554	508	519	538	54	55	33	36
RL-SEP-821	Sep-65	425	532	554	508	520	538	54	55	33	36
RL-SEP-923	Dec-65	466	532	554	508	516	538	52	55	33	36
ISO-226	Mar-66	527	532	552	505	503	538	52	55	33	36
ISO-404	Jun-66	464	521	565	508	510	535	52	55	33	36
ISO-538	Sep-66	486	521	565	508	510	535	52	55	33	36
ISO-674	Dec-66	527	521	552	508	508	535	52	55	33	36
ISO-806	Mar-67	530	521	552	508	508	535	55	55	34	36
ISO-967	Jun-67	528	521	552	508	503	535	55	55	34	36
ARH-95	Sep-67	528	521	552	508	503	535	55	55	34	36

Table 6-2 Waste Volume Stored in 241-C Farm Single-Shell Tanks April 1952 through December 1980 (Kgal)

Reference	Tank	C-107	C-108	C-109	C-110	C-111	C-112	C-201	C-202	C-203	C-204
ARH-326	Dec-67	534	517	549	435	502	535	55	55	34	57
ARH-534	Mar-68	531	516	554	435	499	534	55	55	34	57
ARH-721	Jun-68	531	516	543	435	499	534	55	55	34	57
ARH-871	Sep-68	531	516	543	435	499	534	55	55	34	57
ARH-1061	Dec-68	528	514	543	435	499	534	55	55	34	57
ARH-1200A	Mar-69	528	514	543	435	498	534	55	55	34	57
ARH-1200B	Jun-69	525	514	543	220	497	532	55	55	34	57
ARH1200C	Sep-69	524	513	543	224	497	532	55	55	34	57
ARH1-1200D	Dec-69	301	138	543	224	147	532	55	55	34	57
ARH-1666A	Mar-70	303	138	165	375	147	213	55	55	18	57
ARH-1666B	Jun-70	304	532	541	470	146	541	1	0	6	43
ARH-1666C	Sep-70	547	532	543	536	150	543	1	0	6	42
ARH-1666D	Dec-70	547	532	543	536	151	543	1	0	6	42
ARH-2074A	Mar-71	546	532	542	536	151	543	1	0	6	42
ARH-2074B	Jun-71	546	532	542	536	151	543	1	0	6	42
ARH-2074C	Sep-71	546	532	542	536	151	543	1	0	6	42
ARH-2074D	Dec-71	541	532	542	211	151	543	1	0	6	42
ARH-2456A	Mar-72	288	334	540	376	150	542	1	0	6	42
ARH-2456B	Jun-72	289	266	540	376	172	543	1	0	6	42
ARH-2456C	Sep-72	289	266	540	376	174	543	1	0	6	42
ARH-2456D	Dec-72	260	271	530	376	172	532	1	0	6	42
ARH-2794A	Mar-73	260	270	529	376	172	532	1	0	6	42
ARH-2794B	Jun-73	261	270	529	376	172	531	1	0	6	42
ARH-2794C	Sep-73	299	516	505	376	172	531	1	0	6	42
ARH-2794D	Dec-73	513	516	504	376	171	531	3	1	7	44
ARH-CD-133A	Mar-74	514	515	504	376	171	530	3	1	7	44
ARH-CD-133B	Jun-74	514	515	504	376	114	530	3	2	8	44
ARH-CD-133C	Sep-74	515	516	504	376	115	530	3	2	8	44
ARH-CD-133D	Dec-74	513	516	505	376	114	532	3	2	7	44
ARH-CD-336A	Mar-75	450	516	505	376	114	483	4	2	7	44
ARH-CD-336B	Jun-75	450	516	505	376	114	483	4	2	8	44

Table 6-2 Waste Volume Stored in 241-C Farm Single-Shell Tanks April 1952 through December 1980 (Kgal)											
Reference	**Tank**	**C-107**	**C-108**	**C-109**	**C-110**	**C-111**	**C-112**	**C-201**	**C-202**	**C-203**	**C-204**
ARH-CD-336C	Sep-75	255	516	142	268	114	194	4	2	8	44
ARH-CD-336D	Dec-75	255	87	62	268	114	109	4	2	8	44
ARH-CD-702A	Mar-76	257	76	62	233	73	109	4	2	8	44
ARH-CD-702B	Jun-76	257	76	62	211	62	109	4	2	8	44
ARH-CD-702I	Sep-76	257	65	62	211	62	109	4	2	8	44
ARH-CD-822-OCT	Oct-76	257	65	62	211	62	109	4	2	8	44
ARH-CD-822-NOV	Nov-76	257	65	62	211	62	109	4	2	8	44
ARH-CD-822-DEC	Dec-76	257	65	62	211	62	109	4	2	8	44
ARH-CD-822-JAN	Jan-77	257	65	62	211	62	109	4	2	8	44
ARH-CD-822-Feb	Feb-77	257	65	62	211	62	109	4	2	8	44
ARH-CD-822-MAR	Mar-77	257	65	62	211	62	109	4	2	8	44
ARH-CD-822-APR	Apr-77	252	65	62	211	62	109	4	2	8	44
ARH-CD-822-MAY	May-77	252	65	62	211	62	109	4	2	8	44
RHO-CD-14-JUN	Jun-77	249	65	62	211	62	109	4	2	8	44
RHO-CD-14-JUL	Jul-77	249	65	62	211	62	109	4	2	8	3
RHO-CD-14-AUG	Aug-77	332	65	62	211	62	109	4	2	8	3
RHO-CD-14-SEP	Sep-77	450	65	62	211	62	109	4	2	8	3
RHO-CD-14-OCT	Oct-77	279	65	62	211	62	109	4	2	8	3
RHO-CD-14-NOV	Nov-77	337	65	62	211	62	109	4	2	8	3
RHO-CD-14-DEC	Dec-77	367	65	62	211	62	109	4	2	8	3
RHO-CD-14-JAN	Jan-78	464	65	62	211	62	109	4	2	8	3
RHO-CD-14-FEB	Feb-78	340	65	62	211	62	109	4	2	8	3
RHO-CD-14-MAR	Mar-78	340	65	62	211	62	109	4	2	8	3
RHO-CD-14-APR	Apr-78	340	65	62	211	62	109	4	2	8	3
RHO-CD-14-MAY	May-78	Report not located									
RHO-CD-14-JUN	Jun-78	340	65	62	211	62	109	4	2	8	3
RHO-CD-14-JUL	Jul-78	340	65	62	211	62	109	4	2	8	3
RHO-CD-14-August 1978	Aug-78	337	65	62	211	62	109	4	2	8	3
RHO-CD-14-September 1978	Sep-78	337	65	62	211	62	109	4	2	8	3
RHO-CD-14-October 1978	Oct-78	337	65	62	211	62	109	4	2	8	3
RHO-CD-14-November 1978	Nov-78	337	65	62	211	62	109	4	2	8	3

Table 6-2 Waste Volume Stored in 241-C Farm Single-Shell Tanks April 1952 through December 1980 (Kgal)

Reference	Tank	C-107	C-108	C-109	C-110	C-111	C-112	C-201	C-202	C-203	C-204
RHO-CD-14-December 1978	Dec-78	337	65	62	211	62	109	4	2	8	3
RHO-CD-14-January 1979	Jan-79	337	65	68	213	62	109	4	2	8	3
RHO-CD-14-February 1979	Jan-79	337	65	68	213	62	109	4	2	8	3
RHO-CD-14-March 1979	Mar-79	337	65	68	213	62	109	4	2	8	3
RHO-CD-14-April 1979	Apr-79	337	65	68	213	62	109	4	2	8	3
RHO-CD-14-May 1979	May-79	337	65	68	213	62	109	4	2	8	3
RHO-CD-14-June 1979	Jun-79	337	65	68	213	62	109	4	2	8	3
RHO-CD-14-July 1979	Jul-79	337	65	68	213	62	109	4	2	8	3
RHO-CD-14-August 1979	Aug-79	337	65	68	213	62	109	4	2	8	3
RHO-CD-14-September 1979	Sep-79	337	65	68	213	62	109	4	2	8	3
RHO-CD-14-October 1979	Oct-79	337	65	68	213	62	109	4	2	8	3
RHO-CD-14-November 1979	Nov-79	337	65	68	213	62	109	4	2	8	3
RHO-CD-14-December 1979	Dec-79	337	65	68	213	62	109	4	2	8	3
WHC-MR-0132	Mar-80	337	65	68	213	62	109	4	2	8	3
WHC-MR-0132	Jun-80	337	65	68	213	62	109	4	2	8	3
WHC-MR-0132	Sep-80	337	65	68	213	62	109	4	3	9	3
WHC-MR-0132	Dec-80	337	65	68	213	62	109	4	1	9	3

Table 6-3. Potential Waste Losses Through Spare Inlets on WMA C SSTs

Tank	Date	Waste Type Present in Tank
C-101	June 1965 – December 1967	Received waste from CR Vault. Tank contains CR Vault waste (28kgal), PUREX P2 (452kgal), and Coating Waste (CWP2) (94kgal).
C-103	October 1953 – March 1957	Tributyl Phosphate Plant (TBP) Waste
	June 1961 – December 1961	PUREX CWP2
C-104	August 1958	PUREX CWP1
	June 1965 – March 1966	After receiving 15,000 gallons of unknown waste type (likely PUREX CWP2 based on RL-SEP-332, page B-2) from 244-CR Vault, the tank was filled above the spare inlets. Majority of waste in tank is PUREX CWP2
C-105	Pre-October 1967	Waste type unknown; soil contamination found beneath spare inlet nozzles during excavation in October 1967
C-106	November 1951	Water added to metal waste (MW2)
C-106	December 1965 – March 1966	PUREX P2 HLW supernate
C-109	June 1961 – December 1961	PUREX CWP2
	June 1965 – March 1968	Tank received 19,000 gallons from 201-C Sr Semiworks (HS). Tank contains 112,000 gallons of evaporator bottoms (BT-SltCk), 300,000 gallons of PUREX CWP2, and 142,000 gallons of Sr Semiworks waste (HS).
C-111	May 1957	TBP Waste
	September 1957	Scavenged 242-B BT-SltCk waste (i.e. concentrated 1C/CW and TBP wastes)
C-201	December 1955 – January 1956 June 1961 – June 1963	201-C Hot Semiworks waste from PUREX flowsheet tests (Note: this is not waste type HS).
C-202	January 1957 – March 1957 June 1957 – October 1958 June 1961 – December 1963	201-C Hot Semiworks waste from PUREX flowsheet tests (Note: this is not waste type HS). Last waste transferred into tank was 201-C building flush solutions.
C-204	March 1968 – March 1970	201-C Hot Semiworks waste from PUREX flowsheet tests (Note: this is not waste type HS) and 201-C building flush solutions.

6.3 Suspect Pipeline Waste Loss Events

Several pipelines in the WMA C are known to have failed while transferring tank wastes. Table 6-4 identifies eleven pipelines in WMA C that are known or suspected to have failed. The date the failure was detected, the waste type and the volume of waste that was leaked to the soil (if known) are listed in Table 6-4. Unplanned releases (UPRs) have been identified for some of the failed pipelines listed in Table 6-4. In some cases, the failed pipeline was contained within a concrete diversion box, vault, or pipeline encasement. The surfaces of these concrete structures were coated with a chemically resistant paint. However, the integrity of the coatings and concrete structures are unknown. It is not known whether waste leaked from these concrete structures.

Seven potential tank waste loss events not previously reported in DOE/RL-88-30, revision 16 are identified in Table 6-4. These potential waste loss events resulted from:

- Failure of pipeline V172 (June 1964),
- Possible failure of un-number pipeline from 241-C-801 Cesium Loadout facility to tank 241-C-103 (November 1964)
- PUREX coating waste transfer pipeline failure in diversion box 241-CR-151 (February 1965); pipeline number was not provided in reference and could not be determined from available information,
- Failure of pipeline 8041 (March 1965),
- Failure of a flexible jumper in diversion box 241-CR-152 (May 1966),
- Failure of pipeline V103 (pre-1988),
- Failure of pipeline V112 (date unknown)

A *Field Investigation Report for Waste Management Areas C and A-AX* (RPP-35484) was completed in 2007 and investigated unplanned waste releases from single-shell tank (SST) 241-C-105, UPR-200-E-86 (pipeline V108/V812 failure) and UPR-200-E-81 (unnamed pipeline failure). The reader is directed to this field investigation report for additional information on these three UPRs.

Table 6-4. Failed Pipelines in WMA C

Date	Waste Type [1]	Waste Discharged (Gallons)	Event Description	References [2]
6-1964	HS - 201C Strontium Semiworks Waste	No estimate	"The underground process line from the 252-C diversion box to 112 tank, C Tank farm, failed. The failed pipeline was isolated. Jumpers were fabricated and installed to establish a new process route." The failed **pipeline is line V172**.	RPP-RPT-29191, page 115
11-1964	Cesium Depleted PUREX HLW Supernate (P1)	No estimate	Installation was completed on an alternative effluent return route from the 801-C Cesium Loadout Building to Tank 103-C. See drawing H-2-4574, *Process & Service Piping Tanks to Loadout Station* for details of this piping. A three-way ball valve was inserted in the 801-C effluent return line to SST C-102 to enable routing waste to SST C-103 or C-102.	RPP-RPT-29191, page 115
2-1965	PUREX CWP2	No estimate	"On February 18, 1965 the 244-CR Vault was found flooded up to approximately the level of the tank tops. Immediate steps were taken to reduce the liquid level by jetting the solution to the 011 Tank. Partial cause of the flooding is attributed to a **failure in the coating waste line which enters the 151-CR diversion box.** Drainage from this diversion box collects in the 002-CR vault sump. Water from a sampler flush line and drainage from rain and snow contributed to the liquid level in the vault. To date, the 001, 002, and 003 sumps have been emptied, and the 011 sump is being emptied, to the 011 Tank. This liquid is being pumped from the 011 Tank to Tank 103-A in the 241-A Tank Farm. In trying to establish a coating waste routing from the Purex Plant to the 241-C Tank Farm a leak was also discovered in the underground line adjacent to the 152-A Diversion Box. Because of the two apparent leaks in this line it has been abandoned as being unusable."	RPP-RPT-29191, page 116
3-1965	PUREX CWP2	No estimate	"A liquid level rise in Tank 103-C, the cesium feed tank, was apparently caused by a failed line in the encasement between the 152-CR diversion box and Tank 102-C which permitted coating waste from the Purex Plant to leak into the encasement and drain to Tanks 101-C, 102-C, and 103-C via the tank pump pits. Coating waste has been routed through a spare line to Tank 102-C and no further leaks have been detected. The coating waste solution accumulated in Tank 103-C did not significantly affect cesium loading capability as a cask was loaded normally following the incident."	RPP-RPT-29191, page 116

Table 6-4. Failed Pipelines in WMA C				
Date	**Waste Type** [(1)]	**Waste Discharged (Gallons)**	**Event Description**	**References** [(2)]
			Note: **Pipeline 8041** inside a concrete encasement was used to route the PUREX CW to SST C-102 (see drawing H-2-44501, sheet 92). This encasement traverses from diversion box 241-CR-152 along the west side of SSTs C-101, C-102, and C-103. In order for the PUREX CW to drain into SSTs C-101, C-102, and C-103, the encasement containing the failed transfer pipeline must have partially filled with waste. The integrity of this encasement is unknown and may have leaked waste to the soil. Drawing H-2-2338, sheet 45 indicates pipeline 8041 is out of service. Pipeline 8041 connects from nozzle U-3 in the 241-CR-152 diversion box and nozzle U-2 in pit 02C atop SST C-102.	
5-1966	PUREX CWP2	No estimate	"A leak in the PUREX coating waste route (152-CR diversion box) was detected by an abnormal liquid level increase of the 002CR vault sump. The **leaking flexible jumper** in the 152CR diversion box was replaced." Note: Diversion box 241-CR-152 and 244-CR Vault sump are concrete structures with painted surfaces. It is uncertain whether leaked waste was contained inside diversion box 241-CR-152 and 244-CR Vault sump.	RPP-RPT-29191, page 118
Pre-1988	PUREX P2 supernate	No estimate	**Pipeline V-103** - "Earlier investigations of the extremely high levels of contamination found between Tanks 104-C and 105-C are described in reference (10). The following observations were documented at the time and were the bases for the conclusion that both tanks were sound: The fill line V-103 was stated to have been abandoned at an earlier date due to pipeline leakage, and the activity noted in DW 30-03-02 could have been due to migration of pre-existing contamination that was first seen in the exploratory scans. This line was part of the old PUREX supernate (PSN) transfer route from Tank 241-AX-101. The material was thermally hot, and water injection was required to maintain a temperature below 60^{o}C. The cause of failure was believed to have been due to thermal shock induced by the intermittent transfers. In-tank photographs failed to show any evidence that either tank was unsound.	Environmental Protection Deviation Report 87-10, page 4

Table 6-4. Failed Pipelines in WMA C

Date	Waste Type [1]	Waste Discharged (Gallons)	Event Description	References [2]
			However, the Tank 241-C-105 photos indicated that the tank had been filled to a level above that of the cascade and sidefill pipelines. The possibility of leakage through the wall penetration seals was discussed. The liquid levels in Tank 241-C-105 and -104 remained at a high level for almost six months after the first exploratory well scans, and the observed activities, including that in DW 30-03-02, had remained stable throughout, whereas seepage from either tank would normally have been seen as steadily increasing radiation at the 35 to 41 feet farm excavation depth. The activity at this depth however has diminished in all wells since 1974."	
Unknown	Unknown	No estimate	Line V112 is identified as a leaker adjacent to diversion box 241-C-151. The date and amount of waste leaker from this pipeline is unknown.	RPP-25113, page 7

Notes:
(1) Waste types are defined in RPP-26744, Hanford Soil Inventory Revision 1.
(2) The UPRs listed above have been combined with UPR-200-E-133, Contaminated Soil at C Farm per DOE/RL-88-30, revision 16, page 665.
(3) PSS - Supernate from washing sludges in tank farms or 244-AR Vault. This waste type is not defined in RPP-26744.

6.4 241-C-801 Contaminated Drywell

Waste discharged to the contaminated drywell associated with the 241-C-801 building is technically not an unplanned release. However, it is worth noting that this drywell is a potential source of contamination in the vicinity of WMA C.

The 241-C-801 building was used from 1961 through 1968 to load cesium and occasionally technetium onto casks containing ion exchange material (Letter 7G400-03-SMM). A cask would be staged in the 241-C-801 building and connected to waste transfer piping at a shielded enclosure within the 241-C-801 building. Tank waste (PUREX P1 and P2) was transferred from SST C-103 through underground piping to a valve pit located inside 241-C-801. The tank waste would then flow into the cask, the target radionuclide would be absorbed by the ion exchange material, and then waste would flow back to SST C-102. The cask loading area within the 241-C-801 building has a drain line connecting to the valve pit. The valve pit and cask loading area have separate drains lines connecting to a drywell located outside of the tank farm fence (drawings H-2-4573 and H-2-4554). This dry well is located approximately 23 meters (75 feet) north of the 241-C-801 building; outside the tank farm fence (DOE/RL-88-30, rev. 16, page 659).

No record was located that provides information on the volume and types of wastes potentially discharged to this drywell. An unknown amount of PUREX P1 and P2 waste types along with decontamination solutions <u>may</u> have been discharged to this drywell as a result of operations conducted at the 241-C-801 building.

6.5 Drywell Monitoring Data

Drywell monitoring information in C-Farm was reviewed to identify other areas of potential contamination. Log data are summarized in the Addendum to the C Tank Farm Report (GJO-HAN-18, September, 2000). Figure 6-2 provides a visualization of ^{60}Co contamination that appears to originate from two locations: the vicinity of tanks C-104/105 and tanks C-108/109. The contamination is depicted as migrating laterally and downward in the east northeasterly direction. SGE measurements (Figure 6-3) also indicate low resistivity plumes in the C-104/105 area and northwest of C-108.

^{60}Co is not a significant contaminant of concern (COC), but it acts as a useful tracer for contaminant movement in the vadose zone, since it can be readily detected through steel casing. ^{60}Co is relatively mobile in the subsurface and likely serves as a surrogate for COCs such as ^{99}Tc, which are impossible to detect in the vadose zone with logging methods in cased boreholes. The appearance and rising levels of ^{99}Tc in groundwater samples in the vicinity of C Farm is evidence of on-going migration from the vadose zone.

Figure 6-4 is a plan view of tanks and boreholes in C Farm. Two cross-sections are included as Figures 6-5 and 6-6 that show contamination as measured with spectral gamma logging and moisture data, where available, to determine possible relationships with boreholes in the down dip direction of the two potential sources.

Cross-section A-A' (Figure 6-5) shows significant ^{60}Co contamination in borehole 30-08-02 beginning at an elevation of approximately 600 ft (about 50 ft bgs). Contamination was first noted at this depth approximately 30 years ago. Changes in contaminant profile have occurred over the last thirty years in several pulses. The figure shows the change that occurred between 1997 and 2004; changes were last noted in the pre-retrieval monitoring for tank C-108. Borehole 30-06-10 also shows an influx of contamination since 1997 to the bottom of the borehole. It is likely the contamination continues to increase at depths below the bottom of the borehole. Additionally, pre-retrieval monitoring around tanks C-108 and C-109 indicate possible movement in boreholes 30-09-07 and 30-09-06. It is believed contamination in these boreholes is related and likely originated from the same source.

The contamination may have originated on the northwest side of tank C-108 where the low resistivity anomaly is located. It migrates downward in the vicinity of 30-08-02 to a fine-grained layer at approximately 570 ft in elevation. From there, it moves laterally to the east, following the dip to the vicinity of 30-06-10, where it is observed to be moving downward, below TD of the borehole at an elevation of 520 ft (130 ft bgs).

Figure 6-6 indicates the contaminant profile near tanks C-104 and -105 that appears to originate from the cascade line. The stratigraphic dip is interpreted using moisture data that typically increases in thin, fine grained, sediment layers. As in Figure 6-5, the dip appears to be east northeast and the ^{60}Co contamination is found at greater depths in this direction.

If a contaminant inventory is to be determined consistent with that of past leak assessments (i.e., based on ^{137}Cs concentrations) then it must be determined what the source may be (i.e., tank leak or cascade line leak). It appears from the log data the C-108/109 area may be the result of a tank and the C-104/105 area may be the result of a cascade line leak. Figure 6-7 shows a comparison of log data acquired from two boreholes which lie near the cascade lines from both areas. It is noted in borehole 30-04-03 that ^{60}Co appears at a depth where the cascade line is located and in 30-08-02 a direct connection cannot be made as there is no contamination exhibited in the depths between the cascade line and the ^{60}Co contamination. However, there is ^{137}Cs contamination at the cascade line elevation for both tanks. This evaluation should not be considered a definitive conclusion but may suggest the need for further investigation to define the sources in both areas and find the ^{137}Cs that likely lies near the origin of a leak.

Finally, Figure 6-8 is provided to indicate log data for a presumed cascade line leak in B Farm. It is included to show a cascade line leak can be significant in terms of leak volume and inventory. It is likely that drillers tended to avoid drilling close to cascade lines or tank walls. Thus, boreholes may not be close enough to the tank walls where it is presumed cascade lines would back up and perhaps spill. The distance of the boreholes from the tank and cascade line could cause a gross underestimation of the contaminant profile using the current log data. Additional investigation may be required to determine the proper designation and the volume and inventory of the tank waste in the vadose zone from these sources.

Figures 6-9, 6-10, and 6-11 provides a visualization of the general level of ^{137}Cs contamination present near surface in the 241-C Tank Farm. A rough calculation was made to estimate the magnitude of ^{137}Cs inventory present in the top 15-ft of soil present in the 241-C Tank Farm. The calculated ^{137}Cs inventory can then be used along with waste types in the Soil Inventory Model to estimate a range of waste volumes and COCs that may be present in the near surface soil.

The ^{137}Cs concentration is generally less than 100 pCi/gm in the top 15-ft of soil in 241-C Tank Farm. The area encompassed by the tanks in the farm is approximately 440-ft (10-ft north of tank C-201 and 50-ft south of tank C-101) by 560-ft (fence to fence distance). The volume of soil at a depth of 15-ft in this area is approximately 3,696,000-ft^3, ignoring the in volume of the in-ground structures such as encasements, pipelines, etc. Assuming the soil density is approximately 1.7 MT/m^3, the mass of soil is approximately 177,900 MT (3,696,000-ft^3 * 0.028317 m^3/ ft^3 * 1.7 MT/m). Using a ^{137}Cs concentration of 100 pCi/gm, the ^{137}Cs inventory is approximately 17.8 Ci (100 pCi/gm * 1E-12 Ci/pCi * 177,900 MT *1E+6 gm/MT) in the top 15-ft of soil in the 241-C Tank Farm.

Figure 6-2 Visualization of ^{60}Co Contamination in 241-C Farm

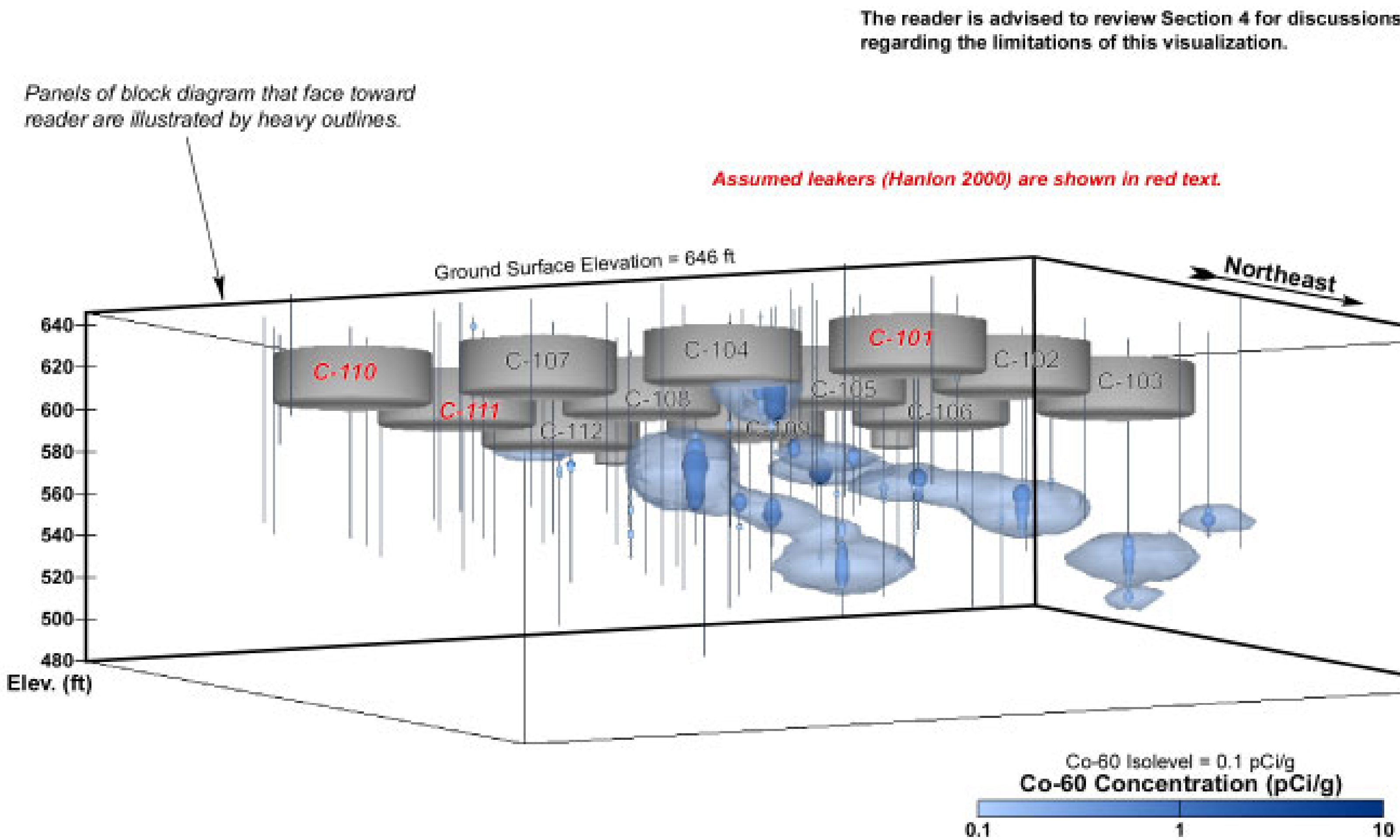


Figure D-18. C Tank Farm Visualization

Figure 6-3 C Farm SGE Measurements

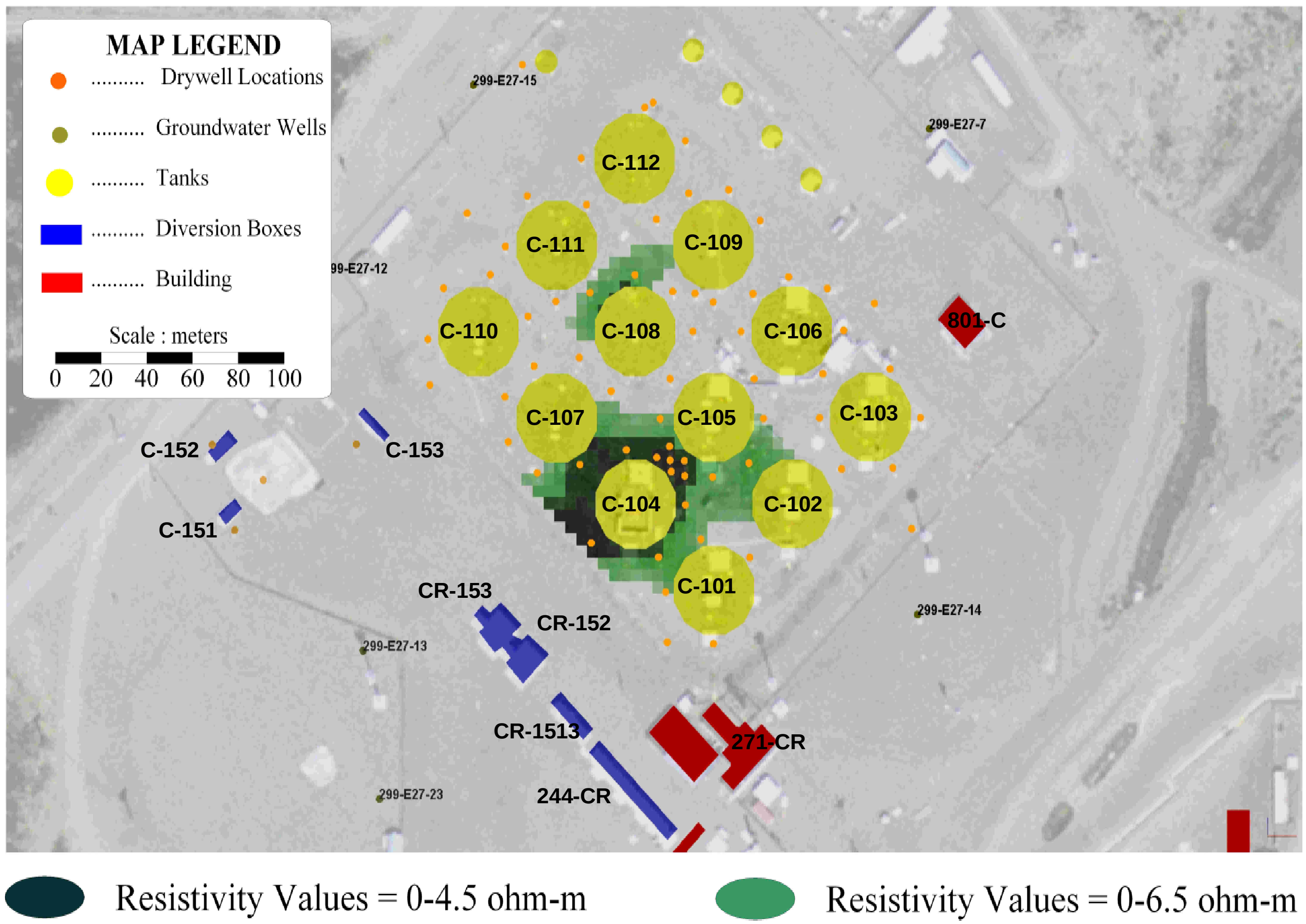


Figure 6-4 Drywells Located in 241-C Farm

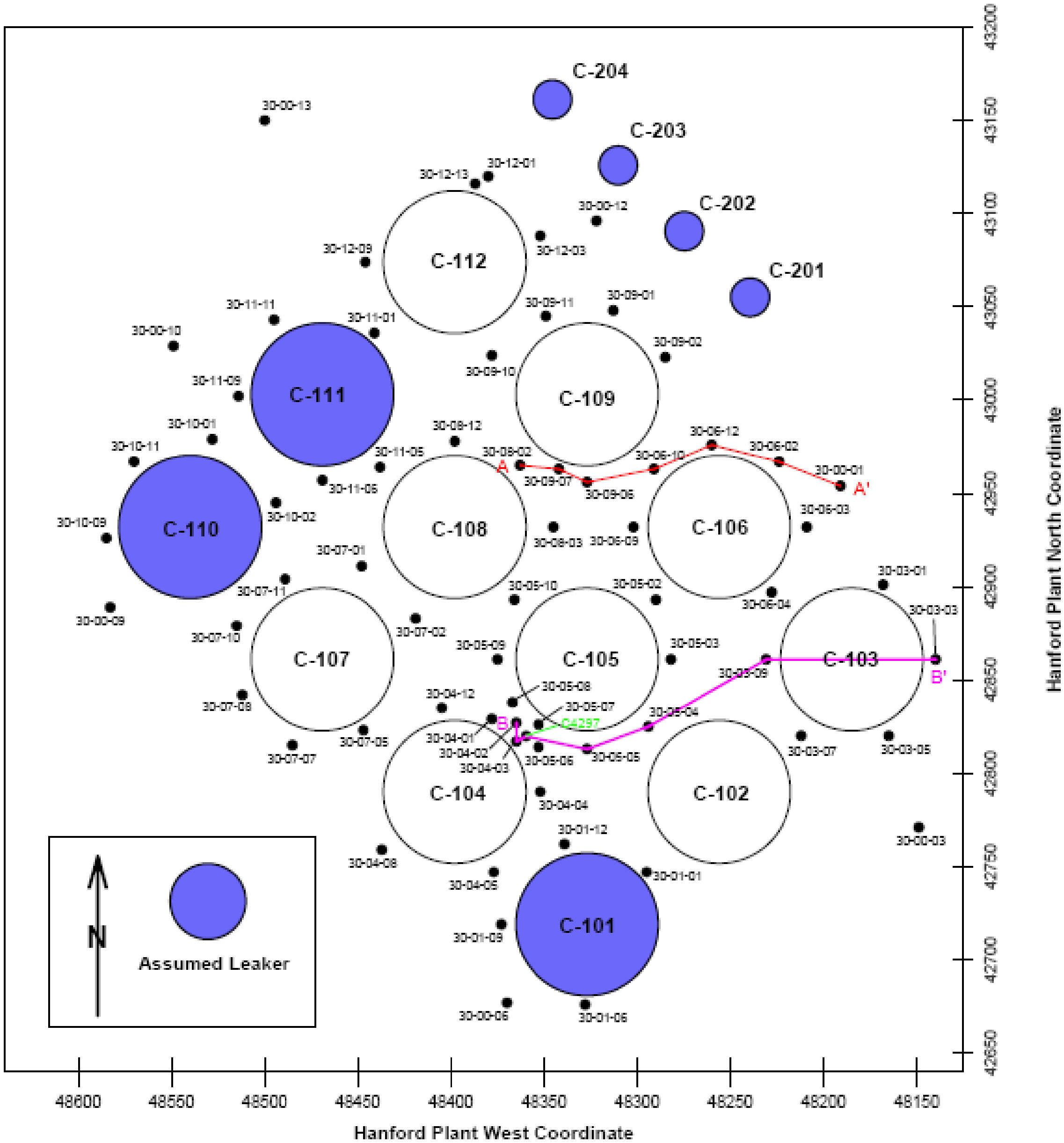


Figure 6-5 Contamination Present in Cross-section A-A

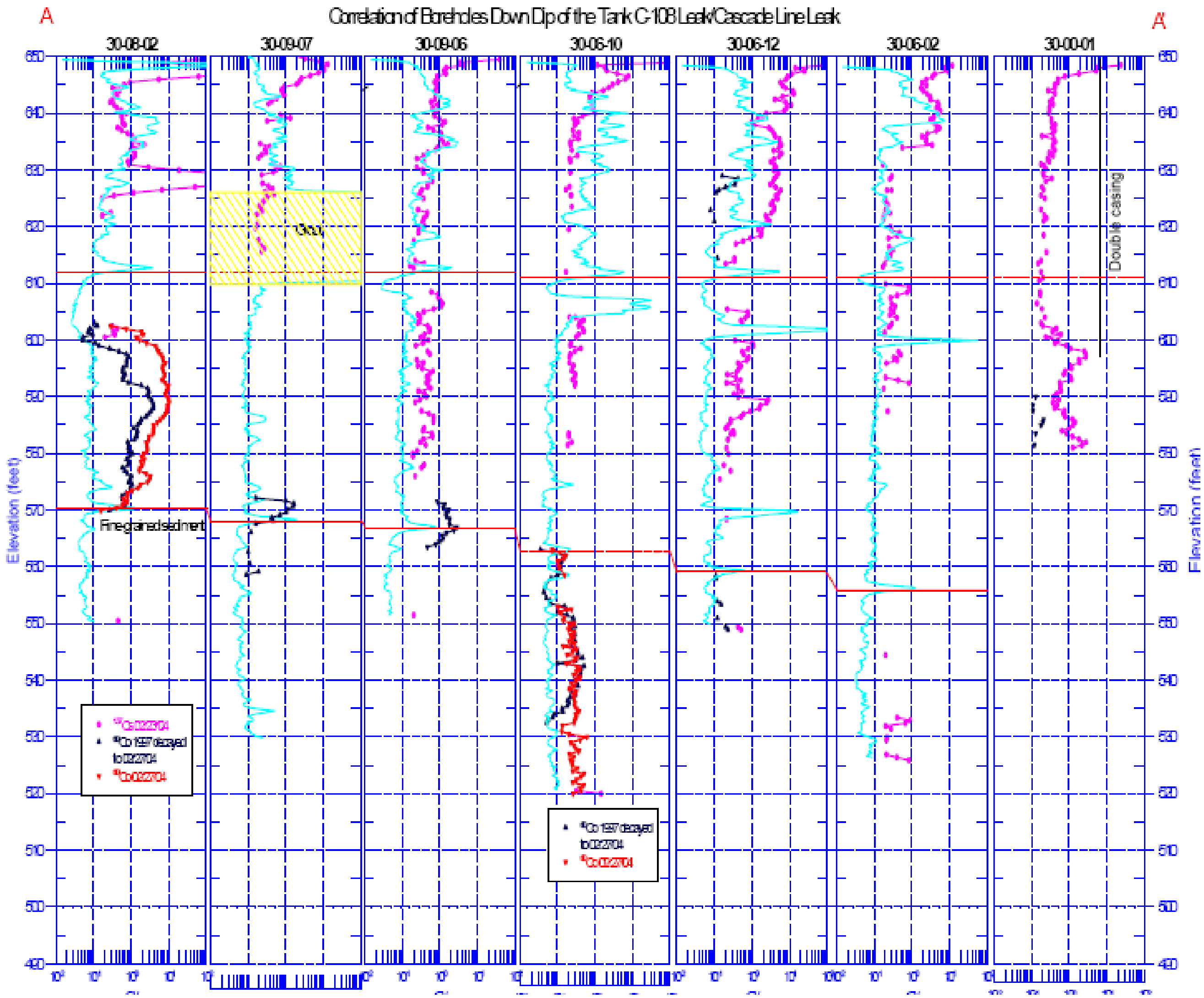


Figure 6-6 Contamination Profile near Tanks C-104 and C-105

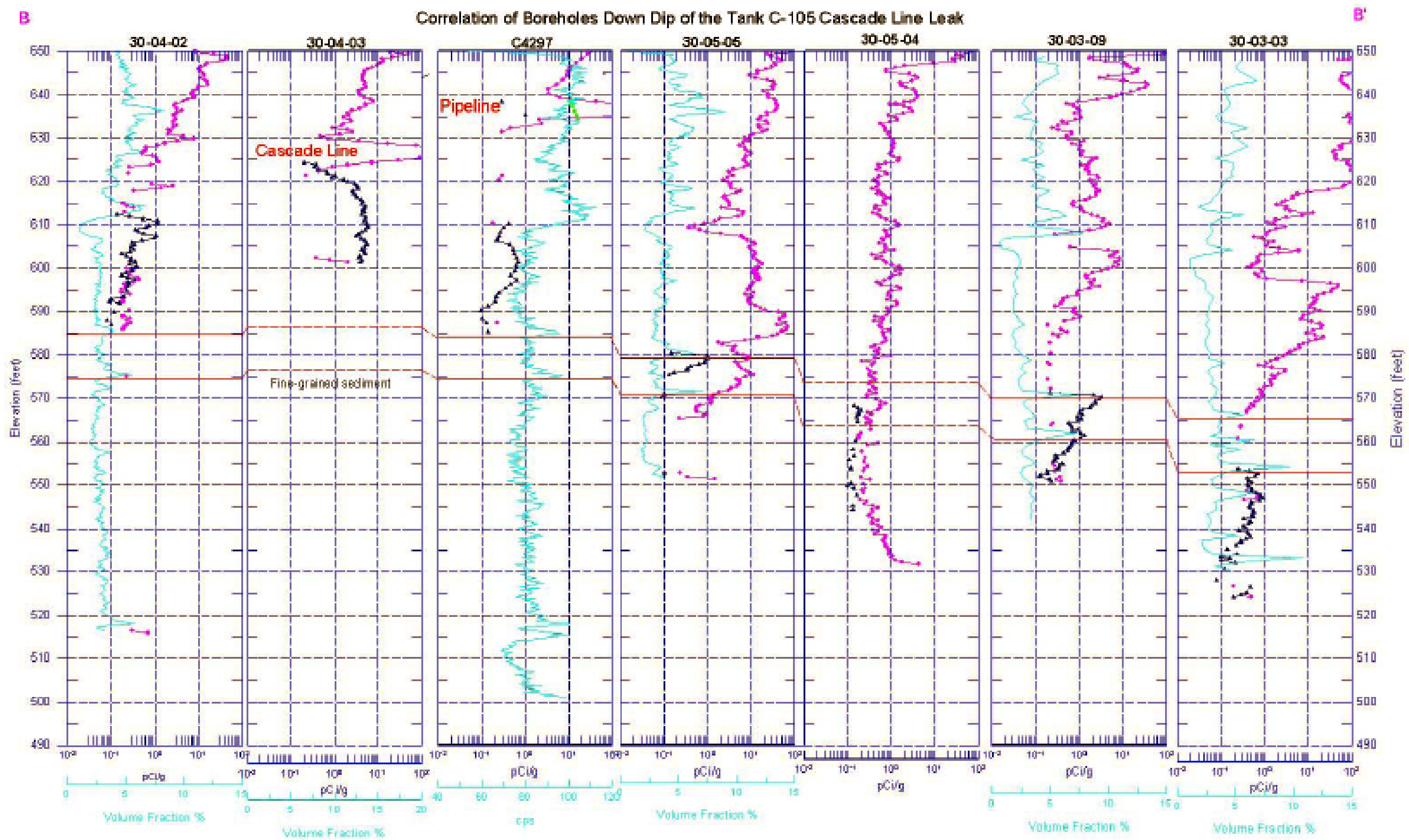


Figure 6-7 Drywells nearby Cascade Lines for Tanks C-108 and C-104

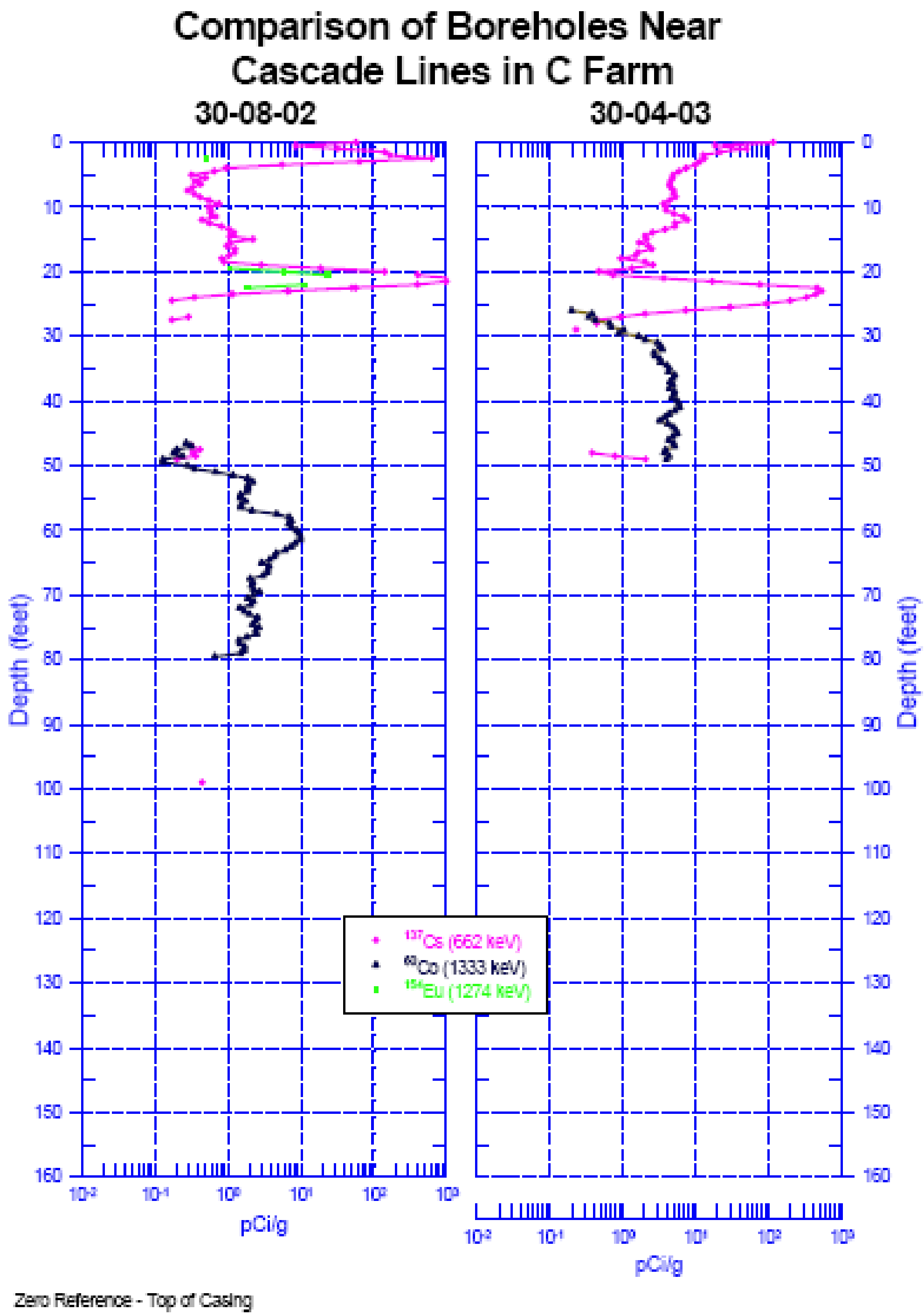


Figure 6-8 Drywells Cascade Lines for Tanks B-106 and B-110

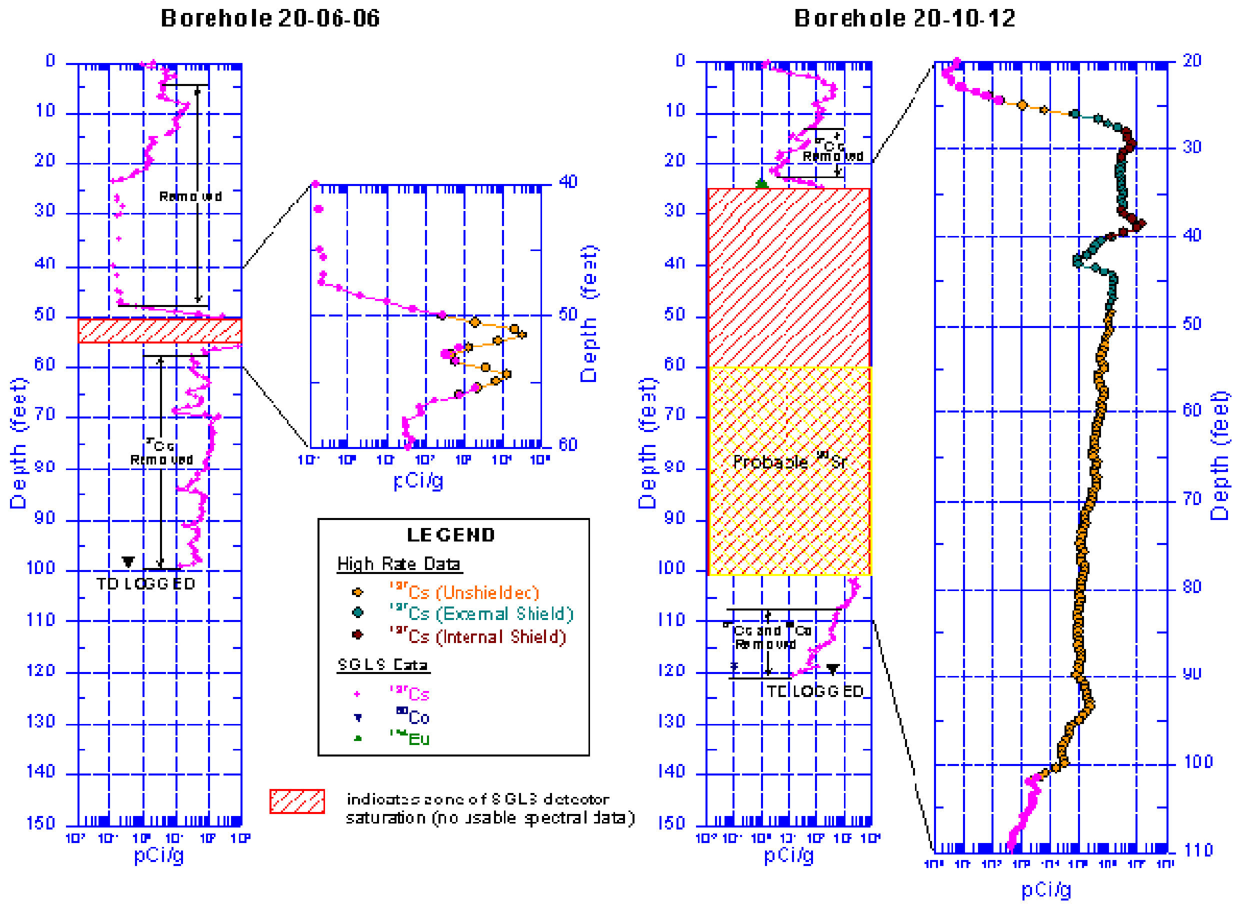


Figure D-2. Correlation Plots and Corresponding Zone of Interest Plots Showing High Rate Cs-137 Concentrations in Boreholes 20-06-06 and 20-10-12

Figure 6-9 Visualization of ^{137}Cs Contamination at 2-ft below ground

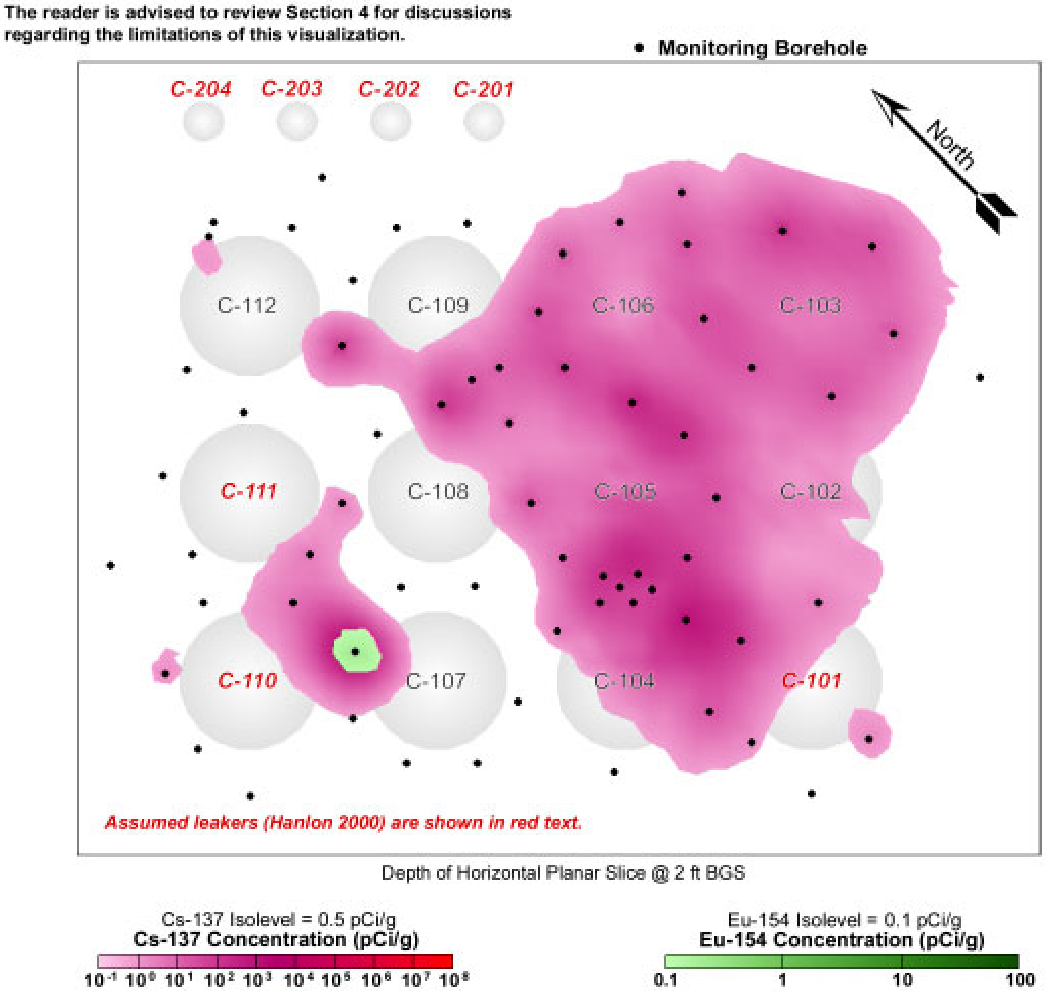


Figure D-4. C Tank Farm Visualization

Figure 6-10 Visualization of ^{137}Cs Contamination at 8-ft below ground

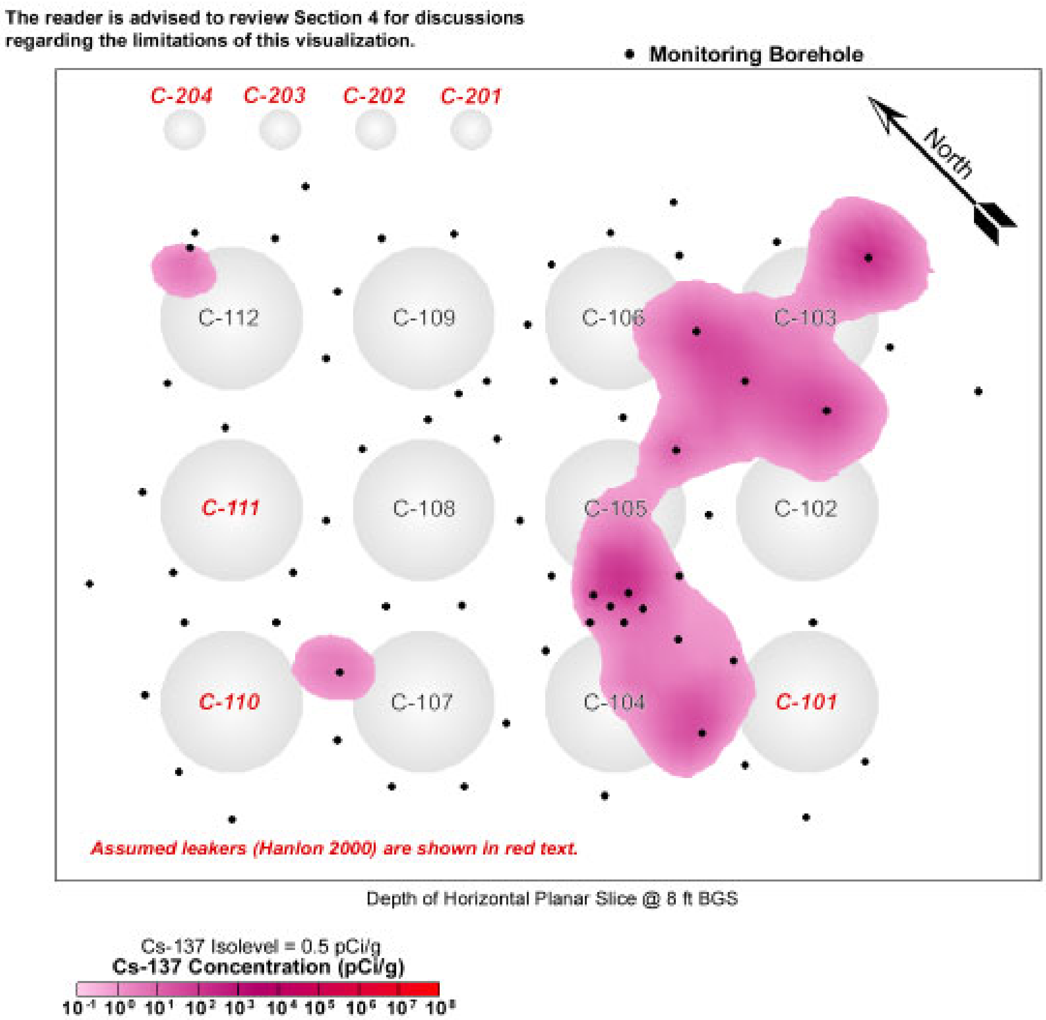


Figure D-5. C Tank Farm Visualization

Figure 6-11 Visualization of ^{137}Cs Contamination at 18-ft below ground

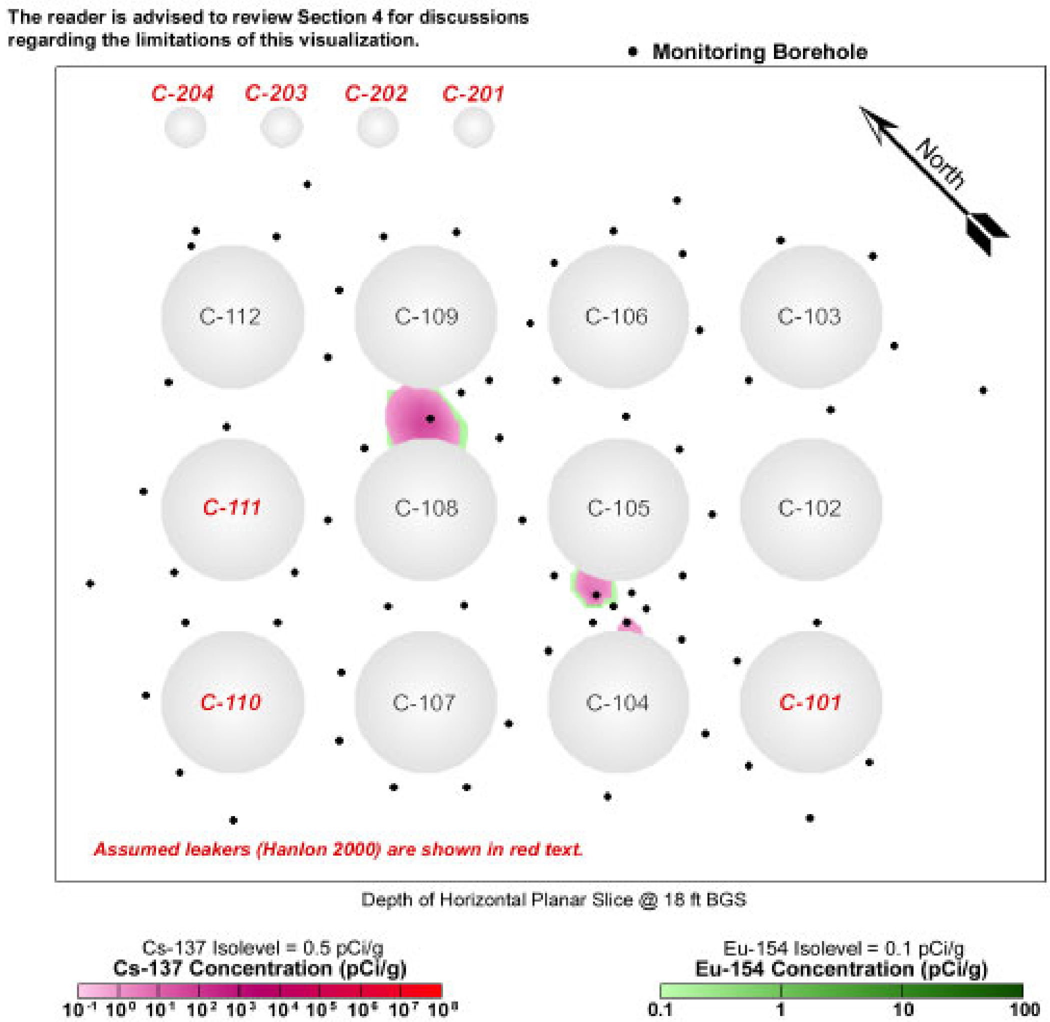


Figure D-6. C Tank Farm Visualization

6.6 Recommendations for Future Vadose Zone Investigations

Based on the SGE data and the documented pipeline leaks, it is recommended that further investigation of the following areas be conducted to further quantify subsurface contamination:

- Areas between tanks C-102 and C-105, between tanks C-104 and C-105, and between tanks C-101 and C-104
    - Pipeline 8041 used to transfer PUREX coating waste to tank C-102 failed in March 1965, causing waste leakage into a concrete encasement traversing from diversion box 241-CR-152 to tanks C-101, C-102, and C-103. Waste from this encasement then flowed into tanks C-101 and C-103 through the annulus of connecting pipelines. This concrete encasement traverses along the north side of these tanks. The relatively low areas of resistivity (Figure 6-3) in the region between tanks C-102 and C-105 and area between tanks C-101 and C-104 may be due to PUREX coating waste loss from this concrete encasement.
    - C-102 has no boreholes around it that may intersect contaminated soils. Some push-mode hole-drilling should be considered around this tank to investigate potential contamination.

- The drywells associated with the C-801 loadout facility should be further investigated to quantify potential discharges.

- There are no drywells around the C-200 series tanks. The soil around the C-200 series tanks be further investigated to quantify potential discharges.

- The soil around 244-CR vault
    - The vault is concrete structure with painted surfaces. The vault was flooded several times with waste, which may have leaked to the surrounding soil.

- Relatively low areas of resistivity in the region between tanks C-1082 and C-109
    - Tank C-109 was filled with waste above the spare inlet nozzles for an extended period of time (see Table 6-3). The relatively low areas of resistivity (Figure 6-3) in the region between tanks C-1082 and C-109 may be due to leakage from the spare inlets on either of these tanks, an unknown pipeline leak, or an unknown tank leak.

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APPENDIX A

MEETING SUMMARIES

MEETING SUMMARY

From: J. G. Field, CH2M HILL Hanford Group, Inc
Phone: 376-3753
Location: Ecology Office,
Date: March 6, 2007
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Joe Caggiano, ECOLOGY
Jim Field, CH2M HILL
Les Fort, ECOLOGY
John Harris, CH2M HILL
Michael Johnson, CH2M HILL
Jeffery Lyon, ECOLOGY

PURPOSE:

1. Assess Tank C-101 leak inventory

Review of Previous Meeting Summary:
The 2/15/07 meeting summary was reviewed and approved w/minor changes to previous comments. It was noted that previous comments still need to be incorporated to the leak process document.

Assessment of Tank C-101 Leak Inventory

A Draft Appendix A for the process document (RPP-32681) was distributed for discussion lead by Mike Johnson.

Participants agreed that the Appendix should be retitled to “Tank C-101 Assessment Information Example.” Appendix A will not provide an example of a complete assessment, only information presented for the assessment.

After discussion the need for additional evaporation information and heat load calculations was noted. Both Fluor and Nuvotech have estimated evaporation for C-101 based on heat load calculations. Temperature data for the tank at the time of the leak was not available. A drawing showing the tank and riser configurations was also requested.

Little information was presented for waste composition other than to note the basis for the waste type at the time of the leak. Participants agreed to use Soil Inventory Model composition estimates to estimate inventories. These will be discussed more as needed in the next meeting.

MEETING SUMMARY

From: J. G. Field, CH2M HILL Hanford Group, Inc
Phone: 376-3753
Location: Ecology Office,
Date: March 20, 2007
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Joe Caggiano, ECOLOGY
Michael Connelly, CH2M HILL
Jim Field, CH2M HILL
Les Fort, ECOLOGY
Michael Johnson, CH2M HILL
Bob Lober, ORP
Jeffery Lyon, ECOLOGY

PURPOSE:

Assess Tank C-101 leak inventory

Review of Previous Meeting Summary:
The March 6, 2007 meeting summary was reviewed and approved.

Assessment of Tank C-101 Leak Inventory

Assessment of the C-101 tank leak inventory continued.

An update to the C-101 Information Example in Appendix A of the Tank Leak Inventory Process Plan (RPP-32681) was distributed before the meeting.

The attached comments from Joe Caggiano were discussed. All comments were accepted. Clarifications will be added to the text regarding comment 3, “tank capacity.” The 546,000 gallons is not a typo, it exceeds the operating tank capacity, but is below the top of the liner.

Drawings and figures in Appendix A will be enlarged to make them more legible.

Discussion then focused on Table 1, attached. This table summarizes C-101 tank leak information included in Appendix A of the leak evaluation process report (RPP-32681).

Discrepancies in leak levels reported in a 1980 tank integrity assessment were discussed. Estimates appear to range from 10,000 to 24,000 gal. The reason for the differences and why liquid level decreases before 1968 were not discussed in the 1980 evaluation remain unknown.

The data shows there was a 36,000 gallon liquid level decrease in the tank between January 1965 and September 1969. The source of the leak could be a spare inlet port, the cascade overflow line to tank C-102 (although reported as plugged, it may have only been partially plugged), a tank leak and/or evaporation. The liquid level continued to decrease below the level spare inlet port (17 ft 4 in).

Some evaporation may have occurred, but if the condenser shown in the drawings and period photographs were operating as expected, even though there was sufficient heat load in the tank to evaporate the supernate, evaporated liquid would have been condensed back to the tank and the majority of the liquid level decrease could not have been due to evaporation. There is no evidence to indicate there was significant contamination near the condenser or any indication the condenser was not functioning at the time of the liquid level decrease.

The low activity found in drywells near the tank is inconsistent with a 20,000 to 36,000 gal PUREX supernate leak. One possibility is that the leaked waste volume was not only PUREX waste. However there is no data to support this. A sample from tank C-101 taken in 1969 showed a Cs-137 content of 3.85 Ci/gal.

Conclusion

There is insufficient data available to establish a minimum range or leak mass for tank C-101. The upper range appears to be 36,000 gallons. The mass of the C-101 leak is in question. The group agreed that a 1,000 gallon release, as contained in RPP-23405, is indefensible and agreed, for lack of better supporting evidence, to leave the estimated leak volume at 20,000 gallons as in Hanlon. Based on the four organizations assessing the data in 1980, the 20,000 gallon leak volume estimate apparently represents a compromise estimate based on unspecified evidence or evaluation that is not documented in the record. Therefore, assessment attendees accept the sensitivity assumptions and modeling in the Initial SST Performance Assessment as a starting point for risk evaluations. These estimates should not be changed until more data is obtained. Ecology's response to the C-101 leak assessment is shown in Table.2, attached.

NEXT MEETING AGENDA ITEMS
Tank C-110 Leak Assessment

ACTIONS:
J. Field: Prepare and distribute 3-20-07 Meeting Summary
M. Johnson: Prepare C-110 Tank Leak information
J. Field: Submit RPP-32681 to Ecology for Review
J. Field: Prepare C-101 Inventory Assessment Report
All: Review C-110 Information

NEXT MEETING:

Date:	March 27, 2007
Time:	3:00-4:30
Location:	ECOLOGY Office

Attachments

From: Caggiano, Joseph (ECY) [Jcag461@ecy.wa.gov]
Sent: Tuesday, March 20, 2007 11:07 AM
To: Field, Jim G
Cc: Harris, John P III; Johnson, Michael E; Fort, Les
Subject: RPP-32681

Jim,
Some comments after a quick read through Appendix A of the subject document:
1) The tank schematic of Fig. 1is a good addition. For purposes of interpreting the geophysical logs, it would be beneficial to have an elevation or depth below surface of the various lines running from diversion boxes to tanks and between tanks, as peaks in the logs tend to occur at certain depths that may correspond to potential releases from poorly sealed pipes at these locations.
2) PSN waste (pg. 35) is not in Table 6-1. Was this an oversight, and were other waste types not included?
3) On pg. 35, top line, 546,000 gals in the tank would exceed tank capacity which is listed as 530,000 gals. Is this correct or a typo?
4) Figs. 6 and 7 would be good additions if one could read them. To my old eyes, they are just a blur. So, suggest either enlarging them or deleting them if they serve no value.
5) Legibility is also less than desirable in Fig 4, the drywell logs. While one can see a general profile, the scale at the bottom reflecting pCi/g units is illegible, so the quantitative assay value of the logs is lost.
Overall, I feel that the document is progressing nicely and should be able to be released soon. We can talk more about this in our meeting this afternoon.

Joe

Table 1. C-101 Tank Leak Information					
	When	**Amount**	**Range (gal)**	**Possible sources**	**Comments**
Current "Hanlon" estimate	1980		20,000	liquid level decrease	Average based on 1980 team findings
liquid level decrease	Jan 65-Sept 69	574,000 to 538,000 decrease	36,000	spare inlet leak, leak, evaporation	PUREX
1980 team findings	Jan 1968 to Dec 1969	4 in decrease from 194.5 to 190.5	11,000		
	Jan 1968 to Dec 1969		17,000 to 24,000	on p.4 RHO-CD-896	Basis for 17,000 unknown. Ave. of 17,000 and 24,000 is 20,000 gal
Surveillance	Na		24,000		
Process Control	Na		10,000-24,000		Basis for 10,000 unknown.
drywell data	1970-79	max 17,000 c/s 29-36 ft bgs	indicates minimal contamination at drywell. Inconsistent with leak events such as SX-108 and T-106.	Found 1970 in drywell 30-01-09	Contamination also in 30-01-06 at 73 ft. Contaminants decayed to < 200 c/s by 1979
SGE data	obtained 2006			shows resistivity anomaly NW of C-101 around C-104	Anomaly NW of spare inlet ports
Evaporation	Jan 65-Sept 69		0-30,500 gal	Heat load calcs show pot 550 gal/month or 30,500 in 56 mo.	Condensers on tanks. Amount of evaporation that actually occurred is unknown. No temp data, but sources show potential 180 F temp.
Soil Inventory Model Estimates for 1000 gal		Tc	0.22	Ci	
		Cs-137	852	Ci	
		Sr-90	7.7	Ci	
		Cr	1.5	Kg	
			0-36,000 possible leak volume range		
			average?		

Table 2. Ecology's response to C-101 Leak Assessment:

Criteria evaluated	Acceptable data set	Basis	Comment
Range of values:	10,000 gallons to 36,000 gallon leak	Max- based on in tank level measurements Min – Tank Farm Contractor Process Control organization determined a minimum volume; reported in the leak assessment report.	C-101 tank dry well indicates low mass of contaminants; SGE indicates plume in area near tank located near tanks C-104 and C-105
recommended value, to be used for any modeling reference case, SST PA Base Case or other Risk Assessments:	20,000 gallons*	Conclusion of previous leak assessments; value is a compromise that reflects the uncertainty of the data sets provided	Soil information is inconsistent with liquid level loss information; C-102 tank levels can not be used to confirm a liquid overflow from tank C-101; C-101 condenser on passive ventilation outlet should have minimized evaporative loss
Type of Waste:	P1	Type of waste identified in 1980 reports; information presented in 2007 leak assessment evaluation.	
Tank designation:	Assumed Leaker	Liquid loss and drywell information	
Type or location of tank leak:	Unknown, information implies loss was below tank outlets and below plugged cascade line	1980 report; information presented in 2007 leak assessment evaluation.	Liquid level indicated drop below plugged cascade line,
Conclusion: Tank leak information is insufficient to make definitive conclusion of volume or the mass of contaminant loss; soil data is inconsistent with waste volume and type. Recommended value is the value previously stated in Hanlon reports that represents an unexplained and unexplainable compromise by the 1980 evaluation team that is not well documented.			
Recommendations: (1) Area in vicinity of C-101, C-104, and C-105 requires DQO and further soil investigation; (2) further tank assessments necessary to establish relationship of nearby plume (C-104/105) to C-101 tank; (3) maintain HNF-EP-0182 volume estimate and notes related to C-101			

MEETING SUMMARY

From: J. G. Field, CH2M HILL Hanford Group, Inc
Phone: 376-3753
Location: Ecology Office,
Date: April 3, 2007
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Joe Caggiano, ECOLOGY
Jim Field, CH2M HILL
Les Fort, ECOLOGY
Michael Johnson, CH2M HILL

PURPOSE:

Wrap up Tank C-101 leak inventory Assessment
Assess Tank C-110 leak inventory

Review of Previous Meeting Summary:
The March 20, 2007 meeting summary was reviewed and accepted with changes.
The main change was to state in the meeting summary conclusions that the assumed waste type for the tank C-101 leak was the HDW/SIM waste stream, predominantly PUREX P1 waste.

Assessment of Tank C-101 Leak Inventory

The C-101 assessment was reviewed and waste type assumptions were discussed.
A leak assessment report will be prepared by CH2M HILL as an RPP- document. The report will include C-101 and C-110 initially. The report will be revised to include assessments for other C-Farm tanks and UPRs as they are assessed. Upon completion of a draft report the document will be informally transmitted to Ecology for review and concurrence prior to release.

Leak Process Document Review (RPP-32681)
The tank leak process document is in internal CH2M HILL and ORP review. Informal comments have also been received from Ecology. After initial comments are incorporated the report will be formally submitted to Ecology for a 30 day review and concurrence. Simultaneously ORP plans to send the report to the tribes for review.

Assessment of Tank C-110 Leak Inventory
Information on the C-110 tank leak was distributed before the meeting.
The attached summary Table was discussed. There was no liquid level decrease observed for this tank, only an increase of < 250 cps in 1974-1978 gross gamma measurements in drywells

30-10-09 and 30-10-02. Drywells were not installed before 1974. There was also no indication of anomalies observed in Surface Geophysics Exploration (SGE) data.
However, there is also no nearby source for the contamination other than Tank C-110.

The only basis discussed and referenced for a C-110 leak was a “Questionable integrity” designation based on a 1989 letter *Single-Shell Tank Leak Volumes* (Baumhardt 1989). As stated in the letter, it was “unreasonable to assume that more than 2,000 gallons leaked without a surface level decrease.” This is roughly equivalent to a +/- ¾ inch undetected decrease, which is reasonable for manual tape measurements being used at the time.

The most likely source determined for a leak from this tank was at the overflow ports. Based on surface level history the waste only exceeded the height of the overflow ports (17 ft 4 in.) before 1954 and in 1971-72. Although the waste level was not reported as being over the overflow ports, it was very close and the assessment group noted that tank elevations in drawings have been found to be in error by several in.. Consequently an overflow is plausible.

The gamma measurements observed follow a ^{106}Ru decay curve indicating the observed gamma activity was Ru. This would have not have been seen in gamma measurements if the leak occurred before 1954. So the most likely source for the activity was a 1971-72 overflow. If the leak occurred during 1971-72 the composition of the supernatant waste stream would have been that measured in 1975 showing ~ 0.32 Ci/gal of Cs-137. This is about five times higher than the predicted Soil Inventory Model waste type estimate for a 1969 leak.

As a rough check on waste type and volume estimates CH2M HILL will compare Ru-106 gamma measurements with equivalent Cs-137 measurements for a CSR (i.e. cesium removal) waste type. This approach, distance of drywells from the tank, and estimated soil density will be used to calculate a rough leak volume estimate.

As stated, the location of the C-110 leak is likely at the overflow line 17 ft 4 in above tank bottom. As a worst case, the liquid level in SST was steady at 144 in. from the tank center from 1972 to 1975, indicating that there was no leak below this level.

Discussion of Next Meetings
Meetings will be scheduled to continue every two weeks, Tuesday at 3;00.
Next tank C-111, followed by C-105, a quick review of other C-Farm SST liquid surface data then look at UPRs and C-200 tanks. *[Note: The discussion on the C-200 tanks was not held.]*

MEETING SUMMARY

CH2MHILL
Hanford Group, Inc.

From: J. G. Field, CH2M HILL Hanford Group, Inc
Phone: 376-3753
Location: Ecology Office,
Date: April 24, 2007
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Joe Caggiano, ECOLOGY
Jim Field, CH2M HILL
Les Fort, ECOLOGY
John Harris, CH2M HILL
Jeff Luke, CH2M HILL
Jeffery Lyon, ECOLOGY

PURPOSE:

Wrap-up C-110 assessment and start C-111

Review of Previous Meeting Summary:
The April 17, 2007 meeting summary was reviewed and approved.

C-110 Leak Assessment

Additional information requested in the meeting held April 03, 2007 regarding the C-110 leak loss was discussed and the summary Table was revised (revised Table attached).

The following new information was discussed:

Basis for 2,000 gal Leak Volume:
A manual tape with an electrode was used for many of the liquid level measurements reported in the 1950's through the 1970's. The statistical accuracy of the manual tape and electrode measurement technique was 0.75 in. (~2,060 gallons), as determined in July 1955 (HW-51026, 1957, page 4, *Leak Detection – Underground Storage Tanks*, General Electric Company, Richland WA).

An estimated leak volume for SST C-110 of 2,000 gallons was assigned in 1989. "This estimate was made because radiation was detected at an associated drywell, but there was no detectable surface level decrease. A liquid surface was being measured at the time radiation was detected in the drywell. It is unreasonable to assume that more than 2,000 gallons leaked without a surface level decrease" (Baumhardt, R. J. 1989, *Single-Shell Tank Leak Volumes)*.

Radioactivity Concentration and Leak Volume:
The maximum activity detected in drywell 30-10-09 was 240 cps at 40 to 60 ft bgs in July 1975. The activity detected in drywell 30-10-09 was shown to correlate to a radionuclide decay rate for ^{106}Ru. The maximum ^{106}Ru activity detected in drywell 30-10-09 in July 1975, 240 cps, corresponds to an estimated 800 ρCi/gm ("Estimate for ^{106}Ru in 30-10-09", E-mail dated April 24, 2007 from R. McCain, S. M. Stoller Corporation to M. E. Johnson, CH2M HILL Hanford Group). The estimated ^{106}Ru concentration in the soil around drywell 30-10-09 is a very rough estimate of equivalent ^{106}Ru concentration based on the total gamma data. This estimate of ^{106}Ru concentration in the soil was used to estimate the volume of waste potentially lost from SST C-110. The ^{106}Ru concentration and the estimated waste loss volume should not be considered as absolute values, but only a rough order of magnitude estimate.

The ^{106}Ru activity was localized to 40 to 60 ft bgs; with the peak activity detected ~54 ft bgs. If we assume a spherical leak volume centered on the drywell with a radius of 10-ft., the estimated volume of contaminated soil is ~4,200-ft^3 (~119 m^3). Using a soil density of 2 gm/cm^3 yields an estimated contaminated mass soil of ~238 MT. Assuming the concentration of the ^{106}Ru activity detected in drywell 30-10-09 is 800 ρCi/gm, the ~238 MT of contaminated soil would contain an estimated 0.2 Ci of ^{106}Ru. Since the estimated ^{106}Ru concentration in the SST C-110 supernate was ~0.02 Ci/gal in June 1975, the volume of SST C-110 supernate corresponding to 0.2 Ci of ^{106}Ru is ~10 gallons. Assuming a larger volume of contaminated soil would not significantly alter the estimated leak volume.

The gamma measurements observed follows a ^{106}Ru decay curve indicating the observed gamma activity was Ru. Because of the short half-life of ^{106}Ru, the ^{106}Ru would have not have been seen in gamma measurements if the leak occurred before 1954. So the most probable period for a tank overflow is 1971-72. If an overflow occurred during 1971-72 the composition of the supernatant waste stream would have been that measured in 1975 showing ~ 0.32 Ci/gal of Cs-137. This is about five times higher than the predicted Soil Inventory Model waste type estimate for a 1969 leak.

C-110 Conclusions

The C-110 leak appears to be the result of a tank overflow 17 ft 4 in (208 in) above the tank bottom. As a worst case, the liquid level in SST was steady at 144 in. from the tank center from 1971 to 1975, indicating that if there was a breach in the tank wall, it was above this level.

Because no liquid level decrease was observed, based on liquid level accuracy for the manual tape and electrode instrumentation in the tank in 1971-72, the volume of the leak was previously determined to be less than 2,000 gallons. Rough calculations of the gamma activity observed in dry wells indicate that the volume of the leak could have been significantly smaller. The supernatant was predominantly CSR waste. Supernatant samples of this waste obtained in 1975 provide waste composition measurements. The measured 1975 C-110 supernatant composition appears to be consistent with calculated ^{106}Ru dry well activity.

C-111 Leak Assessment

Summary information and the attached summary Table for C-111 were discussed.

Based on temperature measurements, the liquid level decrease appears to be evaporation.
An action was taken to compare the rate of liquid level decrease with evaporation estimates assuming a 5 cfs air flow at 190 F temperature. This calculation will also be used to further assess how much of the liquid level decrease can reasonably be attributed to evaporation losses.

NEXT MEETING AGENDA
Continue C-111 Leak Assessment

ACTIONS:
M. Johnson: Prepare evaporation calculations and plots and compare with liquid level decrease.
J. Field: Prepare and distribute 4-24-07 Meeting Summary
J. Field: Continue to prepare C-Farm leak assessment report

NEXT MEETING:

Date:	May 1, 2007
Time:	3:00-4:30
Location:	ECOLOGY Office

Tank C-110 Leak Information Summary					
	When	**Estimated Leak Volume (gallons)**	**Range of Leak Volume (gallons)**	**Possible Sources**	**Comments**
Declared questionable integrity	1977	No estimate	No estimate	No source identified	Tank was identified as questionable integrity based on unexplained activity identified in drywell 30-10-09.
Declared "assumed leaker	1984	No estimate	No estimate	No source identified	Tank was identified as questionable integrity based on unexplained activity identified in drywell 30-10-09.
Current HNF-EP-0182 leak volume estimate	1989	2,000	No range provided	No source identified	"This estimate was made because radiation was detected at an associated drywell, but there was no detectable surface level decrease. A liquid surface was being measured at the time radiation was detected in the drywell. It is unreasonable to assume that more than 2,000 gallons leaked without a surface level decrease." Letter number 8901832B R1 dated May 17, 1989 from R. J. Baumhardt, Westinghouse Hanford Company to R. E. Gerton, U.S. Department of Energy Richland Operations Office
Liquid Level Decrease	N/A	N/A	N/A	N/A	No unexplained liquid level decreases observed. Liquid level data indicates spare inlet nozzles were **not** submerged. **Steady liquid level at ~144 in. (~376,000 gallons) reported for April 1972 through June 1975**
Drywell data	October 1974 through April 1978	No estimate	No estimate	No source identified	A gross gamma peak reading at 53 to 56 ft bgs observed on drywell 30-10-09. Initially ~210 cps (10-1974), increasing slightly to ~240 cps (07-1975), then declining to ~50 cps (04-1978). **Activity in drywell 30-10-09 correlated to Ru-106 decay curve.** A gross gamma peak reading at ~47 ft bgs observed on drywell 30-10-02. Initially ~65 cps (09-1974), increasing slightly to ~72 cps (01-1975), then declining to ~50 cps (04-1980). **Activity in drywell 30-10-09 correlated to Cs-137 decay curve.**
SGE data	October 2006	No estimate	No estimate	No source identified	No areas of low resistivity are found around SST C-110
1980 Prior leak investigations		No estimate	No estimate		SST C-110 was **not** evaluated in the 1980 report (RHO-CD-896)
SIM Estimate		2,000			Assumes leak date of 1969 and uses TBP-UR and 1C1 as waste types in tank.
Mean Inventory	^{137}Cs	~75 Ci			For a leak in 1971-72 the composition of the supernatant waste stream would have been that measured in 1975 with a CSR waste type and ~ 0.32 Ci/gal of Cs-137, about five times higher than the ^{137}Cs estimate in SIM
	^{99}Tc	0.02 Ci			
	^{90}Sr	16.3 Ci			
	Cr	1.5 kg			

Tank C-111 Leak Information Summary					
Item	**When**	**Estimated Leak Volume (gallons)**	**Range of Leak Volume (gallons)**	**Possible Sources**	**Comments**
Declared "suspect leaker" in 1968 and "questionable integrity" in 1974	1968; 1974	No estimate	No estimate	No source identified	Tank was identified as questionable integrity based on RHO-CD-1193, 1981, *Review of the Classification of Hanford Single-Shell Tanks 110-B, 111-C, 103-T, 107-TX, 104-TY, and 106-U*. No primary source could be located corroborating the "Suspect Leaker" date of 1968, which is listed in LET-013074 and HNF-EP-0182 rev. 219. The first documented date for classification of SST C-111 as a "Suspect Leaker" is reported on March 25, 1974 in ARH-2794-D, 1974, Manufacturing and Waste Management Division Waste Status Summary October 1, 1973 Through December 31, 1973, Atlantic Richfield Hanford Company, Richland WA.
Current HNF-EP-0182 rev. 219 (June 2006) leak volume estimate	1968	5,500	No range provided	No source identified	"There were 27 tanks for which leak volumes have not previously been reported. Of these 27 tanks, the leak volume of 6 tanks could be determined using liquid level data, and 2 additional tank leaks were estimated as 2,000 gallons each." Table 2B lists the estimated leak volumes for the 27 tanks, including SST C-111 (Letter number 8901832B R1 dated May 17, 1989 from R. J. Baumhardt, Westinghouse Hanford Company to R. E. Gerton, U.S. Department of Energy Richland Operations Office). Note: The reference does not provide a basis for SST C-111 leak estimated of 5,500 gallon.
Liquid Level Decrease	1965-1969	~23,000	None	N/A	Unexplained liquid level decreases from ~520,000 to 497,000 gallons observed 1965 - 1969. Liquid level data indicates spare inlet nozzles were **not** submerged at this time. **Steady waste level at ~176 in. (~497,000 gallons) reported for May 9 1969 – December 26, 1969 (RHO-CD-1193, page 28).** **After transferring ~349,000 gallons of waste to SST C-**

Tank C-111 Leak Information Summary					
Item	**When**	**Estimated Leak Volume (gallons)**	**Range of Leak Volume (gallons)**	**Possible Sources**	**Comments**
					104, the waste level in SST C-111 was steady at ~49 in. (~109,400 gallons) from 1970 through June 1972. **In June 1972, ~24,700 gallons of waste was transferred from catch tank C-301 into SST C-111 (RHO-CD-1193, pg. 27), increasing the waste level to ~58-in. (~134,100 gallons). From June 1972 to 1974 the surface level remained at a level of 58 in. (~134,000 gallons).**
1974 Leak Estimate	1968	22,000	None	7,000 Ci Cs-137 (1968)	Accession # D196207372, LET-013074, "Radionuclide Inventories in Leaks from Transfer Lines and Tanks", letter dated January 30, 1974 from M. C. Fraser and D. J. Larkin to H. P. Shaw, Atlantic Richfield Hanford Company, Richland WA
Drywell data	1970 – 1986	No estimate	No estimate	No source identified	Monitoring of drywells 30-11-01 (1979), 30-11-05 (1975), 30-11-06 (1970), 30-11-09 (1970), and 30-11-11 (1975) all have shown less than the background radioactivity level of 50 cps gross gamma (RHO-CD-1193, page 27 and WHC-SD-WM-TI-356).
SGE data	October 2006	No estimate	No estimate	No source identified	No areas of low resistivity are found around SST C-111
1981 Prior leak investigations		No estimate	No estimate		SST C-111 was evaluated in the 1981 report (RHO-CD-1193). Four teams reviewed the classification status of SST C-111 with the teams comprised of: (1) Tank Farm & Evaporator Process Control Group, (2) Tank Farm Surveillance Analysis Group, (3) Process Engineering, 200 East Area Maintenance and Earth Sciences, and (4) Process Engineering. Teams 1, 2 and 4 concluded SST C-111 should be classified as a "Confirmed Leaker". However, team 3 concluded that "… without confirmatory drywell evidence Tank C-111 could not, at the 95% Confidence Level, be declared a Confirmed Leaker. Therefore, following the established Ground Rules for reclassification of single-shell tanks, Tank C-111 must continue to be classified as of Questionable Integrity." (RHO-CD-1193, pg. 13)
SIM Estimate		5,500			
SIM Mean Inventory	^{137}Cs	~195 Ci			Assumes leak date of 1968 and uses the following waste

Tank C-111 Leak Information Summary					
Item	**When**	**Estimated Leak Volume (gallons)**	**Range of Leak Volume (gallons)**	**Possible Sources**	**Comments**
	^{99}Tc	0.054 Ci			types and maximum leak volume estimate: 1C1 (BT1): 8.01E-03 liter TBP-UR (BT2): 5.86E-01 liter TFeCN (BT2): 1.50E+03 liters CWP1 (CWP1): 9.37E+03 PUREX (P2) OWW1: 3.01E+00 liter Sr-Cs Rec Wst (P1)_HS: 8.56E+03 liter PUREX (P2) Cool Wtr-Stm Cond: 1.39E+03 liter
	^{90}Sr	841.8 Ci			
	Cr	5.3 kg			

MEETING SUMMARY

From: J. G. Field, CH2M HILL Hanford Group, Inc
Phone: 376-3753
Location: Ecology Office,
Date: May 1, 2007
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Jim Field, CH2M HILL
Les Fort, ECOLOGY
Michael Johnson, CH2M HILL

PURPOSE:
Complete C-111assessment

Review of Previous Meeting Summary:
The April 24, 2007 meeting summary was reviewed and approved with minor edits.

C-111 Leak Assessment
Additional information requested in the meeting held April 24, 2007 regarding the C-111 liquid level decrease was discussed.
The following new information to be included in the C-111 assessment report was added.

Clarification of Transfer History
SST C-111 received 8,000 gallons of PUREX OWW in October 1956 (HW-46382, pg. 4), 6,000 gallons of PUREX OWW in December 1956 (HW-47640, pg. 4), 53,000 gallons of PUREX CW in January 1957 (HW-48144, pg. 4), 91,000 gallons of PUREX CW in February 1957, (HW-48846, pg. 4), and 119,000 gallons of PUREX CW in March 1957 (HW-49523, pg. 4). SST C-111 contained approximately 332,000 gallons of waste on March 31, 1957.

In April 1957, SST C-111 received 573,000 gallons of PUREX CW

SST C-111 was filled and emptied several times during June through December 1957.

Drywell Activity

Minor surface level contamination and less than 1-picocuries of ^{137}Cs per gram of soil was detected at depth in these drywells when gamma spectral logging was conducted between 1997 and 2000 (GJPO-HAN-18, July 1998, *Vadose Zone Characterization Project at the Hanford Tank Farms, C Farm Tank Farm Report*, U.S. Department of Energy, Grand Junction Office, Grand Junction, Colorado and GJO-98-39-TARA, September 2000, *Vadose Zone Characterization Project at the Hanford Tank Farms, Addendum to the C Tank Farm Report,* U.S. Department of Energy, Grand Junction Office, Grand Junction, Colorado).

Evaporation

The waste volume in SST C-111 decreased by ~20,000-gallons from January 1, 1965 through June 30, 1965. This waste volume decline was described as due to the installation of new electrode for determining liquid level. The SST C-111 waste volume remained at 519,000 to 520,000-gallons for three months (July thru September 1965). SST C-111 showed a decrease in waste volume from October 1965 through June 1969, losing 1,000 to 5,000-gallons per quarter for a total level decline of 22,000 gallons.

High temperature conditions in SSTs typically create airflow mixing and airflow rates of 3 to 6-cfm are considered plausible under these conditions. The psychometric chart indicates at 190^{o}F and 100% relative humidity, air contains ~1.0 lbs of water per lb of dry air and has a density of ~0.024 lbs dry air/ft^3 (R. H. Perry and C. H. Chilton, 1973). At an airflow rate of 5-cfm, ~7,500 gallons of water per year would be exhausted from SST C-111. Assuming the air exhausting from SST C-111 was at 190^{o}F and 70% relative humidity, then the air would contain ~0.52 lbs of water per lb of dry air, at a density of ~0.033 lbs dry air/ft^3, and 5-cfm would exhaust ~5,460 gallons of water per year. Therefore, the loss of liquid level in SST C-111 can be adequately explained by an exhaust airflow rate of 5-cfm of air at 190^{o}F and a relative humidity of 70% to 100% .

A key difference in current evaporation calculations and previous estimates is that previous report estimate evaporation for a 100 F temperature. They do not appear to be aware of and do not consider reports found during the current assessment showing 190 F tank waste temperatures or higher.

C-111 Conclusions

Evaporation calculations and plotted liquid level and evaporation rates clearly indicate that the liquid level decrease can be attributed to evaporation and suggest that high tank waste temperature information was apparently not available for previous assessments. The assessment team believes that the data supports the potential to reclassify tank 241-C-111 as sound. Therefore, no leak volume or inventory is assigned for Tank 241-C-111.

Next Meeting AGENDA
C-105 Leak Assessment

ACTIONS:
M. Johnson: Prepare C-105 information
J. Field: Prepare and distribute 5-02-07 Meeting Summary
J. Field: Continue to prepare C-Farm leak assessment report

<u>Next Meeting:</u>

Date:	May 15, 2007
Time:	3:00-4:30
Location:	ECOLOGY Office

MEETING SUMMARY

From: J. G. Field, CH2M HILL Hanford Group, Inc
Phone: 376-3753
Location: Ecology Office,
Date: May 15, 2007
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Joe Caggiano, ECOLOGY
Michael Connelly, CH2M HILL
Jim Field, CH2M HILL
Les Fort, ECOLOGY
John Harris, CH2M HILL
Paul Henwood, S.M. Stoller
Nina Minard, ECOLOGY
Mark Wood, FLUOR

PURPOSE:
Start C-105 assessment

Review of Previous Meeting Summary:
The May 1, 2007 meeting summary was reviewed and approved with the following added for liquid level changes observed after installing a new electrode.

The waste volume in SST C-111 decreased by ~20,000-gallons from January 1, 1965 through June 30, 1965. This waste volume decline was described as due to the installation of a new electrode for determining liquid level. After the new electrode was installed, the SST C-111 waste volume remained at 519,000 to 520,000-gallons for three months (July thru September 1965). SST C-111 showed a decrease in waste volume from October 1965 through June 1969, losing 1,000 to 5,000-gallons per quarter for a total level decline of 22,000 gallons.

C-105 Leak Assessment
Tank C-105 leak information was presented and discussed. Logging data obtained from nearby drywells and logging and sample data from drywell C4297 shows the potential for three separate releases: a tank overflow at the spare inlet nozzle, a pipeline leak and a tank leak. Information presented will be included in the assessment report.

Actions were assigned for the next meeting. Participants agreed that potential spare inlet and pipeline leaks were likely small in comparison to the high gamma activity measured in drywell 30-05-07. An action was assigned to calculate a leak volume for the plume observed at drywell 30-05-07 assuming: a 9 ft radius, a Cs-137 concentration of 10^7 pCi/g from 35 to 45 ft and 10^5 pCi/g from 45 to 65 ft, and a PUREX supernatant (P1) waste.

Volume and inventory calculations and further discussion of C-105 leak estimates and uncertainties will continue next meeting.

Next Meeting AGENDA
Continue C-105 Leak Assessment

ACTIONS:
M. Johnson: Check availability of temperature data and add waste surface level diagram to information packet.
J. Field: Prepare and distribute 5-15-07 Meeting Summary.
J. Field/P. Henwood: Calculate C-105 leak volume and inventories as discussed.
M. Wood: Compare C4297 sodium concentration w/SX-108 data.
J. Field: Continue to prepare C-Farm leak assessment report

Next Meeting:

Date:	May 29, 2007
Time:	3:00-4:30
Location:	ECOLOGY Office

MEETING SUMMARY

From: J. G. Field, CH2M HILL Hanford Group, Inc
Phone: 376-3753
Location: Ecology Office,
Date: May 29, 2007
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Joe Caggiano, ECOLOGY
Jim Field, CH2M HILL
Les Fort, ECOLOGY
Paul Henwood, S.M. Stoller
Mark Wood, FLUOR
Beth Rochette, ECOLOGY

PURPOSE:
Continue C-105 assessment

Review of Previous Meeting Summary:
The May 15, 2007 meeting summary was reviewed and approved.

Additional information was requested for the C-111 assessment report to further explain the 8 inch liquid level decrease "after the new electrode was installed." The assessment report will include the statement, "The decrease in liquid level measurements observed after installing a new manual tape electrode is attributed to instrument error." A brief discussion of electrode measurement changes will also be included.

The status of the tank farm leak process document and initial leak assessment report were also discussed. ORP is preparing a letter to transmit the leak process document to Ecology for concurrence and to stakeholders for review. The leak assessment report for tanks C-101 and C-110 was informally transmitted to Ecology for comment and is scheduled to be released in parallel with the leak process document.

C-105 Leak Assessment
Temperature data and a tank waste surface diagram were added to the C-105 information to be included in the assessment report. The temperature data was more recent than estimated tank leak dates and was not considered further.

C-105 leak volume calculations developed based on assumptions discussed in the previous meeting were reviewed. Calculations were made for Cs-137 waste concentrations of 0.62 Ci/gal and 3.1 Ci/gal based on average and maximum concentration estimates for PUREX Supernate (PSN or P1 liquid) in the Soil Inventory Model (SIM). For a concentration of 3.1 Ci/gal a leak volume of 480 gal was calculated. For a concentration of 0.62 Ci/gal a leak volume of 2,400 gal was estimated. These calculations were determined to provide an average leak loss.

Next a comparison was made between the sodium concentration for samples analyses from well C4297 and the analyses for sodium samples from a borehole at SX-108. The sodium concentration for SX-108 was much higher as was Cs-137.

For a maximum leak volume for the plume measured at drywell 30-05-07 additional calculations were requested. The maximum volume calculations will assume the same waste concentrations, but a larger leak radius. The larger radius was determined to be a possibility if more of the waste leaked under tank C-105. The maximum radius will be estimated based on Cs-137 sorption capacity properties and assuming the center of the leak radius is near the tank knuckle on the tank wall which is generally a weak point on the tank.

Participants then discussed whether “lower activity”/near surface contamination observed near C-105 in drywells other than 30-05-07 should be included in leak volume estimates. Because the “lower activity” contamination appears to be from sources other than the tank, it will not be included in “tank leak” estimates. However, the lower activity sources will be discussed further to estimate near surface leak volumes from other C-Farm Unplanned Releases (UPRs).

Next Meeting AGENDA
Final C-105 Leak Assessment

ACTIONS:
J. Field: Prepare and distribute 5-29-07 Draft Meeting Summary.
M. Wood: Determine maximum leak volume radius.
J. Field: Calculate maximum C-105 leak volume and inventory based on input from Mark Wood.
M. Johnson: Prepare information for other C-Farm tanks and UPRs
J. Field: Continue to prepare C-Farm leak assessment reports

<u>Next Meeting:</u>

Date:	June 12, 2007
Time:	3:00-4:30
Location:	ECOLOGY Office

MEETING SUMMARY

From: J. G. Field, CH2M HILL Hanford Group, Inc
Phone: 376-3753
Location: Ecology Office,
Date: June 12, 2007
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Joe Caggiano, ECOLOGY
Jim Field, CH2M HILL
Les Fort, ECOLOGY
Paul Henwood, S.M. Stoller
Beth Rochette, ECOLOGY

PURPOSE:
Continue C-105 assessment

Review of Previous Meeting Summary:
The May 29, 2007 meeting summary was reviewed and approved.

C-105 Leak Assessment

It was concluded that contamination measured in drywell 30-05-07 was likely the result of a tank leak, probably from the base of the tank. The balance of the meeting was to discuss the volume and inventory of the contamination.

An e-mail from Ecology regarding the ~ 100 kgal liquid level decrease in tank C-105 observed between 1963 and 1967 was discussed. Previous documentation attributes the 1963 to 1967 liquid level decrease in tank C-105 to evaporation. However, evaporation calculations assuming a 5 cfm air flow and a temperature of 150 F accounted for only 25% of the liquid level decrease. The actual tank temperature from 1963 to 1967 is unknown. The 150 F temperature is between 100 F (estimate for tank temperature before receiving the SU and a measured temperature of 220 F for the A-102 supernatant transferred to tank C-105 in May 1963. The 5 cfm airflow was assumed as the natural air flow temperature within the tank, prior to installation of an exhauster.

Based on steam tables, at an air flow of 5 cfm and temperature of 220 F ~ 40 gal/min would be exhausted or 18 million gallons/year. The group will take a closer look at the relative amount of A-102 supernatant to the amount and type of waste already in the tank in an attempt to more closely bound temperature and evaporation estimates.

Marc Wood completed the action to determine a “Maximum” radius for the contamination observed at drywell 30-05-07. The radius was determined to be about 12 ft for the distance from the tank side wall to drywell C4297, the closest drywell to 30-05-07 and 3 ft from the tank to 30-

05-07. In addition, a concentration for the PSN-IX supernatant in tank C-105 in 1969 was 4.34 Ci/gal (ARH-1945). Therefore calculations were revised using this concentration in place of the SIM concentration estimates of 0.62 to 3.1 Ci/gal used in previous calculations.

1. For a minimum leak volume a 30 ft cylinder (10 ft with Cs-137 logged at about 10^7 pCi/g and 20 ft at about 10^5 pCi/g.) and with a pt. source leak and a 3 ft radius (distance from the tank to drywell 30-05-07). The assumption that the leak may not have extended much beyond 30-05-07 assumes the leak concentration is below Cs-137 sorption capacity and is based on the theory, to be explained in the assessment report, that Cs-137 sorption capacity is reached before a plume continues to migrate. The resulting calculation is 165 Ci plume. For a 4.3 Ci/gal waste concentration this would be less than a 40 gal leak.

2. For a maximum leak volume for the plume measurements (10 ft at 10^7 and 20 ft and 10^5) at drywell 30-05-07 a cylinder with a 12 ft radius was assumed. This is the distance between the tank and the closest dry well to 30-05-07(drywell C4297) showing no indication of contamination comparable to that found in 30-05-07. A plume activity of 2,630 Ci was calculated. For a concentration of 4.34 Ci/gal this equates to 620 gal. This was deemed plausible if the logged concentrations of 10^7 pCi/g were at sorption capacity. If this were the case the plume could have migrated to near, but just short of drywell C4297 w/o detection.

3. A maximum leak volume of approximately 5,200 Ci and 1,200 gal was calculated assuming a 30 ft long, 3 ft radius (distance from tank wall to 30-05-07) cylinder at a Cs-137 sorption capacity based on SX-108 sample data (1.7 E +8 pCi/g) encircled by a 12 ft radius cylinder (distance from tank wall to C4297). This scenario is inconsistent with Cs-137 sorption capacity theory.

4. The leak could also have spread out along the tank wall to less than ¼ of the tank circumference without being detected by other drywells then migrated to a 12 ft radius. This would equate to approximately 5 times the volume of a point source leak as calculated in all of the previous scenarios, multiplied by scenario 2 this equates to 13,000 Ci and 3,100 gal for a maximum leak volume based on drywell measurements.

The above scenarios will be written up in tabular form. Evaporation volume estimates reviewed more closely and a maximum leak volume determined in the next meeting

Additional discussion

The C-Farm assessment reports for tanks C-101 and C-110 were discussed. Ecology reviewed the report and had no initial comments. The report will be further reviewed by Ecology and comments sent next week. Recognizing the need to reference the assessment report in the C-110 TWRWP, Ecology suggested CH2 remove reference to the leak process document in the assessment report for tanks C-101 and C-110 (Rev. 0) and concurred with issuing the C-101 and C-110 leak assessment report before the leak process document is completed.

For the next three meetings we will wrap up C-105 discussion, then start C-Farm UPR discussions, followed by discussion of liquid levels and available data for other C-Farm tanks.

NEXT MEETING AGENDA
Final C-105 Leak Assessment, UPR Assessments

ACTIONS:
J Field: Prepare and distribute 6-12-07 Draft Meeting Summary.
Joe Caggiano: Review leak assessment report
Les Fort: Further review C-105 temperature for evaporation estimates
J. Field: Prepare C-105 alternative calculations table
M. Johnson: Prepare information for other C-Farm tanks and UPRs
J. Field: Continue to prepare C-Farm leak assessment reports

NEXT MEETING:

Date:	July 10, 2007
Time:	3:00-4:30
Location:	ECOLOGY Office

MEETING SUMMARY

CH2MHILL
Hanford Group, Inc.

From: J. G. Field, CH2M HILL Hanford Group, Inc
Phone: 376-3753
Location: Ecology Office,
Date: July 24, 2007
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Joe Caggiano, ECOLOGY
Jim Field, CH2M HILL
Les Fort, ECOLOGY
Paul Henwood, S.M. Stoller
Linda Lehman, CH2M HILL
Beth Rochette, ECOLOGY
Mark, Wood, Fluor Hanford

PURPOSE:
Continue C-105 assessment, Start UPR assessments

Review of Previous Meeting Summary:
The June 12, 2007 meeting summary was reviewed and approved.
On July 10 Ecology was briefed on a preliminary C-Farm DQO and work plan. No tank farm leak assessment meeting was held as previously scheduled.

C-105 Leak Assessment

CH2M HILL presented the attached information. It was determined that without a measured tank waste temperature at the time of the liquid level decreases, evaporation calculations have too much uncertainty and neither the liquid level decreases or evaporation estimates should be used as a basis for C-105 leak volume estimates. Participants agreed that the only reasonable basis for the C-105 leak volume estimates is the vadose zone contamination measured in drywell 30-05-07 and the proximity of 30-05-07 to the tank and other drywells with lower measured gamma activity. Calculations for three scenarios were discussed (see attached). For the "upper bounding" scenario an approximation was made and more formal calculations are still needed. Ecology will review the vadose zone information and calculations presented for further discussion and a final determination next week. It was agreed that the terms "average" and "mean" should not be used with respect to volume estimates because there is insufficient data for a statistical assessment. Estimates are for an "upper bound" scenario and "reference case."

UPR 200-E-82
Marc Wood presented information on UPR 200-E-82. It was noted that there was no Cs-137 detected in soil samples taken from direct push measurements around the UPR, likely because

they were too far away. Dry well 30-00-11 is the closest dry well, but there are no nearby drywells. Original estimates are that this was a 2,600 gallon pipe leak. A Gunnite cap was installed, but not for 20 years after the leak. It was determined that old data could be used to estimate an upper range leak volume based on Cs sorption principles. Following the meeting, this information was assembled and is attached for discussion in the next meeting.

NEXT MEETING AGENDA

1. Final C-105 Leak Assessment, UPR 200-E-82 Assessment

ACTIONS:

1. J. Field: Prepare and distribute 7-24-07 Draft Meeting Summary.
2. ECOLOGY: Review C-105 dry well calculations
3. Marc Wood: Send UPR-82 figures to assessment participants
4. Marc Wood: Prepare UPR-82 leak volume calculation based on Cs sorption approach.
5. J. Field: Bring C-Farm map showing UPR locations to next meeting

<u>NEXT MEETING:</u>

Date: August 8, 2007
Time: 3:00-4:30
Location: ECOLOGY Office

Attachment 1

Tank C-105 Assessment

It is probable that the contamination around SST C-105 stems from different events. Pipeline V103, the cascade overflow pipeline from SST 241-C-104, spare inlet nozzles on SST C-105, and a leak near the base of tank C-105 are all probable sources of waste loss events.

This assessment concluded that a tank leak was a probable source of drywell 30-05-07 contamination. "Lower activity" contamination in other dry wells was determined to be from near surface sources and was not attributed to a tank leak. The "lower activity" sources near tank C-105 will be further assessed in the future to estimate near surface leak volumes and inventories for other C-Farm Unplanned Releases (UPRs).

Evaporation

Previous documentation attributes a 100 kgal liquid level decrease in tank C-105 from 1963 to 1967 to evaporation. The actual tank temperature from 1963 to 1967 is unknown. The temperature of supernatant received from tank A-102 was 220 ^{o}F.

At a saturated air flow of 5 cfm (assumed as the natural air flow within the tank, prior to installation of an exhauster) and temperature of 220 ^{o}F, steam tables show ~ 40 gal/min would be exhausted or 18 million gallons/year. This would more than account for the liquid level decrease. However, the actual temperature of the waste at the time of the leak is somewhere between the waste temperature prior to receipt of A-102 waste and the temperature of the A-102 waste. A weighted average temperature of 192 ^{o}F was calculated based on the relative amounts of A-102 supernatant added (407,000 gal) compared to the supernatant waste volume before receiving A-102 (125,000) gal. and assuming the temperature of C-105 waste was only 100 ^{o}F before receiving supernate from tank A-102.

Tank Leak Estimate based on Gamma Logging

The focus of this assessment was to estimate volume and inventory of a tank leak. Although calculations indicate evaporation could account for most of liquid level decrease, contamination observed in drywell 30-05-07 appears to come from tank C-105. The ^{137}Cs activity levels were much lower and nearer to the waste surface or tank spare inlet ports for all other dry wells. Even in dry well C4297, only 9 ft away from drywell 30-05-07, significantly lower gamma activity was measured well above the tank bottom. Therefore only drywell 30-05-07 measurements were included in tank leak calculations.

The concentration for ^{137}Cs in PSN-IX supernatant in tank C-105 in 1969 was 4.34 Ci/gal (Tanaka 1971). The same concentration is assumed at the time of the leak. Leak volumes based on a 4.34 Ci/gal ^{137}Cs concentration, soil density of 2.0 g/cm^3 and gamma logging measurements were calculated as follows:

1. For a minimum leak volume a 3 ft long cylinder (10 ft with Cs-137 logged at about 10^7 pCi/g and 20 ft at about 10^5 pCi/g), with a point source leak and a 3 ft radius (distance from the tank to drywell 30-05-07) is assumed. The assumption that the leak may not have extended much

beyond 30-05-07 is based on the observation that the leak concentration may be below Cs-137 sorption capacity and is based on the theory that Cs-137 sorption capacity is reached before a plume continues to migrate (See Appendix B). The resulting calculation, shown below, is a 165 Ci plume. For a 4.3 Ci/gal waste concentration this would be less than a 40 gal leak.

Volume of 3 ft radius and 10 ft long cylinder = 8.1 m^3 *@* 10^7 *pCi/g*
Volume of 3 ft radius and 20 ft long cylinder = 16.2 m^3 *@* 10^5 *pCi/g*

8.1 m^3 ** 2 g/*cm^3 *** 10^7 *pCi/g = 162 Ci*
16.2 m^3 **2 g/*cm^3 *** 10^5 *pCi/g = 3 Ci*

165 Ci / 4.3 Ci/gal = 38 gal

2. An average leak volume for the plume measurements (10 ft at 10^7 and 20 ft and 10^5 pCi/g) at drywell 30-05-07 a cylinder with a 12 ft radius was assumed. This is the distance between the tank and the closest dry well to 30-05-07(drywell C4297) showing no indication of contamination comparable to that found in 30-05-07. A plume activity of 2,630 Ci was calculated. For a concentration of 4.34 Ci/gal this equates to 620 gal. This was deemed plausible if the logged concentrations of 10^7 pCi/g were near sorption capacity. If this were the case the plume could have migrated to near, but just short of drywell C4297 w/o detection.

Volume of 12 ft radius and 10 ft long cylinder = 129 m^3 *@* 10^7 *pCi/g*
Volume of 12 ft radius and 20 ft long cylinder = 258 m^3 *@* 10^5 *pCi/g*

129 m^3 ** 2 g/*cm^3 *** 10^7 *pCi/g = 2,580 Ci*
258 m^3 **2 g/*cm^3 *** 10^5 *pCi/g = 52 Ci*

2,630 Ci / 4.3 Ci/gal = 614 gal

3. The leak could also have spread out along the tank wall to less than ¼ of the tank circumference without being detected by other drywells then migrated to a 12 ft radius. This would equate to approximately 5 times the volume of a point source leak as calculated in scenario #2, this equates to approximately 13,000 Ci and 3,100 gal for a maximum leak volume based on drywell measurements.

Tank C-105 Leak Assessment Summary					
Item	**When**	**Estimated Leak Volume (gallons)**	**Range of Leak Volume (gallons)**	**Possible Sources**	**Comments**
Current HNF-EP-0182 rev. 219 (June 2006)	NA	0	NA	Contamination in borehole 30-05-07 attributed to a pipe leak	The contamination around SST C-105 likely stems from different events. Pipeline V103, the cascade overflow pipeline from SST 241-C-104, spare inlet nozzles on SST C-105, and a leak near the base of tank C-105 are all probable sources of waste loss events.
Liquid Level Decrease	1963 to 1967	100,000 gallons 36 in.	NA	Tank liquid level measurements	The actual tank temperature from 1963 to 1967 is unknown. The temperature of supernatant received from tank A-102 prior to the leak was 220 F. A weighted average temperature of 192 F was calculated based on the relative amounts of A-102 supernatant added (407,000 gal) compared to the total waste volume before receiving A-102 supernatant (125,000) gal. and assuming the temperature of C-105 waste was 100 F before receiving supernatant from tank A-102.
Leaks volume based on Drywell 30-05-07 log	Well logged in 1974	Minimum 40 gal Average 600 gal Maximum 3,100 gal	40-3,100 gal.	Tank, Line leak (appears less likely)	Use 4.34 Ci/gal for ^{137}Cs concentration from supernatant analysis. Contamination measured at 10^7 pCi/g from 35 to 45 ft bgs (10 ft) and 10^5 pCi/g from 45 to 65 ft bgs (20 ft). Min volume: Assumes point source, cylindrical plume, 3 ft radius, 30 ft deep. Ave volume: Assumes, point source, cylindrical plume, 12 ft radius, 30 ft deep. Max. volume: Assumes, ¼ tank circumference source, with 12 foot radius, 30 ft deep.
SGE data	October 2006	No estimate	No estimate	No source identified	Areas of low resistivity were found on the south side of SST C-105.
SIM Estimate		1,000			Assumes a 1,000 gallon leak loss.
SIM Mean Inventory	^{137}Cs	620 Ci			Assumes leak date of 1972 and uses predominantly a PUREX (PSN-IX or P1) waste type. SIM range for ^{137}Cs is 26 to 3,100 Ci back decayed to 1972 = 50 to 6,100 Ci or 0.05 to 6.1 Ci/gal. This bounds a measured ^{137}Cs conc. Of 4.3 Ci/gal.
Decayed to 1/1/2001	^{99}Tc	.23 Ci			
	^{90}Sr	9.0 Ci			
	Cr	1.4 kg			

MEETING SUMMARY

CH2MHILL
Hanford Group, Inc.

From: J. G. Field, CH2M HILL Hanford Group, Inc
Phone: 376-3753
Location: Ecology Office,
Date: August 7, 2007
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Joe Caggiano, ECOLOGY
Jim Field, CH2M HILL
Les Fort, ECOLOGY
Paul Henwood, S.M. Stoller
Beth Rochette, ECOLOGY

PURPOSE:
Continue C-105 assessment and UPR 200-E-82 assessments

Review of Previous Meeting Summary:
The July 24, 2007 meeting summary was reviewed and approved. It was noted that additional discussion of C-105 leak volume calculations is needed.

C-105 Leak Assessment

An alternate calculation was provided by Ecology and discussed.
The assumptions and calculation will be reviewed and discussed further in the next meeting.

UPR 200-E-82

Information attached in the 7/24/07 meeting minutes was discussed. Prior to assessing a leak volume/inventory for UPR 82 additional information was requested regarding the techniques used for investigations reported in Tanaka (1971). As written, it was unclear to participants whether measurements were based on sample analysis or logging data. It was determined that radioactivity results presented were from analytical data not logging data. A better understanding of the analytical methods used, detection limits, and uncertainty is needed. It was also noted that in the information presented, analytical results are in mCi/g units vs. more common pCi/g units. Actions were assigned to review analytical methods and uncertainty.

It was also noted that the activity levels presented in Tanaka have not been observed in more recent vertical push logging near UPR-182. This may be because the vertical push could only get within 20 ft of the gunnite pile covering UPR 82. It could also indicate the contamination was cleaned up. The possibility of the contamination being a shorter lived nuclide Co-60 or Ru-106 vs. Cs-137 was also raised. An action was taken to investigate these questions.

Finally it was noted that measurements at well #5 (Figure 3) were more characteristic of expected Cs-137 distribution than measurements for Well #11 (Figure 4). A possible reason for the differences is the presence of a “caliche” layer at 15 ft bgs in well #11.

NEXT MEETING AGENDA

1. Final C-105 Leak Assessment, UPR 200-E-82 Assessment

ACTIONS:

1. J. Field: Prepare and distribute August 7, 2007 Draft Meeting Summary.
2. J. Field: Review analytical methods and uncertainty for UPR 82 data.
3. J. Field: Review possible reasons for not detecting Cs-137 near UPR 82 in recent vertical pushes.
4. J. Field: Review C-105 maximum leak volume calculation and assumptions.

NEXT MEETING:

Date: August 28, 2007
Time: 3:00-4:30
Location: ECOLOGY Office

MEETING SUMMARY

CH2MHILL
Hanford Group, Inc.

From: J. G. Field, CH2M HILL Hanford Group, Inc
Phone: 376-3753
Location: Ecology Office,
Date: August 28, 2007
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Joe Caggiano, ECOLOGY
Jim Field, CH2M HILL
Les Fort, ECOLOGY
Paul Henwood, S.M. Stoller
Beth Rochette, ECOLOGY

PURPOSE:
Complete C-105 assessment and continue UPR 200-E-82 assessment

Review of Previous Meeting Summary:
The August 7, 2007 meeting summary was reviewed and approved with a change to delete the calculation submitted by Ecology.

C-105 Leak Assessment
Leak loss calculations and an assessment developed by a joint effort between Ecology and CH2M HILL were discussed and accepted by the panel. The assessment write-up (Attached) will be included in the C-105 assessment report. The maximum leak calculated was approximately 2,000 gallons and 8,000 Ci of Cs-137. The waste type leaked was a PSN-IX supernatant.

UPR 200-E-82
The information shown in Attachment 2 *(not included)* was presented by Mark Wood. This information was previously included with the July 24, 2007 meeting minutes and is included here for convenience. Comments and questions related to the analyses presented in Tanaka (1971) and the approach presented were discussed and compared. The bounding leak inventory calculated by Wood is 2,000 gallons and 8,600 Ci of Cs-137. Ecology will review the attached information and discuss calculated leak losses further in the next meeting.

NEXT MEETING AGENDA
1. Complete UPR 200-E-82 Assessment and start UPR 200-E-86 Assessment

ACTIONS:

1. J. Field: Prepare and distribute August 28, 2007 Draft Meeting Summary.
2. P. Henwood: Review logging data near UPR 200-E-86.
3. M. Wood: Prepare 200-E-86 information developed for the C-Farm FIR
4. Ecology: Review C-105 maximum leak volume calculation and assumptions.
5. Ecology: select next C-Farm UPRs to assess
6. J. Field: Revise RPP-ENV-33418 "Hanford C-Farm Leak Assessments Report: 241-C-101 and 241-C-110," to include assessments for tanks C-111 and C-105.

NEXT MEETING:

Date: September 11, 2007
Time: 3:00-4:30
Location: ECOLOGY Office

Attachment 1 (*August 28, 2007 Meeting Summary*)

Tank 241-C-105 Assessment

As shown in section 3.4.3, it is probable that the contamination around SST 241-C-105 stems from different events. Pipeline V103, the cascade overflow pipeline from SST 241-C-104, spare inlet nozzles on SST 241-C-105, and a leak near the base of tank C-105 are all probable sources of waste loss events.

Based on new data and information presented in Section 3.4.3, this assessment concluded that a tank leak was a probable source of drywell 30-05-07 contamination. "Lower activity" contamination in other dry wells was determined to be from near surface sources and was not attributed to a tank leak. The "lower activity" sources near tank C-105 will be further assessed in the future to estimate near surface leak volumes and inventories for other C-Farm Unplanned Releases (UPRs).

Evaporation

Previous documentation attributes a 100 kgal liquid level decrease in tank C-105 from 1963 to 1967 to evaporation. The actual tank temperature from 1963 to 1967 is unknown. The temperature of supernatant received from tank A-102 was 220 ^{o}F.

At a saturated air flow of 5 cfm (assumed as the natural air flow within the tank, prior to installation of an exhauster) and temperature of 220 ^{o}F, steam tables show ~ 40 gal/min would be exhausted or 18 million gallons/year. This would more than account for the liquid level decrease. However, the actual temperature of the waste at the time of the leak is somewhere between the waste temperature prior to receipt of A-102 waste and the temperature of the A-102 waste. A weighted average temperature of 192 ^{o}F can be calculated based on the relative amounts of A-102 supernatant added (407,000 gal) compared to the supernatant waste volume before receiving A-102 (125,000) gal and assuming the temperature of C-105 waste was only 100 ^{o}F before receiving supernate from tank A-102. Assuming saturated steam at 5 cfm this equates to ~ 8,000 gallons/year. Although more reasonable, this evaporation estimate does not take into account potential heat losses.

Lacking a known tank waste temperature at the time of the leak, evaporation estimates are highly uncertain such that liquid level decreases observed may be entirely or only partially due to evaporation. Consequently, leak volume and inventory estimates will be based only on vadose zone gamma logging measurements.

Tank Leak Estimate based on Dry Well Gamma Logging

As noted, previously, only the contamination observed in drywell 30-05-07 is attributed to a potential leak from tank C-105. The ^{137}Cs activity levels were much lower and nearer to the waste surface or tank spare inlet ports for all other dry wells. Even in dry well C4297, only 9 ft away from drywell 30-05-07, significantly lower gamma activity was measured well above the tank bottom. Therefore only drywell 30-05-07 measurements were included in tank leak calculations.

The concentration for ^{137}Cs in PSN-IX supernatant in tank C-105 in 1969 was 4.34 Ci/gal (Tanaka 1971). The same concentration is assumed at the time of the leak. Leak volumes based on a 4.34 Ci/gal ^{137}Cs concentration, soil density of 2.0 g/cm^3 and gamma logging measurements (see Figure 4-25) were calculated as follows:

1. For a minimum leak volume a 30 ft long cylinder (10 ft with Cs-137 logged at about 10^7 pCi/g and 20 ft at about 10^5 pCi/g), with a point source leak and a 3 ft radius (distance from the tank to drywell 30-05-07) is assumed. The assumption that the leak may not have extended much beyond 30-05-07 is based on the observation that the leak concentration may be below Cs-137 sorption capacity and is based on the theory that ^{137}Cs sorption capacity is reached before a plume continues to migrate (See Appendix B). The resulting calculation, shown below, is a 165 Ci plume. For a 4.3 Ci/gal waste concentration this would be less than a 40 gal leak.

Volume of 3 ft radius and 10 ft long cylinder = 8.1 m^3 @ 10^7 pCi/g
Volume of 3 ft radius and 20 ft long cylinder = 16.2 m^3 @ 10^5 pCi/g

*8.1 m^3 * 2 g/cm^3 * 10^7 pCi/g = 162 Ci*
*16.2 m^3 *2 g/cm^3 * 10^5 pCi/g = 3 Ci*

165 Ci / 4.3 Ci/gal = 38 gal

2. A maximum leak volume was calculated assuming a leak could extend along as much as a quarter of the tank perimeter without being detected. For simplicity of geometry, the leak was assumed to spread horizontally 24 ft, 12 ft outside the tank perimeter and 12 ft under the tank from 35 to 65 ft bgs (12 ft is the distance between the tank and the closest dry well to 30-05-07 (vadose zone borehole C4297) showing no indication of contamination comparable to that found in 30-05-07). This forms a plume 30 feet below the base of the tank with an inner an outer ring (like a rind) with radiuses of 25.5 feet and 49.5 ft respectively. The upper 10 feet of the plume has a concentration of 10^7 pCi/g ^{137}Cs and the concentration of the lower 20 ft is 10^5 pCi/g Cs-137.

For a tank diameter of 75 ft, ¼ circumference = 2πr/4 = 2π(37.5)/4 = 59 ft
*Upper Plume Volume = 10*24*59 = 14,140 ft^3 = 400 m^3 @ 10^7 pCi/g*
*400 m^3 * 2 g/cm^3 * 10^7 pCi/g = 8,000 Ci*

*Lower Plume Volume = 20*24*59 = 28,280 ft^3= 800 m^3 @ 10^5 pCi/g*
*800 m^3 * 2 g/cm^3 * 10^5 pCi/g =160 Ci*

(8,000 + 160)Ci / 4.3 Ci/gal = 1,900 gal or ~ 2,000 gal

MEETING SUMMARY

CH2MHILL
Hanford Group, Inc.

From: J. G. Field, CH2M HILL Hanford Group, Inc
Phone: 376-3753
Location: Ecology Office,
Date: September 25, 2007
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Joe Caggiano, ECOLOGY
Jim Field, CH2M HILL
Les Fort, ECOLOGY
Paul Henwood, S.M. Stoller
Linda Lehman, CH2M HILL
Mike Johnson, CH2M HILL
Marcus Wood, FLUOR

PURPOSE:
Complete UPR 200-E-82 Assessment and start UPR 200-E-86 Assessment.

Review of Previous Meeting Summary:
The August 28, 2007 meeting summary was reviewed and approved with minor edits.

C-Farm Assessment Report
Discussed the draft C-Farm Assessment Report (RPP-ENV-33418 Rev. 1), which adds the tank C-111 and C-105 assessments. Draft report was distributed for review on Sept. 13, 2007. Reminded participants that comments were requested by September 28.

As part of the assessment process, CH2M HILL and Ecology management requested that the team identify/recommend where additional field activities could further reduce inventory uncertainty in tank farm leak volume and inventory estimates.

UPR 200-E-82 Assessment Conclusion
Ecology reviewed the information presented in the previous meeting and concurred with a maximum leak inventory for UPR 200-E-82 of 2,100 gallons of PSN-IX waste, including 100 gallons of waste reported by Tanaka (1971) as reaching the surface. This equates to a maximum ^{137}Cs inventory of 9,000 Ci (what is the decay date for this inventory?).

It was noted that the distribution of waste in the soils was consistent with information reviewed from other sources.

UPR 200-E-86 Assessment
Dr. Wood presented the conceptual model and information for UPR 200-E-86 from the WMA C Subsurface Conditions Descriptions Report (SCDR) (RPP-14430), which includes information from RHO-CD-673; a letter on the PSS line leak from Borshiem to Metz dated November 9, 1972 (UN-216-E-14). No additional drywell data was obtained near this UPR. Dr. Wood observed that the historical conceptual model for the line leak is inconsistent with AR Vault process mass balance data showing a leak loss of 17,385 gallons of PSS containing 1.35 Ci/gal of ^{137}Cs (decay date of February 1971). The historical conceptual model accounts for only a fraction of the ^{137}Cs lost based on process records.

Current plans described in the Near Term C-Farm Characterization Work Plan are to obtain direct push samples from a ring of holes placed around a Gunite cap covering the line leak at a location defined by the occurrence of surface liquid at the time of the leak. Characterization north of the Gunite cap is a good location. However, given the amount of contamination unaccounted for by the historical conceptual model and because no contamination was found in wells 1,2,3, 6 and 7, the contamination could extend further North than previously thought and additional characterization further north of the Gunite covering may be needed.

Additional references will be reviewed to further assess contamination extent in the next meeting.

NEXT MEETING AGENDA

1. Complete UPR 200-E-86 Assessment and start UPR 200-E-81 and UPR 200-E-27. If time, continue discussion on "acceptable" uncertainty and how to handle “small” UPRs and overflows.
2. Quantify UPR & C-Farm leaks in the Soil Inventory Model (SIM)
3. Discuss Mike Johnson's Write-up on potential additional waste loss events in C Farm

ACTIONS:

1. J. Field: Prepare and distribute September 25, 2007 Draft Meeting Summary.
2. P. Henwood: Review logging data near UPR 200-E-81 and UPR 200-E-27.
3. M. Wood: Prepare 200-E-81 information developed for the C-Farm FIR
4. M. Johnson: Review UPR-200-E-86 references for further discussion
5. M. Johnson: Prepare UPR 200-E-27 information
6. J. Field: Prepare SIM C-Farm inventory estimates
7. All: Review RPP-ENV-33418, Rev. 1 “Hanford C-Farm Leak Assessments Report: 241-C-101, 241-C-110, 241-C-111 and 241-C-105.

<u>**NEXT MEETING:**</u>

Date: October 9, 2007
Time: 3:00-4:30
Location: ECOLOGY Office

MEETING SUMMARY

CH2MHILL Hanford Group, Inc.

From:	J. G. Field, CH2M HILL Hanford Group, Inc
Phone:	376-3753
Location:	Ecology Office,
Date:	October 9, 2007
Subject:	Tank Farm Leak Evaluation
To:	Distribution/Attendees
Attendees:	Jim Field, CH2M HILL Les Fort, ECOLOGY Paul Henwood, S.M. Stoller Linda Lehman, CH2M HILL Mike Johnson, CH2M HILL Beth, Rochette, ECOLOGY Marcus Wood, FLUOR

PURPOSE:
Complete UPR 200-E-86 Assessment and start UPR 200-E-81 and UPR 200-E-27.
If time, continue discussion on "acceptable" uncertainty and how to handle “small” UPRs and overflows

Review of Previous Meeting Summary:
The September 25, 2007 meeting summary was reviewed and approved.

UPR 200-E-86 Assessment
Additional references pertaining to the UPR were discussed. ARH-1895-1 p.88-91, 113, and 114 identify a suspected leak in the PSS line between the 244 AR vault and 151-C diversion box at about 10 gal/min and state that “about 80 feet of line must be replaced.” Drawings H-2-58609, H-2-61967 and H-2-61962 presented show that that a new section of line was installed, by-passing the contaminated area. Drawings and information discussed will be included in the assessment report. [Decision made to only include references to drawings in report.]

The bounding volume of the leak was determined to be 17,350 (17K) gallons of PSS liquid waste containing 1.35 Ci/gal of 137Cs (decay date of February 1971). Inventory estimates for other constituents will be ratioed based on the measured Cs concentration and Soil Inventory Model (SIM) estimates. Data is insufficient to determine a minimum or central tendency leak loss inventory for this UPR. Additional characterization work is planned for FY 2008.

UPR 200-E-81 Assessment
Mike Johnson and Marcus Wood presented information on this UPR. RHO-CD-673 identifies UPR 200-E-81 as a line leak from PUREX plant to tank 102-C near the 241-CR-151 diversion box. Approximately 36,000 gallons of waste was lost to the soil. A puddle of contaminated

liquid (approximately 6 X 40 feet) was discovered a few feet west of the 151-CR diversion box. The UPR will be further described in the assessment report. The inventories for several constituents are included in RHO-CD-673; all other constituent inventories will be ratioed to Soil Inventory Model (SIM) estimates. The bounding leak volume was determined to be 36,000 gallons. Like UPR-86, there was no basis for a minimum or central tendency waste volume and additional characterization of this UPR is planned in FY 2007.

UPR 200-E-27 Assessment

Mike Johnson presented information on this UPR. Three references were cited. The *Hanford Site Waste Management Units Report* (DOE-RL-88-30, rev. 15 page 669) states in 1960 "Beta/gamma contamination (specks) with readings of 50 to 100 millirads/hour was found near the vault. Readings of particles on surfaces outside the tank farm fence area were up to 40,000 counts/minute". The *Summary of Environmental Contamination Incidents at Hanford, 1958 – 1964* (HW-84619, page 7) states "On November 1, 1960 during work in the 241-CR vault, winds spread contaminated particles from the vault generally east and out to several hundred feet beyond the limited area fence. Contamination levels around the vault were on the order of 50 to 100 mrad/hr. Particles outside the fence read as high as 40,000 c/m on a GM meter. No private vehicles were involved." The *Chemical Processing Department Monthly Report for November 1960* (HW-67459 page B-2) states that, "a heavy schedule of diversion box work was experienced during the month. This work included unplugging of the drain line in the 001 vault; unplugging of the 001-CR sump weight factor dip tube" and installation and change out of several jumpers in the 244-CR vault. HW-67459 page B-3 also states "a small amount of fission product contamination was spread during work in a diversion box in the 241-CR tank farm. Levels varied from 50 to 100 mrad/hr at the edge of the box". CH2M HILL will look at routine farm surveys to see if they indicate a particulate release is still present in this area. Particulate releases are generally assumed to be small and are not included in SIM. No inventory was determined for this UPR.

Other UPRs and Releases

Other UPRs and releases in the C-Farm were then considered. A print out showing leak volume and inventories currently in SIM for C-Farm was discussed. A description of all UPRs will be included in the assessment report for completeness. In the next meeting Mike Johnson will discuss supplemental contamination information for tank overflows and line leaks and Paul Henwood (S. M. Stoller, Inc.) will provide an overview of Dry well information in C-Farm to determine if other areas should be assessed by the team.

NEXT MEETING AGENDA

1. Review Radiation Surveys for UPR 200-E-27.
2. Review and discuss supplemental contamination information.
3. Look at remaining C-Farm tanks.

ACTIONS:

1. J. Field: Prepare and distribute October 9, 2007 Draft Meeting Summary.
2. P. Henwood: summarize C-Farm dry well data and other potential contamination areas.
3. M. Johnson: Prepare assessment report input for UPRs 200-E-82, 86, 81 and 27.
4. M. Johnson: Review recent radiological surveys associated with UP 200-E-27 and down wind to determine if radioactivity levels are elevated in this location.
5. Ecology: Complete review of RPP-ENV-33418, Rev. 1 “Hanford C-Farm Leak Assessments Report: 241-C-101, 241-C-110, 241-C-111 and 241-C-105.

NEXT MEETING:

Date:	October 23, 2007
Time:	3:00-4:30
Location:	ECOLOGY Office

MEETING SUMMARY

CH2MHILL
Hanford Group, Inc.

From: J. G. Field, CH2M HILL Hanford Group, Inc
Phone: 376-3753
Location: Ecology Office,
Date: October 23, 2007
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Joe Caggiano, ECOLOGY
Jim Field, CH2M HILL
Les Fort, ECOLOGY
Paul Henwood, S.M. Stoller
Mike Johnson, CH2M HILL
Beth, Rochette, ECOLOGY

PURPOSE:
Review Radiation Surveys for UPR 200-E-27.
Review and discuss supplemental contamination information.
Look at remaining C-Farm tanks.

Review of Previous Meeting Summary:
The October 9, 2007 meeting summary was reviewed and approved with changes to include the action to review radioactivity surveys in C-farm associated with the UPR 200-E-27 particulate release. Ecology noted that additional time was needed to complete a review of DRAFT RPP-ENV-33418, *Hanford C-Farm Leak Assessments Report: 241-C-101, 241-C-110, 241-C-111 and 241-C-105*.

UPR 200-E-27 Assessment (continued)
Radioactivity surveys from 1996 to 2001 from the electronic records were presented and discussed. No radioactivity surveys were available closer to the time of the release. If these exist they are likely in the archives in Seattle and may be difficult to find. Photos presented indicate the release was uncovered up to 1993. The 1960 release was foamed after 1993 and covered with gravel and probably grouted when down posted in late 1997. The Radioactive dose was 37mR/hr after being foamed and <5 mR/hr after grouting.

It was agreed that information discussed should be included in the assessment report, but there is no basis provided for an inventory estimate. Subsequent surface investigations could consider sampling in this area.

S. M. Stoller Review of Unaccounted for Borehole Contamination in C-Farm
Stoller presented data for boreholes near tanks C-108/109, C-103 and C-104/105. The data clearly shows the presence and movement of Co-60 (generally at concentrations < 50 pCi/g).

Possible sources for the contamination were discussed including cascade lines near tanks C-104/105, C-108/109, and possible C-103 line leaks or an overfill near the inlet. It appears none of the borehole data presented unambiguously showed an indication of additional tank leaks in C-Farm, other than those previously assessed. However, it clearly showed the presence of additional contamination. Drywell logging data that do not correlate with in-tank liquid level measurements or other evidence of a release may be difficult to interpret. An assumption that the nearest tank is the source may not be valid, as releases from other sources within a farm may migrate to a position so as to be detected in a borehole. The S. M. Stoller presentation will be included in the assessment report.

Other Releases

General surface contamination in the farms was then discussed. It was noted that radioactivity levels for surface contamination are generally lower than radioactivity levels for tank leaks and deep vadose contamination. However, surface level contamination data is needed to assess direct exposure impacts. Surface contamination discussions and recommendation by the assessment team will provide a starting point for identifying additional surface characterization needs in the C-Farm DQO. The possibility of assigning a relative percentage or fraction of tank leak inventory estimates to encompass potential surface contamination was discussed and dismissed.

Next meeting Mike Johnson will present other potential sources of contamination from pipe leaks, overflows and spills and the team will continue to discuss inventory estimates for these sources.

NEXT MEETING AGENDA

1. Review and discuss supplemental contamination information.
2. Look at remaining C-Farm tanks.

ACTIONS:

1. J. Field: Prepare and distribute October 23, 2007 Draft Meeting Summary.
2. M. Johnson: Prepare assessment report input for UPRs 200-E-82, 86, 81 and 27 and other information.
3. Ecology: Complete review of RPP-ENV-33418, Rev. 1 “Hanford C-Farm Leak Assessments Report: 241-C-101, 241-C-110, 241-C-111 and 241-C-105.

<u>NEXT MEETING:</u>

Date:	November 6, 2007
Time:	3:00-4:30
Location:	ECOLOGY Office

MEETING SUMMARY

CH2MHILL
Hanford Group, Inc.

From: J. G. Field, CH2M HILL Hanford Group, Inc
Phone: 376-3753
Location: Ecology Office,
Date: November 6, 2007
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Joe Caggiano, ECOLOGY
Jim Field, CH2M HILL
Les Fort, ECOLOGY
Paul Henwood, S.M. Stoller
Mike Johnson, CH2M HILL
Linda Lehman, CH2M HILL
Beth, Rochette, ECOLOGY

PURPOSE:
Review and discuss supplemental contamination information.
Discuss next Tank Farm to assess

Review of Previous Meeting Summary:
The October 23, 2007 meeting summary was revised per comments received from Ecology. The revisions were reviewed and approved.

Supplemental C-farm Information
Mike Johnson discussed his write-up of supplemental information including potential waste losses from spare inlet nozzles due to tank overflows, suspect pipeline waste loss events and potential contamination from a drywell associated with building 241-C-801. The information presented will be included in the assessment report. Except for specific UPRs and tanks assessed, none of the supplemental information was sufficient to estimate a released waste volume or inventory.

No other tanks or UPRs in C-Farm were identified to be assessed at this time.

Near Surface Source Term
Based on current information an approach was discussed to estimate a near surface source term for the C-tank farm. The total volume of soil in the farm, excluding tank volumes but including below grade equipment and pipe volumes and other UPRS was determined. A curie content for that volume was then estimated based on Dry Well data in the farm. The drywells show that from 0 to 15 feet below grade the Cs-137 content for most wells is < 100 pCi/g. Applying this concentration across the farm equates to about 17.8 Ci of Cs-137 measured in the waste surface.

We can then look at waste types in the farm and estimate the inventory for waste types by the ratio of Cs-137 to the waste type.
This approach is better than a “0” inventory estimate, but additional data is needed to provide a source term for direct exposure. Direct dose measurements provide additional information to characterize surface contamination.

Although current near surface information helps to focus locations for sampling, a probability grid is still preferred to provide a basis for uncertainty estimates and a better statistical basis for a representative source term. It was also noted that near-surface sampling locations will be limited by the tank farm infrastructure. Another option discussed to help focus sampling is to review horizontal cross section dry well plots at 2 ft and 8 ft below ground surface. These plots are available in logging reports.

Assessment Report and Next Tank Farm to Assess
This meeting concludes the C-farm assessments pending completion of direct push or other field sampling investigations and receipt of data. Results and discussions for UPRs and supplemental information will be added to Rev. 1 of the C-Farm Assessment Report. After being drafted, the report will be sent to all team members for review.

Ecology indicated that current discussions are to retrieve tank waste in A and AX farms after C-Farm. As a result, waste tanks, UPRs and other potential releases in A and AX farms will be assessed next.

NEXT MEETING AGENDA

1. Assess Tank 241-A-105

ACTIONS:

1. J. Field: Prepare and distribute November 6, 2007 Draft Meeting Summary.
2. M. Johnson: Prepare Draft Assessment report for review.
3. M. Johnson/Mark Wood: Prepare A-105 discussion for next meeting summarizing discussion in the C and A/AX FIR.

NEXT MEETING:

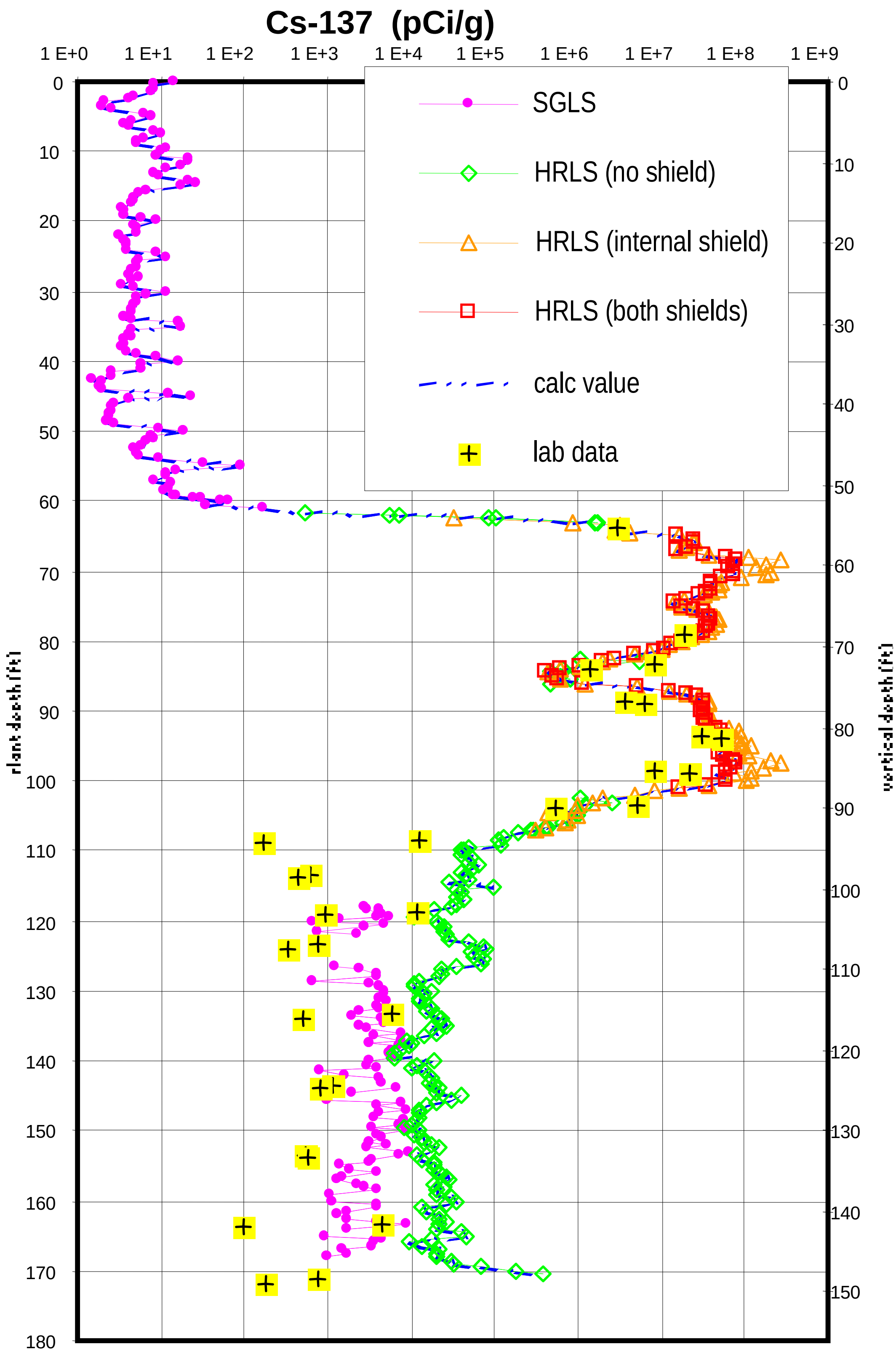
Date:	November 27, 2007
Time:	3:00-4:30
Location:	ECOLOGY Office

Appendix B

Cesium-137 Sorption Logic

Zachara et al (2002) shows that Cs-137 sorbs strongly, rapidly and irreversibly in Hanford soils. The extent of Cs-137 migration is limited by the availability of sorption sites on the soil and cesium ions fill available active sites as fluid moves through the soil column. Thus, when fluids containing Cs-137 enter the soil a plume is formed starting at the source and migrating outward to form a plume size and shape dependent on Cs-137 sorption capacity of the soil, Cs-137 concentration of fluid, and fluid flow characteristics of the soil. Spectral gamma logs in the single-shell tank farms indicate that the Cs-137 sorption capacity for the Hanford soils varies from about 1E+06 to 1E+08 pCi/g. This observation is best illustrated in borehole samples compared with monitoring data for tank SX-108 (Figure 4-30). Thus, these activity levels should be observed when a high-level waste plume approaches a drywell. The gamma data also show that high activity levels found in a Cs-137 plume drop quickly over short distances Therefore, large plumes of Cs-137 below the sorption capacity generally do not form in Hanford soils. This understanding of Cs-137 sorption chemistry in Hanford soils provides a methodology to develop rough leak volume estimates.

The SX-108 slant borehole provides one of the only vadose data sets with both sample data and vadose monitoring data to assess Cs-137 sorption capacity. From 55 to 90 ft bgs, (assumed Cs-137 sorption zone for this data set) the 1999 data shown in Figure XX have an average Cs-137 concentration of 2.0E+07 pCi/g with a maximum of 8.0 E+07 pCi/g. This based on analytical data and HRLS data with both shields (the est fit to analytical data). Back decaying these values to 1965 (the estimated SX-108 leak date) gives an average sorption capacity of 4.3 E+07 pCi/g and a maximum value of 1.7 E+08 pCi/g.


Cs-137 (pCi/g)
1 E+0
1 E+1
1 E+2
1 E+3
1 E+4
1 E+5
1 E+6
1 E+7
1 E+8
1 E+9
SGLS
HRLS (no shield)
HRLS (internal shield)
HRLS (both shields)
calc value
lab data
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150