HANFORD C-FARM LEAK ASSESSMENTS REPORT

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Abstract: The Tank Farm Operations Contractor developed jointly with U.S. Department of Energy, Office of River Protection and State of Washington Department of Ecology a process to reassess selected tank leak estimates (volumes and inventories), and to update tank leak and unplanned release volumes and inventory estimates as emergent field data is obtained. This report documents the results of applying this process to reassess unplanned releases and tank inventory estimates in the 241-C Tank Farm. This revision of the report should be considered a work in progress to be distributed for public review as appropriate. Comments will be incorporated as needed in a future revision.

Tank Operations Contractor (TOC) **RECORD OF REVISION**	(1) Document Number: RPP-ENV-33418	Page 1

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HANFORD C-FARM LEAK ASSESSMENTS REPORT

Change Control Record

(3) Revision	(4) Description of Change – Replace, Add, and Delete Pages	Authorized for Release	
		(5) Resp. Engr. (print/sign/date)	(6) Resp. Mgr. (print/sign/date)
1	Added Sections 4.3 and 4.4 discussions on historical, potential waste loss events associated with tanks C-111 and C-105. Added section 6.0 discussion on historical unplanned waste loss events in 241-C tank farm. Incorporated additional meeting minutes in Appendix A associated with sections 4.3, 4.4, and 6.0.	Michael Johnson Signed 2/26/08	J.G. Field Signed 2/26/08
2	This revision incorporates data obtained after issuing Revision 1 and a more comprehensive assessment and inventory estimates for tank leaks and other releases in C-Farm.	J.G. Field Signed 11/18/11	S.J. Eberlein Signed 11/18/11
2A RS	Table 4-1 had an incorrect value of 1.6 for Tc-99 for tank C-110. The value was changed from 1.6 to 0.11 Ci.	J.G. Field per telecon 1/10/12	S.J. Eberlein 01/11/12

RPP-ENV-33418
Revision □$

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Date
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Prepared for the U.S. Department of Energy
Office of River Protection

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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

The Washington State Department of Ecology along with the Tank Farms Operating Contractor for the U.S. Department of Energy developed a process to review selected tank leak estimates (volumes and inventories), and to update single-shell tank leak and unplanned release volumes and inventory estimates as emergent field data becomes available (RPP-32681, *Process to Assess Tank Farm Leaks in Support of Retrieval and Closure Planning*). This process does not represent a formal tank leak assessment in accordance with procedure TFC-ENG-CHEM-D-42, "Tank Leak Assessment Process," but formal tank leak assessments are recommended for those tanks where the current leak classification was in question. This report documents a collaborative effort to reassess past leaks in the 241-C Tank Farm. This revision of the report should be considered a work in progress to be distributed for public review as appropriate. Comments will be incorporated as needed in a future revision.

Tank waste loss events were re-assessed in accordance with the RPP-32681 process. In addition, those tanks currently assumed as "sound" were reviewed to assess the potential for loss of waste containment. The initial 241-C Tank Farm leak assessment (Revision 1 of this report) was the first of a series of assessments for other farms. Included in the re-assessment and documented in this revised report were the lessons learned from development of other tank farm leak assessment reports; incorporation of the results of integrity assessments for 241-C Farm tanks that have been completed since Revision 1 was issued; and to provide an estimate for the volume and inventory of waste releases from cascade lines, spare inlet overflows and pipeline leaks based on tank waste process data, cobalt-60 plumes in the vadose zone, and soil moisture content. Figure ES-1 shows major components of WMA C including: sixteen single-shell tanks (SSTs) used for waste retrieval and storage and catch tanks, pipelines, pits and diversion boxes used to transfer waste to and from the SSTs.

Table ES-1 summarizes the results of the tank waste loss reassessment for single-shell tanks and provides a comparison to the waste loss estimates contained in HNF-EP-0182, *Waste Tank Summary Report for Month Ending July 31, 2011*, Rev. 280. The volume of waste released to the vadose zone and the waste composition (type) were evaluated to update the estimated inventory of constituents in RPP-26744, *Hanford Soil Inventory Model, Rev. 1.*

DOE/RL-88-30, *Hanford Site Waste Management Units Report* contains the official listing of unplanned releases identified at the Hanford Site included in the Waste Information Data System. The operational history for the 241-C Tank Farm was reviewed to determine if additional information exists for three major unplanned releases (UPR-200-E-81, UPR-200-E-82 and UPR-200-E-86) within Waste Management Area C not associated with tank waste loss events. Additional releases were identified through review of the operational history for the 241-C Tank Farm. Tank waste was discharged through the spare inlet nozzles on the single-shell tanks and through pipeline failures. Unplanned releases and other release events are described in Chapter 5.

Figure ES-1. Location Map of Waste Management Area C and Surrounding Area

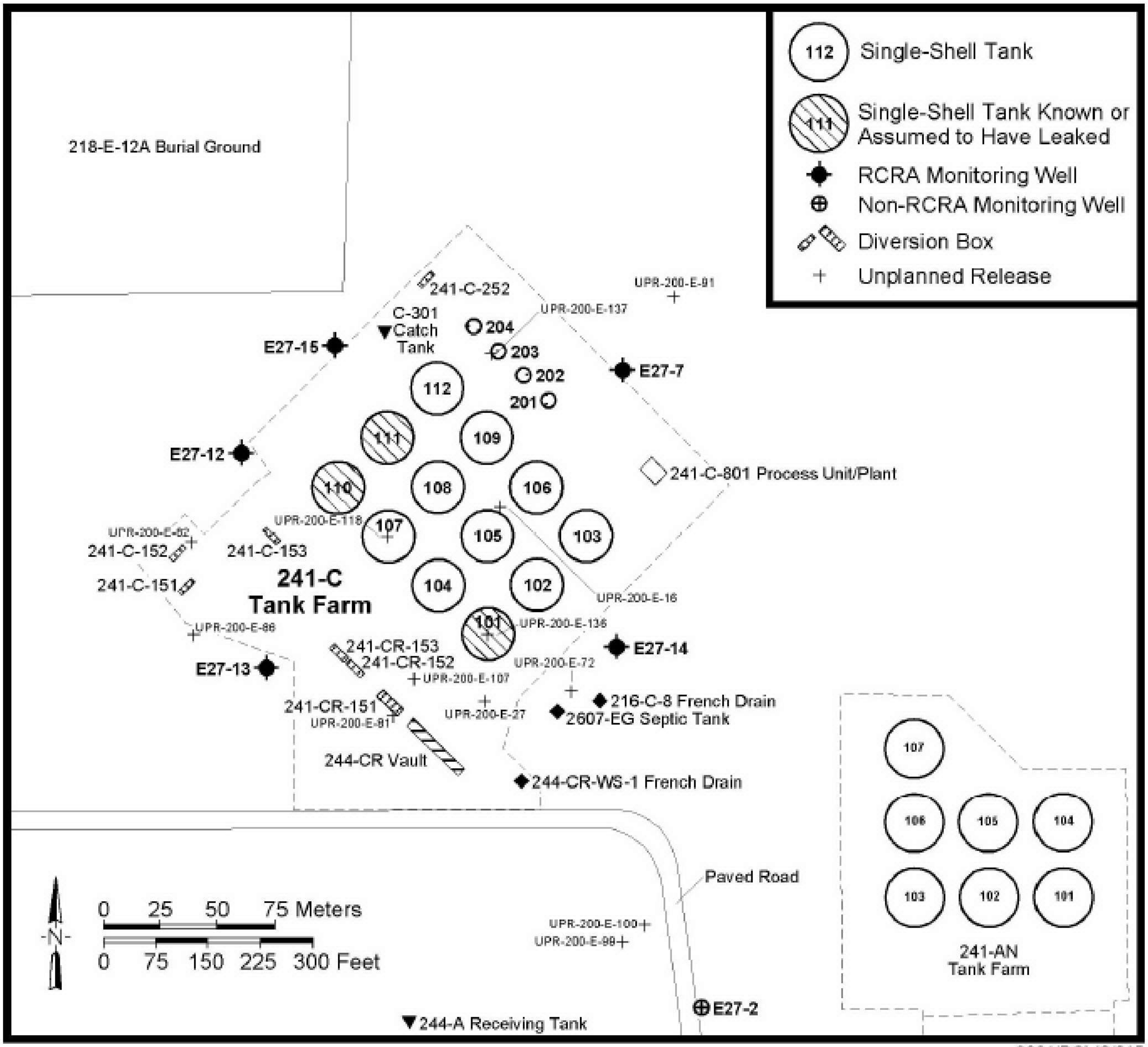

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Table ES-1. Summary of Tank Waste Loss Events (2 sheets)

Tank	Analysis	HNF-EP-0182 Waste Loss Estimate (gallons)	RPP-ENV-33418 Waste Loss Estimate [1]
C-101	Estimated waste release volume based on an assumed CWP2 waste type and drywell readings. According to surface level measurements there was a waste release of up to ~37,000 gal, likely a combination of a CWP2 release from the spare inlet and condensate (depending on condenser operation).	20,000	< 37,000 gal (Recommend tank integrity assessment per TFC-ENG-CHEM-D-42)
C-104	Cascade line leak next to tank C-104. Tank C-104 was filled to 560,000 gal of CWP1 waste in 1965. No transfer was identified, however, the surface level decreased to the spare inlet elevation of ~532,000 gal resulting in a possible 28,000 gal release.	NA	28,000 gal Cascade line release
C-105	Cascade line leak and possible P1 leak at the base of tank C-105. Leak volume estimates are based on high ^{137}Cs activity (> 10^7 pCi/g) in drywell 30-05-07 near the base of the tank and comparatively little or no activity in surrounding drywells.	0	Less than 2,000 gal Cascade line and possible tank liner leak. (Recommendation to reclassify as "assumed leaker," RPP-ASMT-46452)
C-108	Assumed Cascade/Pipeline release. Tank C-108 filled to 568,000 gal of CW-HS waste in 1965; decreased in surface level to 532,000 gal through a transfer to tank C-102; waste loss assumed to be 18,000 gal based on ^{60}Co and soil moisture determinations. Waste volume based on CW waste composition.	NA	18,000 gal Assumed cascade/pipeline release.
C-110	Waste loss appears to be the result of a tank overflow through the spare inlet nozzles. No liquid level decrease was observed.	2,000	Less than 2,000 gal Spare inlet release (Recommendation to reclassify as "sound," RPP-ASMT-38219)
C-111	Evaporation calculations, plotted liquid level data, and evaporation rates indicate that the liquid level decrease can be attributed to evaporation.	5,500	0 gal (Recommendation to reclassify as "sound," RPP-ASMT-39155)
C-112	Release likely occurred prior to 1974. Drywells 30-12-01 and 30-12-13 show a ^{60}Co peak was detected at 30-50 bgs. These drywells are located in proximity to a known release from the salt-well pump pit located on top of the tank and could also be indicating a release from a transfer	NA	7,000 gal of CWP2-IX

Table ES-1. Summary of Tank Waste Loss Events (2 sheets)

Tank	Analysis	HNF-EP-0182 Waste Loss Estimate (gallons)	RPP-ENV-33418 Waste Loss Estimate [1]
	line leak from 252-C Diversion Box to tank C-112.		
C-200s	Evaporation calculations show that evaporation could account for the liquid decreases in all four of the C-200 series tanks.	1,750	0 (Recommend tank integrity assessments per TFC-ENG-CHEM-D-42)
Other C-Farm SSTs	Many of the tanks were overfilled and some show activity in nearby drywells. It was concluded that there was no evidence of a tank liner failure for any of these tanks and insufficient data to estimate any release.	NA	0 gal

[1] Except as noted, ^{137}Cs inventories are decayed to January 1, 2001 consistent with values in SIM.
SST = single-shell tank

Waste types:
CSR = Supernates from which the cesium has been removed by ion exchange. 241-C-801 cask station (1962-1967). B Plant Waste Fractionization (1967-1976)
CW = Cladding Waste
CWP1 = Plutonium Uranium Extraction (PUREX) cladding waste, aluminum clad fuel (1956-1960)
CWP2 = Plutonium Uranium Extraction (PUREX) cladding waste, aluminum clad fuel (1961-1972)
HS = Hot semiworks waste
IX = Ion exchange waste
P1 = PUREX high level waste (1956-1962)

References:
HNF-EP-0182, *Waste Tank Summary Report for Month Ending July 31, 2011*, Rev. 280.
TFC-ENG-CHEM-D-42, Rev. B-2, "Tank Leak Assessment Process."

1.0 INTRODUCTION

Vadose zone inventories are estimated by multiplying the waste release volume by the contaminant concentration in the solution released to the soil. This concentration of the solution is based on process knowledge of the waste composition at the time the release occurred. For some major releases, historical records confirm the waste loss event and provide a strong technical basis for leak volume and inventory estimates. However, for many releases little data is available and there are varying degrees of uncertainty or differences in the available data.

Numerous studies and investigations have estimated the inventory of contaminants in the tank farms vadose zone. Document HNF-EP-0182 provides the current official tank leak volume estimates for tanks classified as "assumed leakers," but it does not provide associated inventory estimates, and tank leak volume estimates reported in HNF-EP-0182 have not been updated for many years. Document RPP-23405, *Tank Farm Vadose Zone Contamination Volume Estimates* summarizes vadose zone tank leak characterization and investigations. The leak volume estimates presented in RPP-23405 are consistent with many of the estimates listed in HNF-EP-0182, but some estimates are much higher and others lower. RPP-23405 suggests that some releases attributed to tank leaks may have been from evaporation of waste, spare inlet overflows, line leaks or spills during process operations. RPP-23405 also provides volume estimates for other unplanned releases (UPRs) in the single-shell tank (SST) farms.

The RPP-23405 volume estimates were used in RPP-26744, *Hanford Soil Inventory Model, Rev. 1* (SIM) to estimate leak inventories for DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site.* RPP-23405 does not address volume uncertainties and some of the leak volume estimates, data interpretations, and conclusions presented in RPP-23405 require further review.

Washington State Department of Ecology (Ecology) along with the Tank Farm Operations Contractor for the U.S. Department of Energy (DOE) developed a process to reassess 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, *Process to Assess Tank Farm Leaks in Support of Retrieval and Closure Planning*). This report documents the results of applying the process described in RPP-32681 to reassess tank and UPR waste release estimates in the 241-C Tank Farm (C-Farm). Current SIM estimates (RPP-26744) and leak volume estimates in the tank waste summary report (HNF-EP-0182) should be updated to reflect revised estimates in this report.

1.1 REVISION 2 CHANGES

A reassessment of the C-Farm tank leak evaluation was undertaken to further establish and refine the nature and extent of waste released to the environment due to tank farm operations. The reassessment focused on the designated Waste Management Area (WMA) C-100-series "sound" tanks, but also provides a discussion on the four C-200-series tanks and reexamines the tanks categorized as assumed to have leaked.

The leak assessment process was developed to be iterative; this update incorporates historical and operating information discovered and collected during the SST farm-by-farm progression through the process described in RPP-32681. Revision 1 of the C-Farm Leak Assessments Report, RPP-ENV-33418, *Hanford C-Farm Leak Assessments Report: 241-C-101, 241-C-110, 241-C-111, 241-C-105 and Unplanned Waste Releases* only evaluated tanks 241-C-101 (C-101), 241-C-105 (C-105), 241-C-110 (C-110), 241-C-111 (C-111), and three prominent unplanned waste release sites to primarily support Retrieval and Tank Integrity evaluations and near-term milestones, as well as select UPRs for initial Corrective Action scoping. Since that report was released in 2008, only one SST farm (T Farm) remains to be investigated to support the above primary objectives. As the assessment process progressed through the various SST farms, the magnitude of transfer line and tank overfills/overflow of waste released to the soil were found to be significant.

This iteration of the leak assessment process examines the spectral gamma measurements and historical total gamma logs in and around all of the WMA C tank farm drywells as a means to indicate waste releases about the designated sound tanks. This analysis uses various conceptual models of the waste and soil chemistry to formulate a means to estimate waste volume and compositions for such releases from the SST system in WMA C. A more thorough review of the C-200 tank operational history is also included in this assessment revision.

Since the initial C-Farm Leak Assessments Report, RPP-ENV-33418 four leak assessments were undertaken in accordance with procedure TFC-ENG-CHEM-D-42, "Tank Leak Assessment Process." In summary:

- Tank C-101 appears to have been overfilled as the probable cause of the observed waste release; however, the observed surface level decrease could also be attributed to evaporation. Liquid level measurements showed that the waste volume from 54 in. and below was steady, indicating the tank release was due to a spare inlet release or a tank leak high on the side of the tank. Additional assessments are planned to evaluate slant hole push logging and sampling results to further investigate releases from tank C-101.

- The waste plume about tank C-105 was determined to be caused by a cascade line release; and may also be the result of a tank liner leak. Tank C-105 is now designated as assumed to have leaked for retrieval actions.

- The observed waste release at tank C-110 was determined to have been caused by the tank being overfilled and waste released through the spare inlet ports; this tank is now designated as sound.

- Tank C-111 past waste temperature data showed evaporation was the cause of the observed waste level and volume decrease and therefore it was reclassified as sound.

It is anticipated that ongoing characterization, integration of Spectral Gamma Logging High Resolution Resistivity (HRR) data, the WMA C pre-1974 gross gamma logging, and more current push-hole logging and sample data will provide additional data and information for continuing iterations of WMA C analyses.

2.0 SCOPE AND CRITERIA

An assessment team comprised of representatives from Ecology, DOE's Office of River Protection and the Tank Farm Operations Contractor was assembled to review available information relating to waste loss events in C-Farm. The assessment team membership is listed in Table 2-1. Team meeting summaries are included in Appendix A.

Table 2-1. Waste Loss Event Assessment Team

Name	Organization	Role
Mike Barnes	Washington State Department of Ecology	Lead regulatory oversight (Primary focus: Tank retrieval and closure).
Joe Caggiano	Washington State Department of Ecology	Regulatory oversight (Primary focus: Vadose zone and groundwater data).
Jim Field	Washington River Protection Solutions	Leak Assessment lead. Knowledge and experience with in-tank (i.e., surface liquid level and liquid observation well) data and vadose zone investigations.
Les Fort	Washington River Protection Solutions	Knowledge and experience in tank farm waste processing and operations and vadose zone characterization.
Paul Henwood	S. M. Stoller, Inc.	Knowledge and experience in gamma and spectral gamma logging and analyzing logging data.
Bob W. Lober	U.S. Department of Energy Office of River Protection	Tank Farms Programs and Projects Division
Beth Rochette	Washington State Department of Ecology	Regulatory oversight (Primary focus: Near-surface unplanned releases)
Marcus I. Wood	CH2M HILL Plateau Remediation Contract	Knowledge and experience in vadose zone and groundwater monitoring processes and data

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

- Collect information and data regarding past tank waste releases in C-Farm
- Collect information and data regarding UPRs (waste releases and raw water releases), including pipeline leaks, spills, and near-surface activity, in 241-C Tank Farm
- Compile information from previously reported waste tank leaks and UPRs to estimate the volume of tank waste released to the vadose zone and the time at which releases occurred
- Compile data regarding the waste composition at the time of a release from the available sources, such as sample data, Tank Waste Information Network System, Best Basis Inventory, Hanford Defined Waste (HDW) model, logging data, etc.
- Combine waste release volume with waste composition to estimate radionuclide and chemical inventory of waste releases to the soils.

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3.0 BACKGROUND

Approximately 57 million gal of radioactive waste from chemical processing and plutonium processing operations are stored in 177 underground storage tanks on the Hanford Site. Of these tanks, 149 are SSTs, which consist of a single steel liner inside a concrete shell. Nominal capacities range from 55,000 to 1,000,000 gal. For the immediate future, plans call for retrieval of waste from the SSTs and transfer to the 28 double-shell tanks (DSTs), with eventual transfer for treatment in the Waste Treatment and Immobilization Plant. Prior to waste retrieval operations, C-Farm tanks stored ~1.8 million gal of waste. As of July, 2011 waste retrieval is completed for tanks C-103, C-106 and four C-200 series tanks, retrieval of waste is in progress for tanks C-104, C-107, C-108, C109, C-110 and C-111, and C farm tanks store ~973,000 gallons of waste (HNF-EP-0182).

3.1 241-C TANK FARM DESCRIPTION

The 241-C Tank Farm is located in the 200 East Area about 2,000 ft north of the Plutonium Uranium Extraction (PUREX) Plant and consists of twelve, nominally 530,000-gal capacity SSTs and four nominally 55,000 gal-capacity SSTs (Figure ES-1). Figure 3-1 depicts the two types of SSTs present in C-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 3-2) to aid in detecting waste release events (listed in Table 3-1). No drywells are installed adjacent to the 200-series SSTs.

The C-Farm was constructed at the Hanford Site during 1943 and 1944 to store high-level radioactive waste generated by chemical processing of irradiated uranium fuel. The twelve 530,000-gal tanks in C-Farm are steel lined and are 75 ft in diameter, with a maximum operational height (cascade overflow level) of 16 ft above the center of the dished tank base; the center of the dished base is 1 ft lower than the base perimeter. The tanks are covered by a 1.25-ft-thick reinforced concrete domed top that extends ~13 ft above the tank operating level. The tanks are entirely below the ground surface and are covered with 8 to 12 ft of backfill material. The maximum operating level of the tank is 21 to 23 ft below ground surface (bgs). Allowing space for footings and other construction requirements, the base of the C-Farm excavation is about 40 ft bgs. The C-Farm tanks are connected in four three-tank cascade series: tanks C-101, 241-C-102 (C-102), 241-C-103 (C-103); tanks 241-C-104 (C-104), C-105, 241-C-106 (C-106); tanks 241-C-107 (C-107), 241-C-108 (C-108), 241-C-109 (C-109); and tanks C-110, C-111, 241-C-112 (C-112). The cascade tanks are arranged with each successive tank sited at a lower elevation (with the receiving tank 1 ft lower than the feed tank), creating a gradient that allowed fluids to flow from one tank to another as they were filled.

Figure 3-1. Single-Shell Tanks in Waste Management Area C

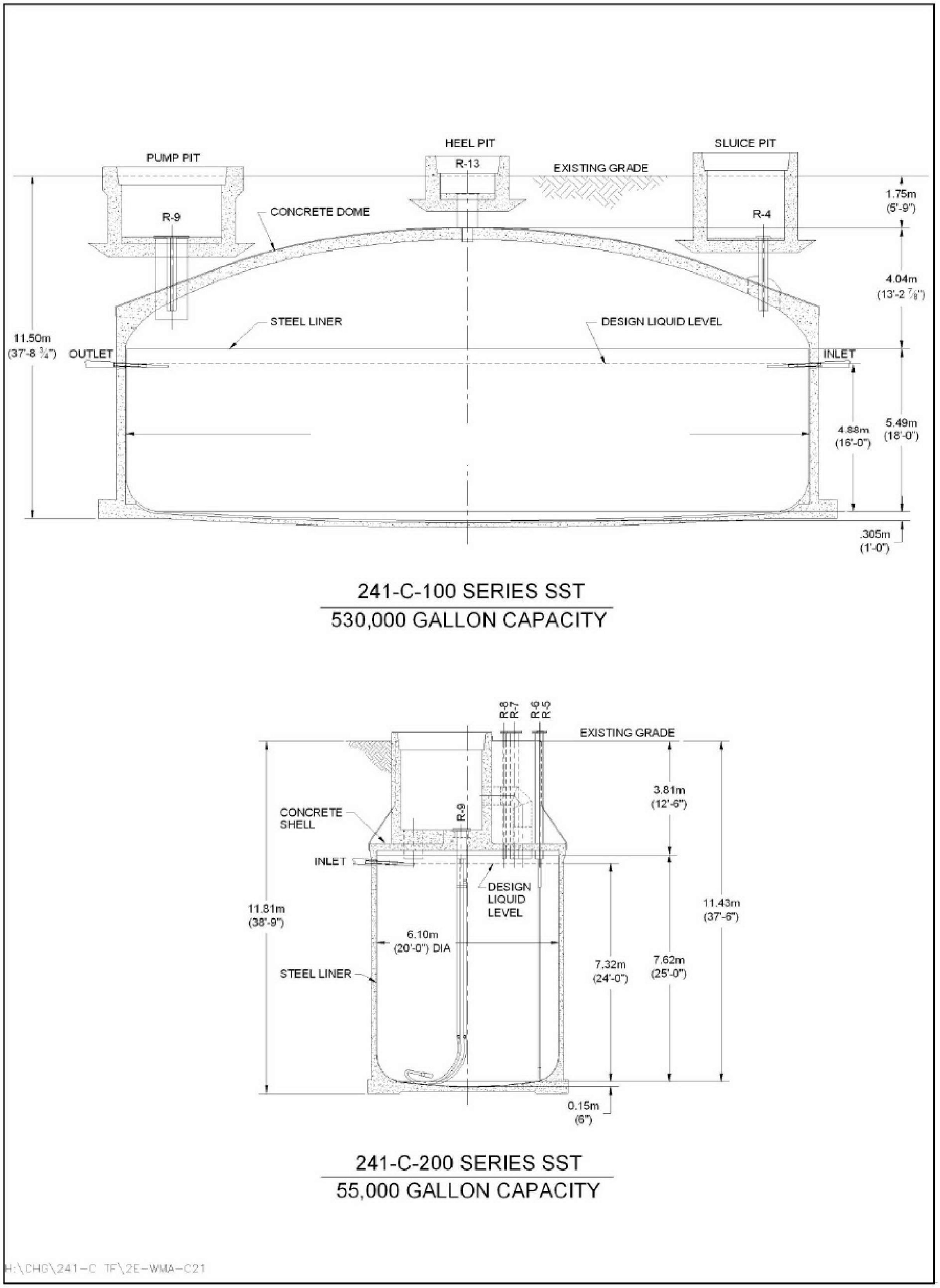
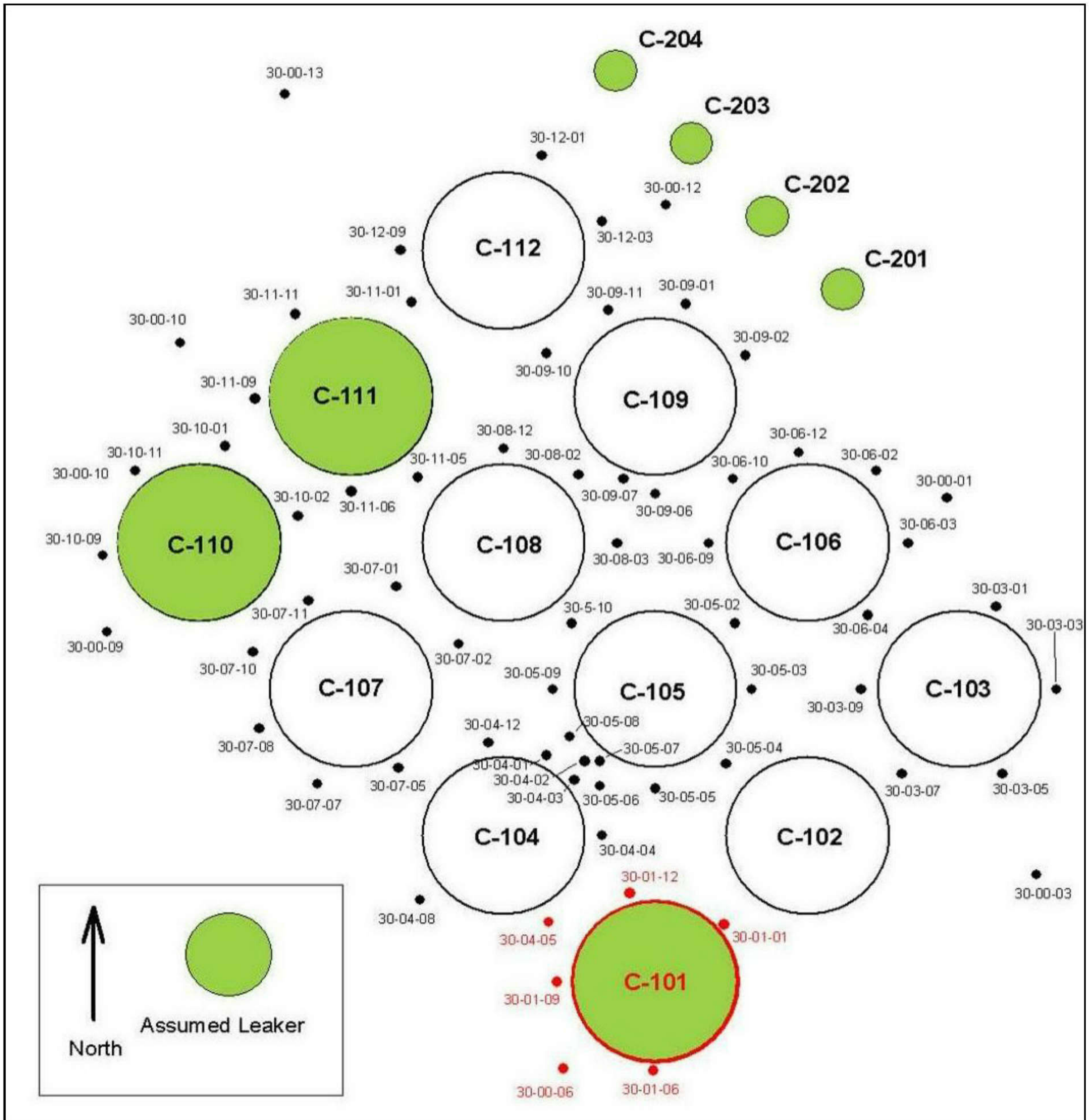


Figure 3-2. 241-C Tank Farm Single-Shell Tanks and Drywells[1]



[1] Assumed leaker designations through 2009 (see HNF-EP-0182, rev 280 for clarifications/changes).

Table 3-1. 241-C Tank Farm Drywells (2 sheets)

Well No.	Well ID	Well Name	Drill Date	Drill Depth (ft)[1]
A6676	30-08-03	299-E27-51	31-Dec-44	150[2]
A6677	30-00-12	299-E27-52	31-Dec-44	150[2]
A6678	30-00-10	299-E27-53	31-Dec-44	150[2]
A6679	30-00-03	299-E27-54	31-Jan-45	150[2]
A6680	30-00-06	299-E27-55	31-Dec-44	150[2]
A6681	30-00-01	299-E27-56	31-Dec-44	150[2]
A6682	30-00-09	299-E27-57	31-Dec-44	150[2]
A6683	30-01-09	299-E27-58	30-Apr-70	100
A6684	30-01-06	299-E27-59	31-Jan-70	100
A6685	30-01-01	299-E27-60	31-Mar-70	100
A6686	30-01-12	299-E27-61	31-Mar-70	100
A6687	30-11-09	299-E27-62	31-Mar-70	100
A6688	30-11-01	299-E27-63	28-Feb-70	100
A6689	30-11-06	299-E27-64	28-Feb-70	100
A6690	30-04-12	299-E27-65	31-Dec-72	135
A6691	30-04-08	299-E27-66	30-Nov-72	145
A6692	30-04-02	299-E27-67	31-Dec-72	130
A6693	30-05-10	299-E27-68	30-Nov-72	135
A6694	30-05-04	299-E27-69	31-Dec-72	120
A6695	30-05-02	299-E27-70	30-Nov-72	130
A6696	30-06-10	299-E27-71	30-Nov-72	130
A6697	30-06-02	299-E27-72	30-Nov-72	125
A6698	30-06-04	299-E27-73	30-Nov-72	130
A6699	30-03-01	299-E27-74	30-Jun-74	100
A6700	30-03-03	299-E27-75	31-Jul-74	100
A6701	30-03-05	299-E27-76	31-Jul-74	100
A6702	30-03-07	299-E27-77	30-Sep-74	100
A6703	30-03-09	299-E27-78	30-Jun-74	100
A6704	30-04-04	299-E27-79	30-Jun-74	100
A6705	30-04-05	299-E27-80	31-Jul-74	100
A6706	30-05-03	299-E27-81	30-Sep-74	100
A6707	30-05-05	299-E27-82	30-Jun-74	100
A6708	30-05-09	299-E27-83	30-Jun-74	100
A6709	30-06-03	299-E27-84	30-Jun-74	100
A6710	30-06-09	299-E27-85	31-Jul-74	100
A6711	30-06-12	299-E27-86	31-Aug-74	100
A6712	30-07-01	299-E27-87	30-Sep-74	100

Table 3-1. 241-C Tank Farm Drywells (2 sheets)

Well No.	Well ID	Well Name	Drill Date	Drill Depth (ft)[1]
A6713	30-07-02	299-E27-88	30-Sep-74	100
A6714	30-07-05	299-E27-89	31-Oct-74	100
A6715	30-07-07	299-E27-90	31-Oct-74	100
A6716	30-07-08	299-E27-91	31-Oct-74	100
A6717	30-07-10	299-E27-92	30-Sep-74	100
A6718	30-07-11	299-E27-93	31-Jul-74	100
A6719	30-08-02	299-E27-94	30-Sep-74	100
A6720	30-08-12	299-E27-95	30-Sep-74	100
A6721	30-09-01	299-E27-96	31-Jul-74	100
A6722	30-09-02	299-E27-97	30-Jun-74	100
A6723	30-09-06	299-E27-98	30-Sep-74	100
A6724	30-09-10	299-E27-99	31-Jul-74	100
A6725	30-09-11	299-E27-100	31-Jul-74	100
A6726	30-10-01	299-E27-101	30-Sep-74	100
A6727	30-10-02	299-E27-102	30-Sep-74	100
A6728	30-10-09	299-E27-103	30-Sep-74	100
A6729	30-10-11	299-E27-104	30-Apr-75	100
A6730	30-11-05	299-E27-105	30-Apr-75	100
A6731	30-11-11	299-E27-106	30-Apr-75	100
A6732	30-12-01	299-E27-107	30-Apr-75	100
A6733	30-12-03	299-E27-108	30-Apr-75	100
A6734	30-12-09	299-E27-109	30-Apr-75	100
A6735	30-04-01	299-E27-115	31-Jul-74	50
A6736	30-04-03	299-E27-116	31-Jul-74	50
A6737	30-05-08	299-E27-117	31-Jul-74	50
A6738	30-05-07	299-E27-118	31-Jul-74	70
A6739	30-05-06	299-E27-119	31-Jul-74	60
A6740	30-00-22	299-E27-120	31-Mar-77	60
A6741	30-00-11	299-E27-121	31-Mar-77	60
A6742	30-00-24	299-E27-122	31-Mar-77	60
A6744	30-00-13	299-E27-124	31-Mar-77	60
A6745	30-12-13	299-E27-125	30-Apr-78	130
A6754	30-09-07	299-E27-135	31-Mar-82	125

[1]Except as noted drill casings are single wall 6 inch diameter steel
[2]Double steel casing: 8 inch diameter inside casing, 12 inch diameter to 54 ft.

3.2 TANK LEAK DETECTION MONITORING

Historically, SSTs were monitored by two independent methods: in-tank and ex-tank monitoring. From the beginning of Hanford Site tank farm operations, the primary leak detection system was routine monitoring of liquid-surface levels within each tank. Routine monitoring of gross-gamma activity in drywells near the SSTs provided a second leak detection method. After the SSTs were pumped and interim stabilized in the early 2000s the Radionuclide Assessment System (RAS) was deployed in tank farms to monitor for potential changes in the radiation profile. Drywells near tanks that had significant interstitial liquid, had exhibited changes in the past, and were near the margins of significant contaminant plumes were prioritized for logging. The monitoring program was discontinued in approximately 2004 and was deemed to be no longer required except during retrieval operations as specified in tank waste retrieval work plans (RPP-9937, *Single-Shell Tank System Leak Detection and Monitoring Functions and Requirements Document*). Figure 3-2 shows the location of drywells in C-Farm and Table 3-1 shows C-Farm drywell numbers, ID, names, dates the drywells were drilled, and depth of the drywells.

3.2.1 In-Tank Monitoring

Originally liquid levels were measured using pneumatic dip tubes (H-10475 C-DEL, *Hanford Technical Manual Section C*, page 908). This practice was later replaced with a conductivity electrode manual tape to detect the liquid surface (H-2-2257, *Conductor Reel for Liquid Level Measurement*). The major limitations of the manual tape measurements were failures of the electrodes, solids forming on the electrodes and measurement precision. The statistical accuracy of the manual tape and electrode measurement technique was 0.75 in. (~2,060 gal), as determined in July 1955 (HW-51026, *Leak Detection -- Underground Storage Tanks*, page 4). Later, liquid-level determinations were automated in many of the SSTs as a means to improve the accuracy and reliability of the measurements. However, surface level measurements remained highly uncertain in the waste tanks that contained boiling wastes (e.g., 241-A, 241-AX and 241-SX Tank Farms), after supernate was removed from tanks leaving solids or precipitated salts, or where solid crusts formed on the waste surfaces. In addition to uncertainty in measurements, liquid level decreases may be caused by a leak, evaporation, or physical changes in the waste surface (i.e., floating solids, surface collapse, or gas release events). Increases were also reported suggesting intrusions into some tanks that could mask potential liquid losses. Because of the nature of the waste and numerous potential causes for liquid level decreases in addition to a potential tank leak, no liquid level decrease criterion was assigned for the C-Farm 100-series tanks except for tanks C-103 (0.50-in. decrease criteria), C-104 (10.00-in. decrease criteria), C-105 (1.00-in. decrease criteria), C-106 (2.0-in. decrease within 2 weeks criteria) and C-110 (3.00-in. decrease criteria) (SD-WM-TI-356, *Waste Storage Tank Status and Leak Detection Criteria*). Liquid observation wells (LOWs) were installed in many of the tanks to measure interstitial liquid levels (ILLs) using gamma and neutron probe measurements.

The manual tapes were replaced by Food Instrument Corporation (FIC) gauge surface level gauges. The FIC gauges were removed and replaced by ENRAF™[1] gauges in 1994 for tank C-103, 1995 for tanks C-106 and C-107, 1996 for tanks C-105 and C-112, 1999 for tank C-104, 2002 for tanks C-101, C-102, C-108, C-109 and C-110, and 2003 for tank C-111.

Following is a description of in-tank monitoring instrumentation summarized from RPP-9645, *Single-Shell Tank System Surveillance and Monitoring Program*.

- **ENRAF™.** The ENRAF™ gauge is the most accurate level gauge currently used in the tank farms. This gauge tracks level changes in tank waste by using a load cell to monitor the weight of a displacer. For the purposes of leak detection, the ENRAF™ gauge needs a free liquid surface below the displacer. The vendor quotes an ENRAF™ precision of ± 0.004 in. and an accuracy of ± 0.04 inches. However, in-tank ENRAF™ instruments are calibrated to an accuracy of ± 0.1 in. and the 2-decimal readout on the gauge provides a precision of ± 0.01 inch.

  The condition providing the highest sensitivity to a potential leak is a smooth, pure liquid waste surface combined with the most accurate gauge (ENRAF™). These measurements are impacted very little by day-to-day variation from either the waste surface or gauge error. If the waste surface becomes more irregular or a gauge with lower resolution is used, the measurement data becomes more scattered (increases) during the normal day-to-day readings. For a heavy slurry waste with a highly irregular surface and a low-resolution instrument, the day-to-day readings exhibit a higher degree of nominal data scatter. Surface level gauges are not used for leak detection if the waste has a solid surface, since the level would not decrease in response to a leak. Liquid levels cannot be measured accurately during waste transfer operations or in self-boiling tanks with a dynamic surface.

- **Manual Tape.** The manual tape is still used in a few tanks. It relies on a metal tape with a plummet contacting an electrically conductive waste surface. A manual tape in good working order on a highly conductive surface should be accurate and repeatable to about 0.25 inch. As the waste dries out, the device becomes less accurate, until ultimately no signal is received. Uncertainty for different tanks varied from 0.25 in. to 2 inches. The drying out of the waste surface is typically observed as increasing levels of data scatter during routine data reviews. Most DSTs use the manual tape as a backup to the ENRAF™.

  The FIC conductivity gauge is no longer used. The FIC was functionally equivalent to the manual tape, except that the tape and plummet were raised and lowered by a motor rather than manually. All FICs have now been replaced by ENRAF™ gauges.

- **Liquid Observation Wells.** The ILL can be measured by using geophysical techniques (neutron or gamma sensors) deployed inside a LOW. The LOWs were installed in tanks

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

containing permeable waste (i.e., tanks containing salt cake vs. sludge) and/or tanks with a solid waste surface. Originally the uncertainty of waste surface level measurements varied from 1 to 3 in. depending on the waste and barometric pressure changes. Interpreting LOW measurements is complicated, especially when the liquid level was moved between two waste layers with different permeability (e.g., saltcake and sludge). Updated methodologies have improved the accuracy of current LOW measurements; these include calibrating the waste depth measuring system daily before going to the field to ensure measurements are within ± 0.25 in. of its known value; verifying the neutron and gamma probes before each use; and comparing all of the measurement scans to a "reference scan" to identify any spikes, drifting, dead zones, or other anomalous problems.

3.2.2 Ex-Tank Monitoring

Total gamma logging was initially performed in the drywells using sodium iodide (NaI) and Green and Red (G-M detectors) total gamma monitoring detectors (Figure 3-3). The total gamma logs were digitized starting in 1975; much of the data before 1975 was not available.

Between 1995 and 2000 all of the drywells in all of the farms were logged using a spectral gamma logging system (SGLS). The SGLS uses a high-purity germanium (HPGe) detector and provides isotope specific gamma measurements (e.g., cesium, europium, cobalt and uranium isotopes). Detection and quantification of low specific activity radionuclides such as uranium-238/235 ($^{238/235}U$), and other transuranics or radionuclides that have experienced significant decay such as cobalt-60 (^{60}Co), generally require an SGLS. For areas of higher activity (> 2,000 pCi/g) a high rate logging system (HRLS) is used to quantify activity levels as high as 1E8 pCi/g.

The Radionuclide Assessment System (RAS) truck was designed for routine gamma monitoring against the baseline established from the SGLS data. The RAS uses a series of three interchangeable NaI(Tl)-based scintillation detectors (RAS-L, RAS-M, and RAS-S) for measurement over the range from background levels to about 10^5 pCi/g cesium-137 (^{137}Cs). The size of a leak that can be detected by RAS depends on the radioactivity level of the waste leaked, the leak rate, proximity of a dry borehole to the leak, and subsurface soil properties controlling flow rate and direction. Consequently, there is no single value that can be stated as the maximum leak that could go undetected by drywell monitoring for an SST. Figure 3-3 shows approximate measurement ranges of different types of gamma radiation detectors.

As with the in-tank measurements, there are uncertainties associated with the ex-tank geophysical logging. Three sources of uncertainty are as follows.

1. Number and location of wells / laterals / leak detection pits: There were rarely more than six drywells surrounding the 100-series SSTs (circumference ~235 ft) and often fewer. These drywells are generally 6-in. diameter steel casings that extend vertically 75 to 125 ft bgs (groundwater is between 245 and 300 ft bgs) and allow access of geophysical probes. Because the holes had to be cased to prevent collapse and loss of the drywell, only gamma-emitting radionuclides within about a 12-in. radius of a drywell are detected.

Alpha- and beta- radiation, are not detected through steel casing. However, most radionuclides or their decay products exhibit characteristic gamma rays that can be quantified even though the predominant mode of decay is from alpha or beta decay. Table 3-2 includes a list of radionuclides and minimum detection levels (MDL) that may be observed in tank farms. One notable exception is Tc-99 that is primarily a, beta emitter that has no detectable gamma rays. This contaminant is generally considered mobile in the vadose zone. Laterals (access tubes for radiation monitoring that lie approximately 10 ft below a tank) Laterals (access tubes for radiation monitoring that lie approximately 10 ft below a tank) provided a much more complete gamma monitoring system compared to drywells alone; however, there are no laterals in C-Farm. Consequently, the absence of gamma activity in a well or leak detection pit does not necessarily indicate that a tank did not leak. Over the course of historical drywell logging, probe types changed several times, thus changing detection limits (See Figure 3-3). The rate of withdrawal of any probe from a drywell and count times also affect the detection capability of any instrument and these too changed with time. Most drywells adjacent to tanks were not constructed until the 1970s and were subsequently logged for gamma radiation. There was very little ex-tank monitoring for a few decades of tank farm operations when many of the releases likely occurred. Chemical contaminants are not detected during logging and can only be found through soil sampling and analyses.

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. It can be used to evaluate the approximate time period when tank waste may have entered the sediments. Early gross gamma logging can indicate the nature of waste streams by considering the decay rate of gamma activity. The gross gamma logging system is most effective with waste types containing high concentrations (activities) of gamma-emitting radionuclides (e.g., ^{137}Cs or ^{60}Co at the present time and short-lived radionuclides in the past) and large releases, and is less effective with lower activity waste types such as aluminum cladding waste (CW) or waste that contains transuranics. In addition to limitations on the effectiveness of gamma measurements for different waste types, there were often lags of months to years between release and detection where multiple waste transfers may have occurred. Consequently, the type of waste in the nearest tank when a leak was detected may not be the same as the waste that leaked. This contributes to uncertainty in inventory and leak volume estimates.

3. <u>Other contamination sources</u>: Gamma activity observed in drywells may also have originated from near-surface waste loss events, transfer line leaks or tank overfills, in which case there is no loss of integrity of the steel liner in the tank.

Geophysical techniques can also be used outside of a tank to measure increased moisture and gamma-emitting contaminants. Dry borehole neutron moisture and/or RAS total gamma leak detection monitoring is performed during retrieval in accordance with tank waste retrieval work plans. The accuracy of dry borehole logging count rate is roughly the square of the total number of counts (*Radiation Detection and Measurement* [Knoll 2000], pp. 94-96). The correlation between counts per second (c/s) and radioactivity or moisture measurements varies by detector.

Leak detection monitoring for retrieval is conducted by observing changes in neutron readings (c/s) compared to an established baseline for the detector being used. Therefore, for a given detector, accuracy of calibration is not a factor. Leak detection approximations presented in Appendix B of RPP-10413, *Tank S-112 Saltcake Waste Retrieval Demonstration Project Leak Detection, Monitoring, and Mitigation Strategy* range from a mean of 100 gal for a leak located 10 ft from a drywell to a mean of 6,200 gal for a leak 45 ft from a drywell. However, 13,000 gal of saline solution injected for leak detection monitoring tests in 241-S Tank Farm were not detected by surrounding drywells (RPP-30121, *Tank 241-S-102 High-Resolution Resistivity Leak Detection and Monitoring Test Report*).

Table 3-2. Radionuclides Detectable with High-Purity Germanium Equipment (2 sheets)

Man-made Gamma Emitting Radionuclides Detectable with High-Purity Germanium Equipment						
Radionuclide	Half life (years)	Primary Gamma Rays		Secondary Gamma Rays		Typical MDL, pCi/g
		E, keV	Y	E, keV	Y	
Co-60	5.2714	1332.50	0.9998	1173.24	0.9990	0.15
Ru-106	1.0238	511.86	0.2040	621.93	0.0993	
Sb-125	2.7582	427.88	0.2960	600.60 635.95 463.37	0.1786 0.1131 0.1049	
Sn-126	2.07E+05	414.52	0.977	666.16 694.83	0.999 0.959	
Cs-137	30.07	661.66	0.851			0.2
Eu-152	13.542	1408.01	0.2087	344.28 964.13 1112.12 778.90	0.2658 0.1434 0.1354 0.1296	
Eu-154	8.593	1274.44	0.3519	723.31 1004.73 873.19	0.2022 0.1801 0.1227	0.2
^{235}U	7.04E+08	185.72	0.5720	205.31	0.0501	0.6
U-238 (Pa-234m)[1]	4.47E+09	1001.03	0.0084	766.36	0.0029	10-15
(Pa-233)	2.14E+06	311.90	0.385	300.13 340.48 415.76	0.0662 0.0445 0.0173	1
Pu-239	24,110	375.05 413.71	1.554E-5 1.466E-5	203.55 345.01 332.85	5.69E-6 5.86E-6 5.48E-6	20,000
Pu-241 (U-237)	14.3	208.005	5.19E-6[2]	164.61 332.35	4.56E-7[2] 2.94E-7[2]	
Am-241[2]	432.2	208.01	7.91E-6	368.05	2.17E-6	50,000

Table 3-2. Radionuclides Detectable with High-Purity Germanium Equipment (2 sheets)

		335.37 662.40[4] 722.01	4.96E-6 3.64E-6 1.96E-6	376.65 322.52 332.35	1.38E-6 1.52E-6 1.49E-6	
Naturally Occurring Radionuclides Detectable with High-Purity Germanium Equipment						
	Primary Gamma Rays			**Secondary Gamma Rays**		
Radionuclide	**Daughter**	**E, keV**	**Y**	**Daughter**	**E, keV**	**Y**
K-40	Ar-40	1460.83	0.1067			
Th-232[3]	Tl-208 Pb-212 Tl-208	2614.53 238.63 583.19	0.3534 0.433 0.3011	^{228}Ac ^{228}Ac ^{228}Ac	911.21 968.97 338.32	0.266 0.1617 0.1125
U-238[4]	Pb-214 Bi-214 Bi-214	351.92 609.31 1764.49	0.358 0.4479 0.1536	^{214}Pb ^{214}Bi ^{214}Pb ^{214}Bi ^{214}Bi	295.21 1120.29 241.98 1238.11 2204.21	0.185 0.148 0.0750 0.0586 0.0486

Minimum detection limit (MDL) based on routine analysis with Spectral Gamma Logging System.

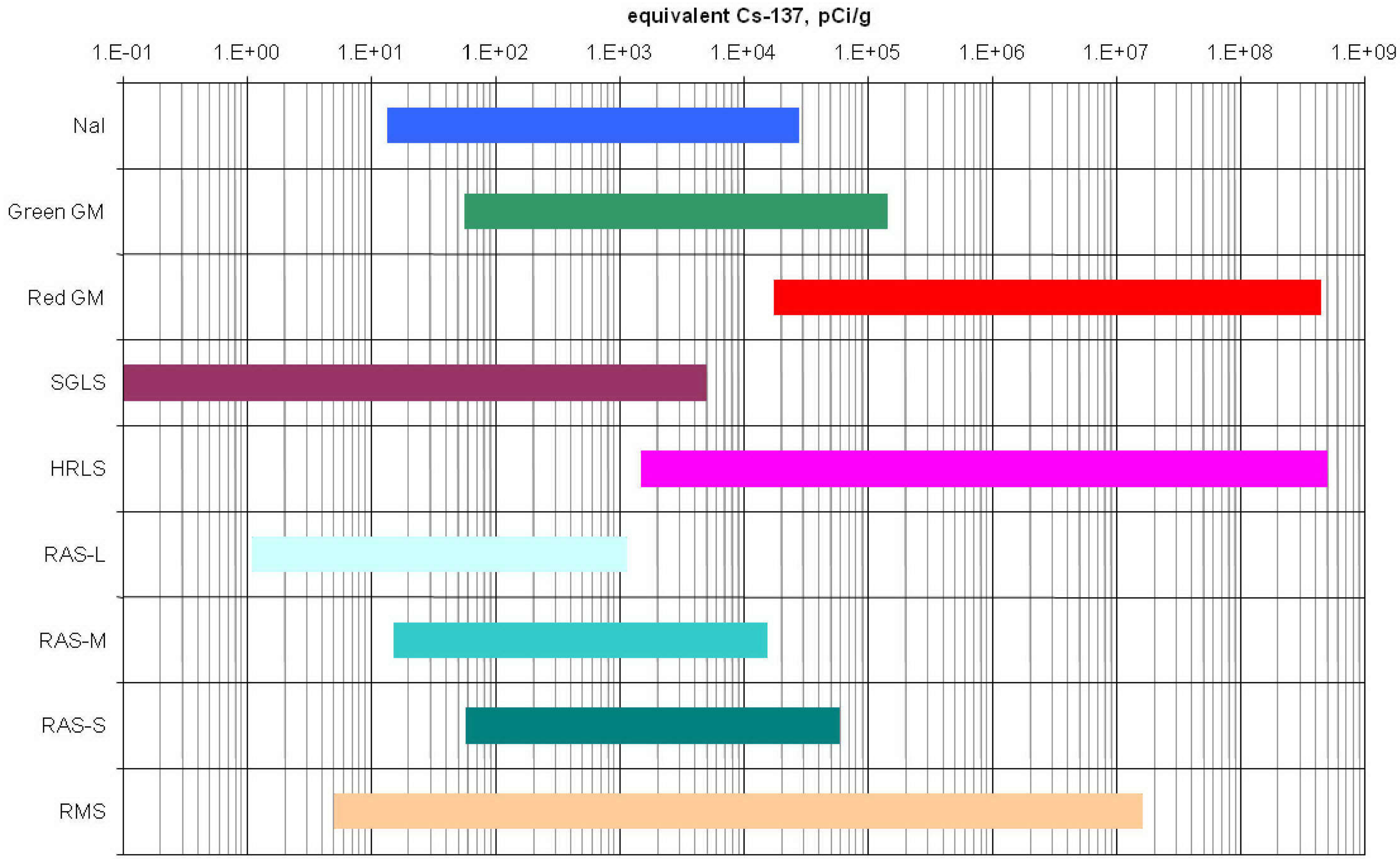
[1] Pa-234m is a short-term daughter of U-238. The yield is relatively low, and these gamma lines are generally not seen in “natural” uranium. Within the uranium decay series, secular equilibrium is achieved slowly, and gamma activity from Pb-214 or Bi-214 will not reach significant levels in less than several hundred thousand years. Hence, the presence of gamma activity originating from Pa-234m, without much higher levels of activity from Pb-214 and Bi-214, is an indication of the presence of anthropogenic U-238, which has been chemically separated from its decay products.

[2] Yield corrected for branching ratio of 0.0000245.

[3] Th-232 occurs naturally in geologic materials. At Hanford “background” values are generally in the range of 0.5 to 1 pCi/g. Th-232 will establish secular equilibrium throughout the decay series relatively quickly. Hence, anomalous values may indicate the presence of anthropogenic Th-232. Concentrations above 2 pCi/g warrant further evaluation.

[4] U-238 occurs naturally in geologic materials. At Hanford “background” values are generally in the range of 0.5 to 2.5 pCi/g. For anthropogenic U-238, the decay series will not be in secular equilibrium, and the peaks shown above will not be elevated. Elevated Bi-214 and Pb-214 concentrations may be an indication that Rn-222 may be present.

Figure 3-3. Measurement Ranges of Tank Farm Gamma Detectors



Notes:

NaI:	Sodium iodide or scintillation detector used to measure total gamma in lower activity wells
Green GM:	Geiger Mueller tube used to measure moderate gamma activity
Red GM:	Geiger Mueller tube used to measure high gamma activity
SGLS:	Spectral gamma logging system, uses a high purity germanium detector to measure gamma energy spectra for separate gamma radionuclides (i.e., ^{137}Cs, ^{60}Co, ^{154}Eu, ^{238}U)
HRLS:	High rate logging system, uses shielding to investigate gamma activity too intense for the spectral gamma logging system.
RAS-L:	Radionuclide Assessment System – large NaI detector
RAS-M:	Radionuclide Assessment System – medium NaI detector
RAS-S:	Radionuclide Assessment System – small NaI detector
RMS:	Radionuclide monitoring system (not used at Hanford)

Ex-Tank High Resolution Resistivity Leak Detection Monitoring. High Resolution Resistivity is used to monitor SSTs for tank leaks during retrieval operations and measures changes in resistivity against baseline conditions as specified in tank waste retrieval work plans. Resistivity measurements are sensitive to changes in subsurface electrical conditions, which in turn are influenced by the introduction of fluids or other materials that may contrast electrically with the generally dry, highly resistive sand fill. Because tank waste is high in sodium and nitrate, changes in resistivity/conductivity are a potential indicator of a tank leak. In leak injection tests in 241-S Tank Farm, where 13,000 gal of saline solution were injected to the soil near tank 241-S-102, it was determined that HRR could detect a leak of 2,100 gal or more with 95% accuracy. Initial tests showed responses after only a few hundred gallons of saline solution were injected (RPP-30121). In comparison, drywell neutron moisture measurements showed negligible changes during leak injection tests. The HRR system provides a continuous measure of resistivity during retrieval as compared to weekly moisture measurements and provides more spatial measurements compared to measurements indicating conditions within about a radius of one foot from a drywell. Furthermore, HRR senses a much larger volume than a drywell, including beneath a tank. However, HRR is affected by the presence of steel infrastructure and external electrical noise sources, thus sufficient monitoring of background conditions (also called "baseline measurements") must be completed to effectively assess the data.

3.3 RETAINED GAS

Many radioactive wastes generate and retain hydrogen, nitrogen, nitrous oxide, ammonia, methane, and other volatile organic compounds; as well as air that backfills void spaces in the waste solids matrix once occupied by interstitial liquid (saltwell pumping). Retained gas is defined as that gas held in the waste predominately by yield strength, producing particle displacing bubbles. The generation rates of the major fuel (hydrogen, ammonia, methane) and diluent species (nitrogen and air) aid in assessing the long-term behavior of tank wastes (surface level measurements) and support analyses of potential changes in waste storage conditions (to assess postulated deflagrations). The presence of such gases as ammonia, methane, and nitrous oxide can have a significant influence on the flammability characteristics of a gas mixture. Increases in retained gas may result in ILL growth or an increase in the measured surface level. The built-up gasses may be released suddenly through waste overturn. Gas release events may result in the tank head space exceeding flammability limits and a sudden decrease in the waste surface level and/or ILL. For some tanks containing retained gas, the ILLs may also increase and decrease with changes in barometric pressure.

The original wastes that were discharged to the waste tanks from the evaporator were essentially free of retained gas. The gases retained in the wastes were generated during interim storage. Non-convective layers and crusts retain large quantities of the permanent gases. In contrast, connective layers do not retain significant amounts of such gases. The principal soluble gas, ammonia, is widely distributed throughout the liquid phases of the waste. Retained gas sampling observations and other findings show the gases that have been retained in the waste for long intervals are enriched in hydrogen. An evaluation of the empirically measured rates of gas generation results from the slow decomposition of nitrogen and ammonia, and differences in transportation rates (RPP-6664, *The Chemistry of Flammable Gas Generation*).

In C-Farm, tanks C-102, C-103 and C-110 were estimated to contain the largest fraction of retained gas, although these tanks were well below the Lower Flammability Limit. While the fraction of retained gas has not been measured, past liquid level increases are an indication of the fraction of gas in the waste. Estimated results of a gas release event for these and other SSTs are reported in WHC-SD-WM-ER-526, *Evaluation of Hanford Tanks for Trapped Gas*.

3.4 TANK LEAKS

Sixty-seven of 149 SSTs have been designated as "confirmed or suspected leakers" over the SST operational timeline (1945 to 1980) (HNF-EP-0182). During the active operation of the SST farms, either an anomalous liquid-level measurement of 0.5 to 2 in. (depending on the type of waste in a tank) or a significant increase in gamma activity in a drywell, lateral or leak detection pit was generally a sufficient reason for the tank to be listed as "questionable integrity" or an "assumed leaker" (SD-WM-TI-356). When a tank was designated as "questionable integrity" it was pumped to a "minimum heel" and taken out of service. In some cases the "questionable integrity" designation was followed up with additional investigations which concluded that a tank did not leak or identified an overflow or transfer line leak source and the tank was returned to operation. 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 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.

3.5 INTERIM STABILIZATION

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 an SST design to a DST design for construction of new tanks. The double-shell design provided both secondary containment and reliable leak detection systems between the two liners. A decision was also made to pump liquids stored in the SSTs into the DSTs to remove pumpable liquid from the SSTs. This process was referred to as interim stabilization of the SSTs.

A consent decree (CT-99-5076-EFS) was established that set a time table and specified criteria to complete interim stabilization, and by 2003 all of the SSTs were interim stabilized except a couple that went directly to retrieval without undergoing interim stabilization (HNF-EP-0182). A tank was considered interim stabilized when it contained less than 50,000 gal of drainable interstitial liquid and less than 5,000 gal of supernate. If the tank was jet pumped to achieve interim stabilization, then the jet pump flow or saltwell screen inflow must have been at or below

0.05 gpm. Due to equipment failure some jet pump tanks were administratively stabilized before reaching the 0.05 gpm criteria (see HNF-EP-0182).

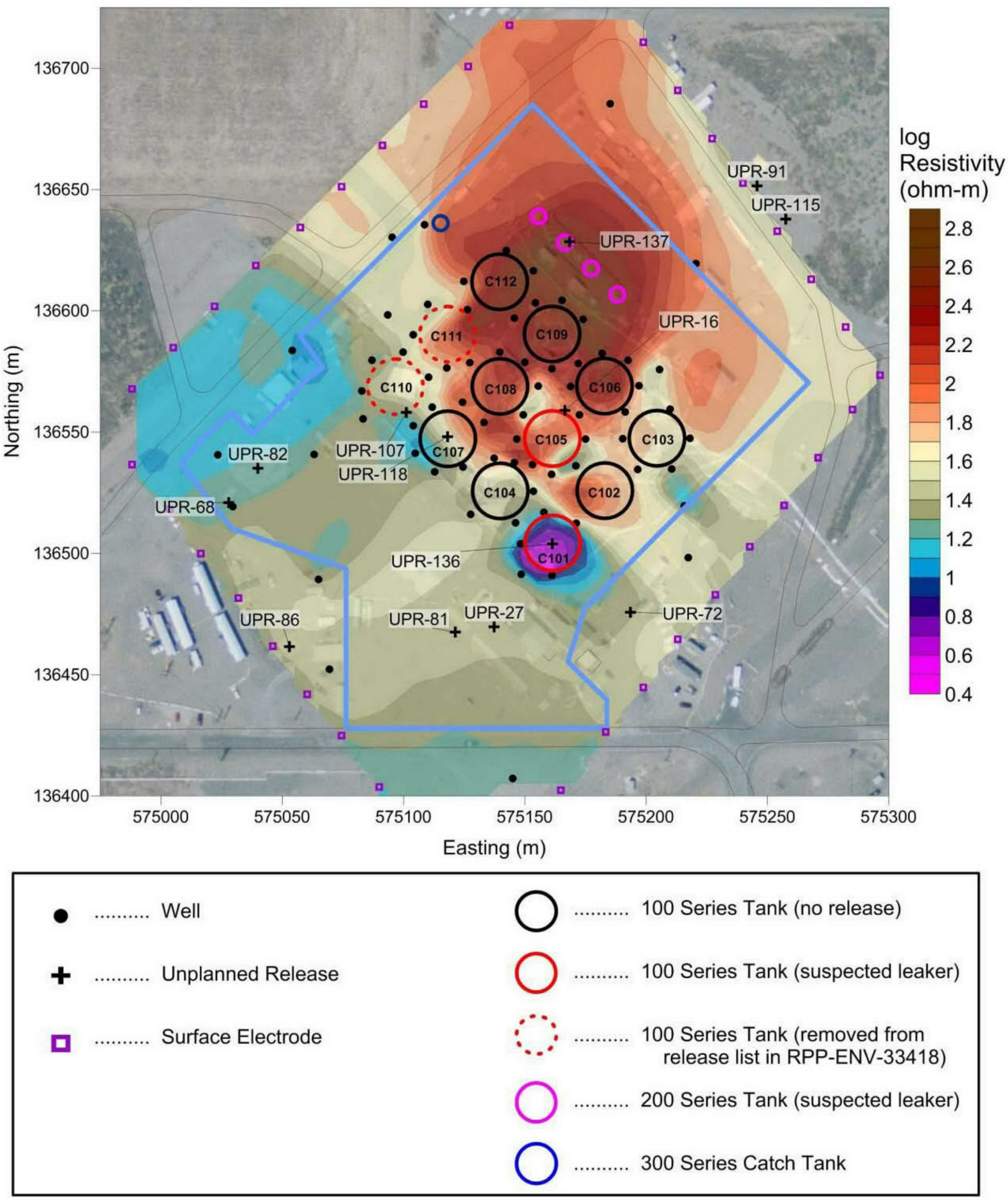
3.6 SURFACE GEOPHYSICAL EXPLORATION IN 241-C TANK FARM

Surface Geophysical Exploration (SGE) is an electrical geophysical imaging approach that produces two and three dimensional maps of the electrical resistivity of the subsurface. Resistivity and its inverse, conductivity, are sensitive to increases in soil moisture content and related variations in ionic mobility. Because tank waste is high in nitrate and sodium, areas of low resistivity indicate locations where waste may have been released to the soil. Surface Geophysical Exploration is used to guide the selection of sampling locations and as a tool to assess resistivity anomalies (high moisture content areas generally associated with potential waste releases) across large areas.

Surface Geophysical Exploration was deployed in WMA C (RPP-RPT-49288, *C Farm Surface Geophysical Exploration-Reprocessing*). Surface Geophysical Exploration data was collected using (1) the well-to-well methodology with existing groundwater and vadose zone wells; (2) surface-to-surface data collected on four lines using surface electrodes located along the periphery of the C-Farm fence; and (3) a combined well-to-surface where the wells and surface electrodes were collected in a joint acquisition survey. The original C−Farm data acquired in 2006 was reprocessed in 2011 (RPP-RPT-49288). Figure 3-4 shows the resistivity distribution for the uppermost layer of the model in WMA C for surface electrodes and well to well resistivity surveys with electrical connections to and between surface electrodes, tank farm drywells and groundwater monitoring wells. These results show low resistivity regions near tanks C-101, C-105, C-107, beneath C-104 and south of C-103.

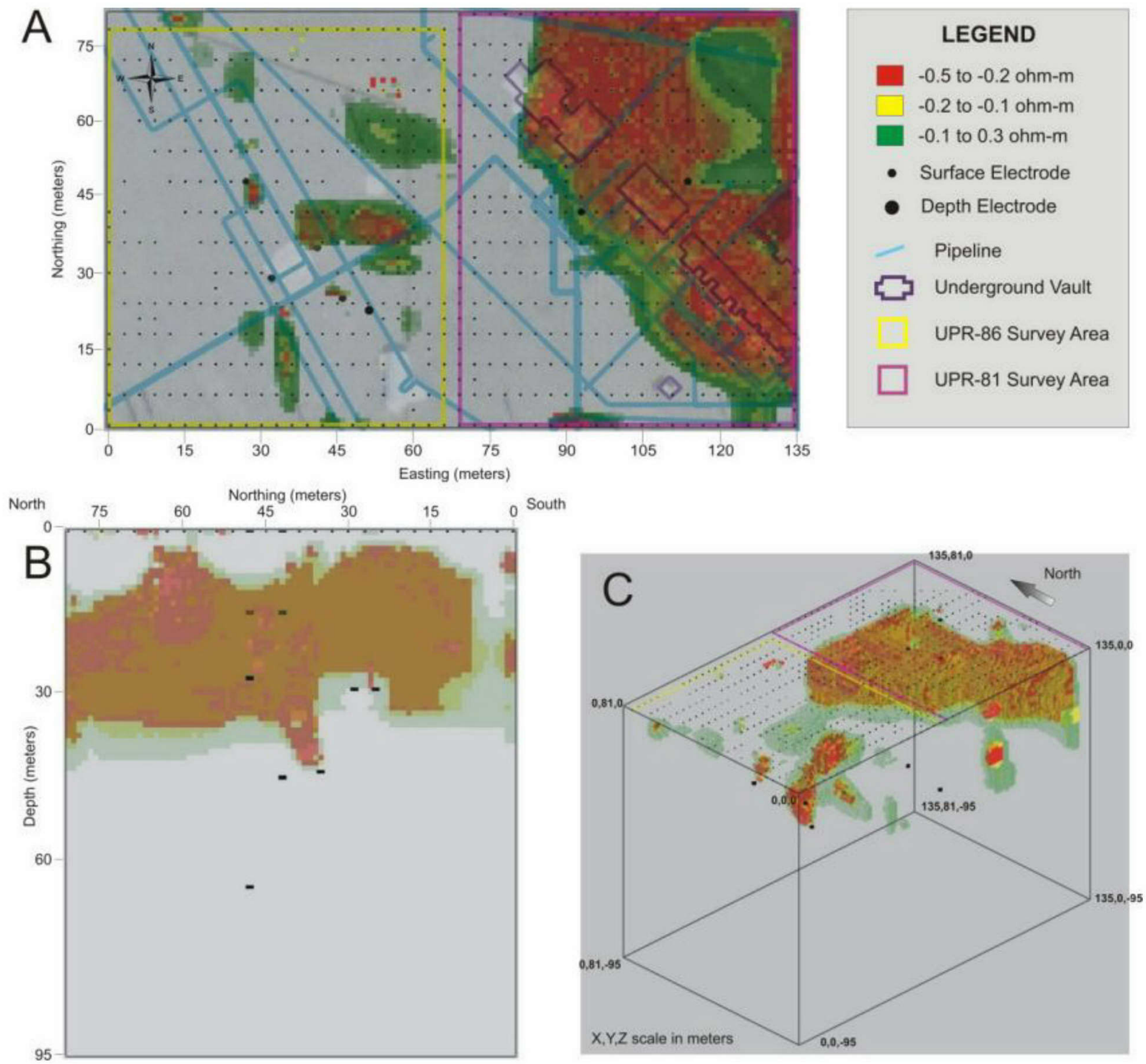
Recent three-dimensional electrical resistivity surveys were also made in C-Farm to study the unplanned releases UPR-200-E-81, UPR-200-E-82 and UPR-200-E-86. Results of these investigations are summarized in RPP-RPT-41236, *Surface Geophysical Exploration of UPR 200-E-81 Near the C Tank Farm* (UPR-81), RPP-RPT-50052, *Surface Geophysical Exploration of UPR-200-E-82 Near The C Tank Farm* (UPR-82), and RPP-RPT-47486, *Surface Geophysical Exploration of UPR 200-E-86 Near the C Tank Farm* (UPR-86). These surveys had the objective of collecting and analyzing electrical resistivity data to identify and locate low resistivity regions in and around the UPR sites that may be indicative of increased soil moisture or salts caused by the UPRs. UPR-81 models identified a low resistivity region over and to the west of the 241-CR-151/152/153 diversion boxes, and another low resistivity region over and to the west of the 241-CR vault (Figure 3-5). In comparison to UPR-81, SGE results in the vicinity of UPR-86 showed higher resistivity and appear to be inconsistent with a 17,000 gallon waste release in this area (Figure 3-5). UPR-82 models showed a general distribution of high electrical resistivity values beneath the UPR-82 release (Figure 3-6), although evidence suggests that the soil itself may be electrically resistive. It was concluded that the spill at UPR-82 was either of low volume and not a source of groundwater contamination for the waste management area, or actions taken to control exposure to the spill have resulted in it being diluted and/or flushed into the underlying groundwater. The size of the UPR-82 release, 2,600 gal, favors the former interpretation.

Figure 3-4. Resistivity Results of the Uppermost Layer for the 241-C Tank Farm Model



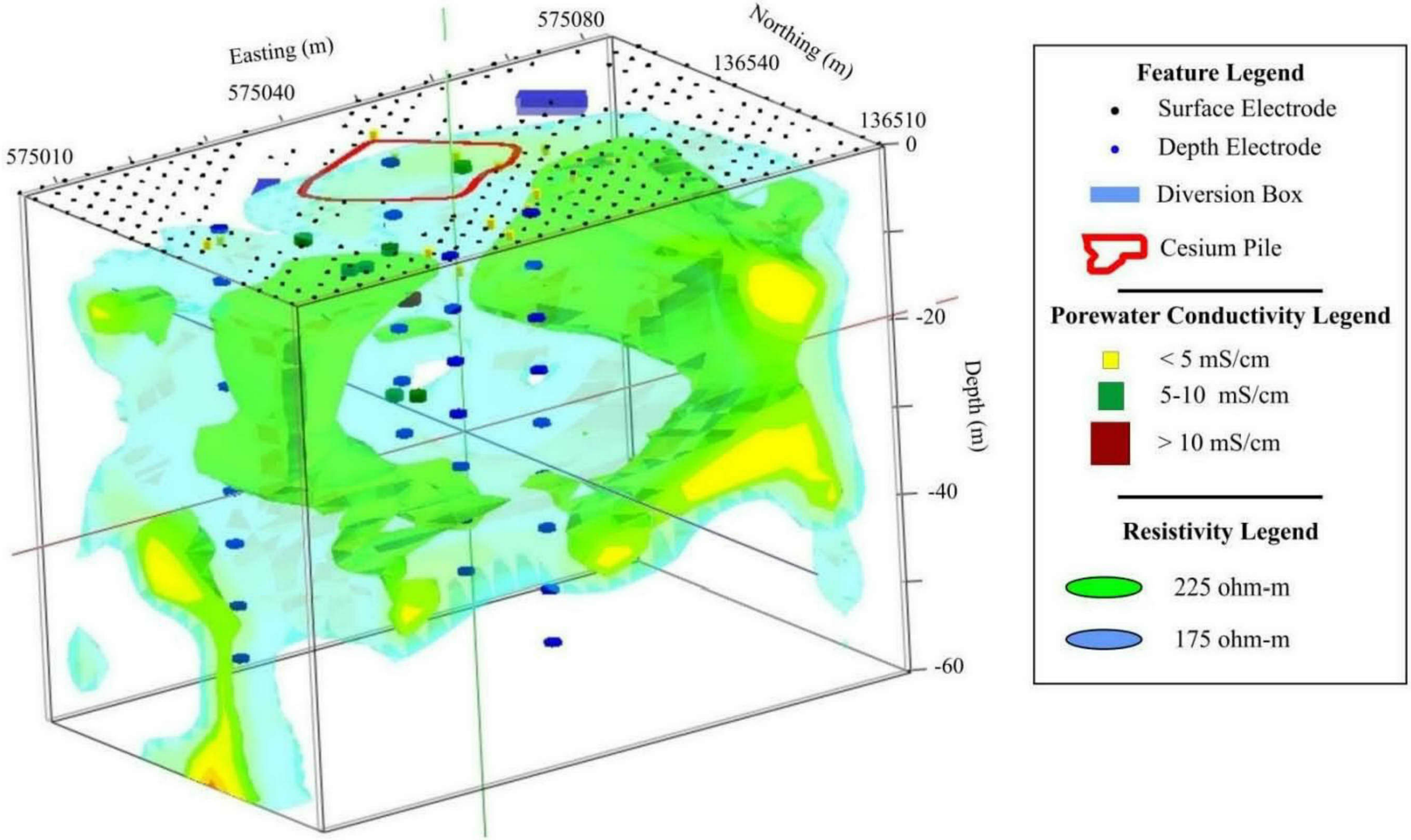
Reference: RPP-RPT-49288, *C Farm Surface Geophysical Exploration-Reprocessing*

Figure 3-5. Distribution of Calculated Resistivity for UPR-81 and UPR-86 Sites



Reference: RPP-RPT-47486, *Surface Geophysical Exploration of UPR 200-E-86 Near the C Tank Farm*.

Figure 3-6. Three-Dimension Rendered Resistivity Values at UPR-82, Viewed from Southwest



Reference: RPP-RPT-50052, *Surface Geophysical Exploration of UPR-200-E-82 Near The C Tank Farm*.

3.7 SUMMARY OF GROUNDWATER CONTAMINATION IN THE UNCONFINED AQUIFER UNDERLYING WASTE MANAGEMENT AREA C

The primary contaminants observed in groundwater monitoring wells at WMA C (Figure 3-7) are sulfate, technetium-99 (^{99}Tc), and nitrate. Also, there are elevated chloride concentrations and low levels of cyanide at some wells. Most sulfate concentration increases in the past have been shown to be influenced by migration from the northeast (Figure 3-8). A time series of the 80 mg/L contour illustrates the movement of sulfate into and across WMA C to the southwest. This mapping also confirms the southwest flow direction across the site.

Figure 3-7. Groundwater Wells in Waste Management Area C

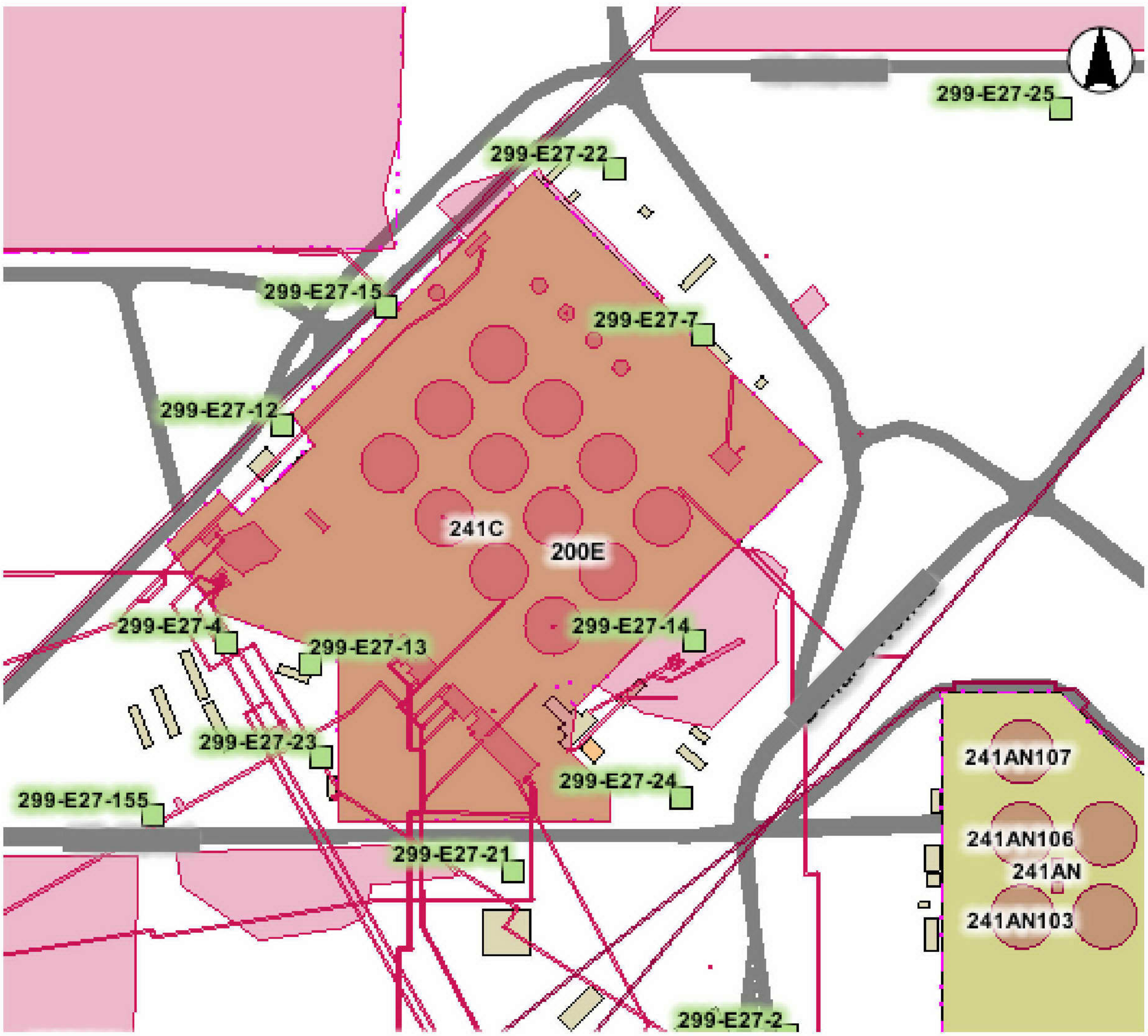
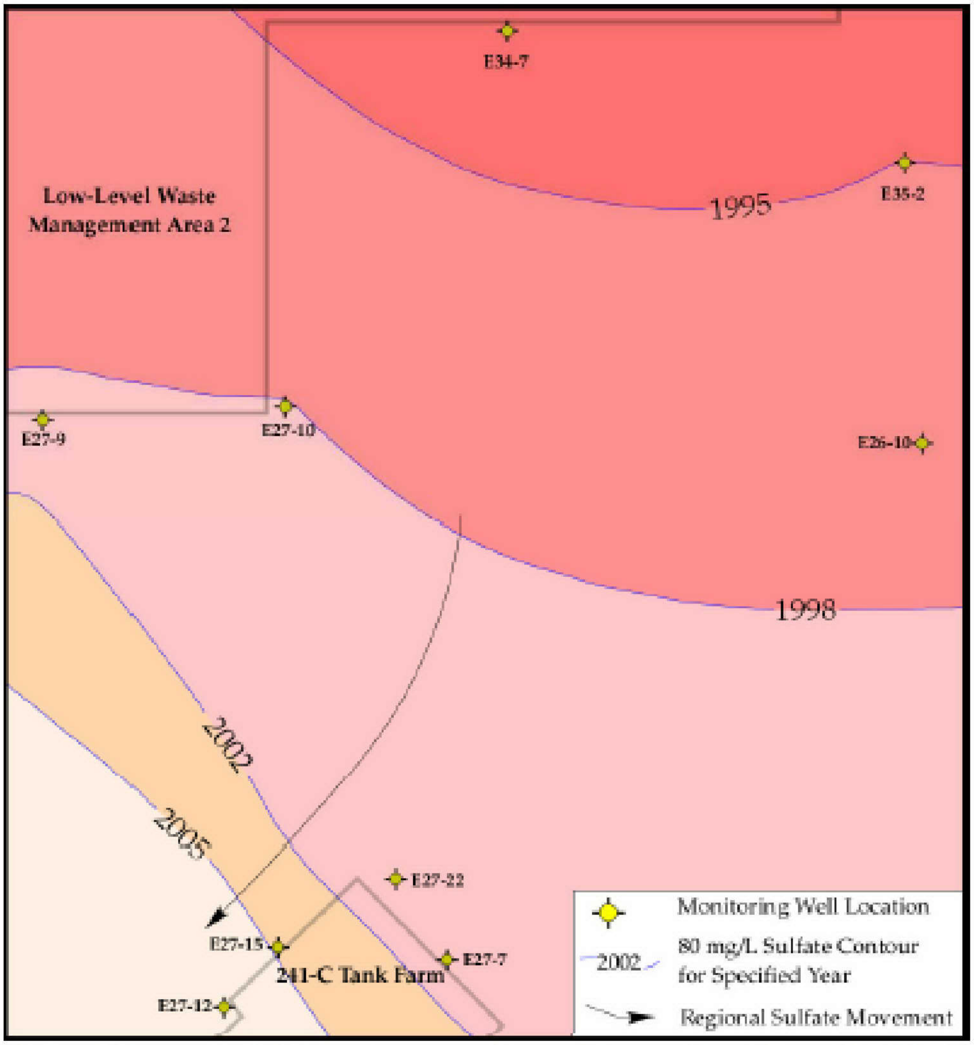


Figure 3-8. Time Series Contours Illustrating the Regional Control of Sulfate from High Values Associated with the Receding Aquifer Along the Basalt Subcrop



Note: Movement of sulfate contours over time confirms southwest flow at WMA C.

Currently, nitrate and sulfate concentrations exceed the drinking water standards (DWS) in wells south of WMA C, 299-E27-14 and 299-E27-24. Nitrate and sulfate concentrations do not exceed the DWS in upgradient wells, suggesting a source within the 241-C Tank Farm. In addition, the dangerous waste contaminant cyanide is also found in these wells. Furthermore, nitrate concentrations at well 299-E27-14 are more than double past and present upgradient well concentrations; 299-E27-7, 299-E27-22, and 299-E27-25.

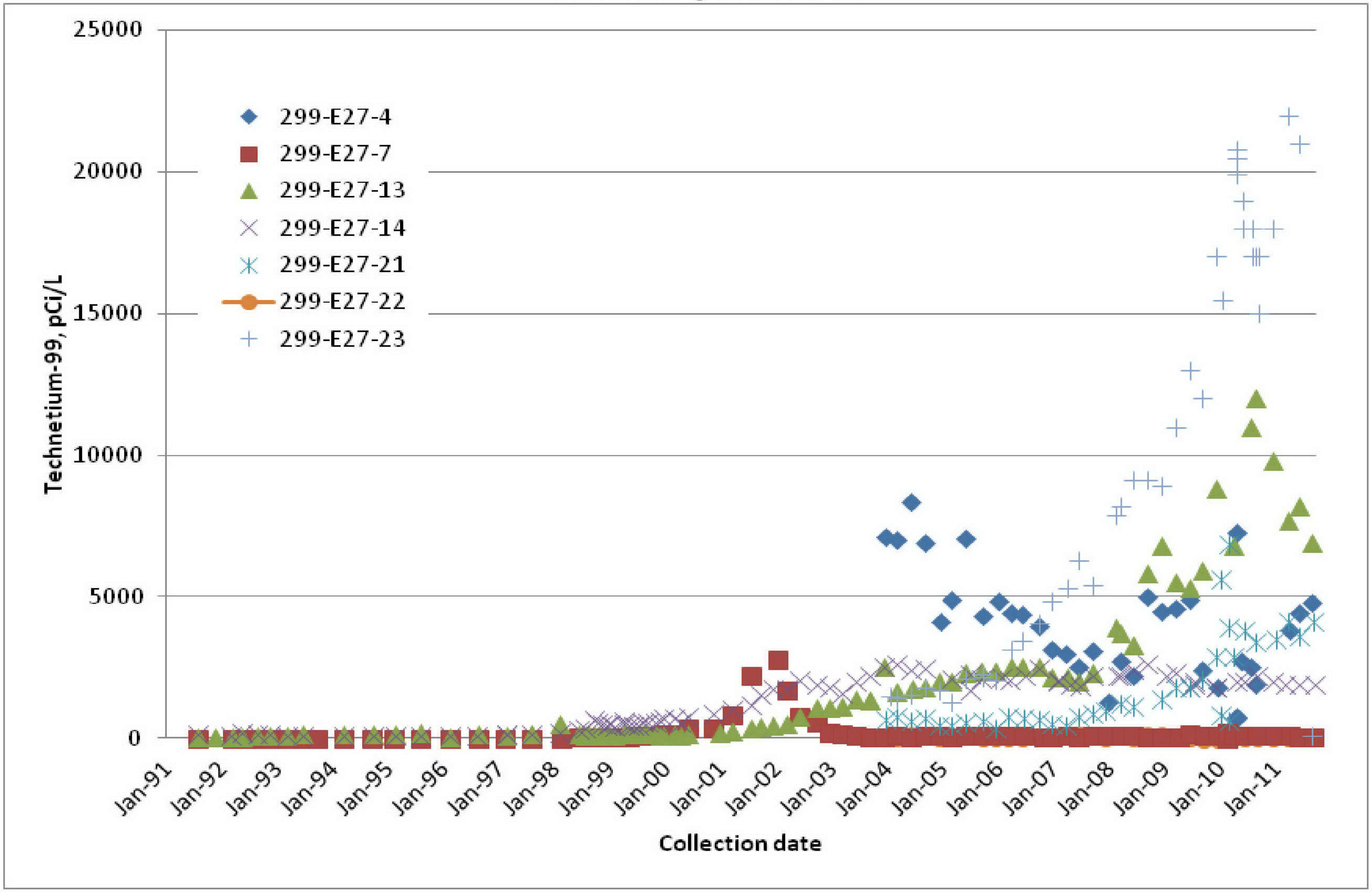
Past maximum technetium-99 (^{99}Tc) concentrations (~8,400 pCi/L) at WMA C occurred in June 2004 in monitoring well 299-E27-4 west of the 241-C Tank Farm. The peak ^{99}Tc concentration at well 299-E27-4 appeared to be associated with a declining trend, so the maximum concentration in this area was probably higher prior to installation of this well. Concentrations continued trending down until 2008 when concentrations began to oscillate. The maximum during the oscillations has remained below 5,000 pCi/L (Figure 3-9).

The current maximum ^{99}Tc concentration (~22,000 pCi/L) at WMA C occurs in well 299-E27-23 located to the southwest of the 241-C Tank Farm and southeast of well 299-E27-4. Figure 3-8 shows sharp peak concentrations in wells 299-E27-4 and 299-E27-21 during the spring of 2010. These peak concentrations are the result of depth discrete samples at approximately 9 meters below the water table. Although there was a sharp increase in concentration with depth in these wells there was little change in concentration with depth at well 299-E27-23. Considering the recent ^{99}Tc concentration increases in wells 299-E27-4, 299-E27-13, 299-E27-21, and 299-E27-23 and the southwest flow direction discussed above, a source from within the 241-C Tank Farm appears likely.

The last contaminant of interest is cyanide. Cyanide-contaminated waste was a byproduct of the uranium recovery process completed in the early 1950s to separate uranium from metal waste generated by the bismuth phosphate process. This process was tributyl phosphate (TBP)-based and was known as TBP waste. Because the TBP waste volume exceeded tank storage capacity, intentional discharges to the subsurface were needed. One of the impediments to subsurface discharge was extremely high concentrations of fission products, particularly ^{137}Cs, in TBP waste. To scavenge ^{137}Cs from TBP waste, a ferrocyanide-based separation process was used. Numerous facilities at C-Farm were used for this process. These included tanks that stored TBP and scavenged TBP waste, the 244-CR vault where scavenging took place, and various diversion boxes and pipes through which waste was transferred. Thus, tank farm operations occurred that could have lost cyanide-contaminated waste to the subsurface. Although WMA C facilities were used in the ^{137}Cs separations processes, the intentional discharges to the subsurface did not take place at or nearby to WMA C.

Cyanide concentrations present beneath WMA C are significantly below the DWS (200 ug/L). The most concentrated and consistent cyanide concentrations at WMA C occur at upgradient monitoring well 299-E27-7 on the northeast side of WMA C. Cyanide concentrations were first measured in December 1999 and reached a maximum value of ~45 µg/L in September 2004.

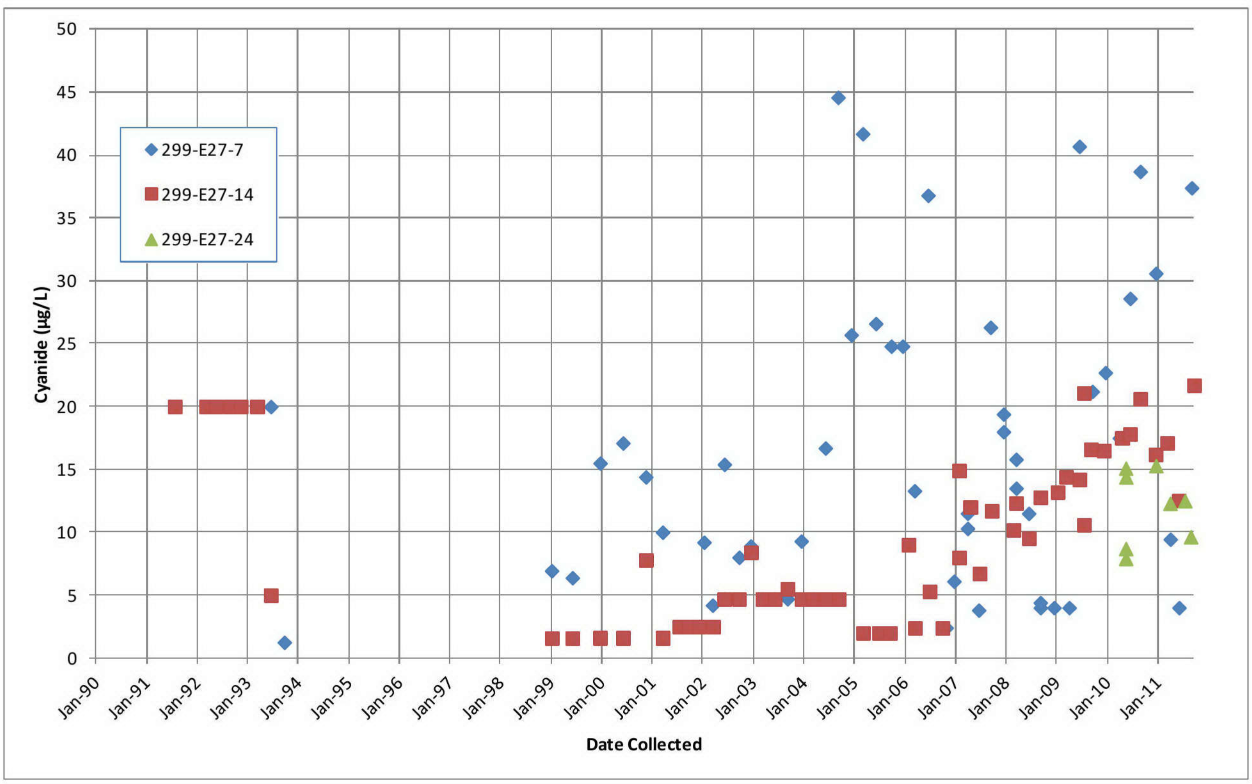
Figure 3-9. Recent Technetium-99 Concentrations in Samples from Groundwater Monitoring Wells in Waste Management Area C



Concentrations since 2004 have been variable at 299-E27-7, while concentrations in well 299-E27-14, located to the south of well 299-E27-7, have shown an increasing trend (Figure 3-10). The mean concentration at well 299-E27-14 over the past couple of years, 2010 and 2011, is about half the mean concentration at well 299-E27-7. Concentrations in new well 299-E27-24, located approximately 66 meters south of well 299-E27-14, are about the same in magnitude as well 299-E27-14; however, well 299-E27-24 is screened at the bottom of the aquifer. Cyanide detection in the remaining WMA C wells is sporadic and concentrations are generally just above the detection limit (4 μg/L).

The largest and most consistent cyanide concentrations in monitoring wells around WMA C occur at upgradient monitoring well 299-E27-7 on the northeast side of WMA C. Cyanide concentrations were first measured in October 1999 and reached a maximum value of ~45 μg/L in September 2004. The latest measurement in June 2007 was 3.8 μg/L (Figure 3-9). Cyanide has also been measured sporadically at all other WMA C monitoring wells to the north, west, and south of monitoring well 299-E27-7. In these locations cyanide concentrations have ranged from non-detected to 18 μg/L.

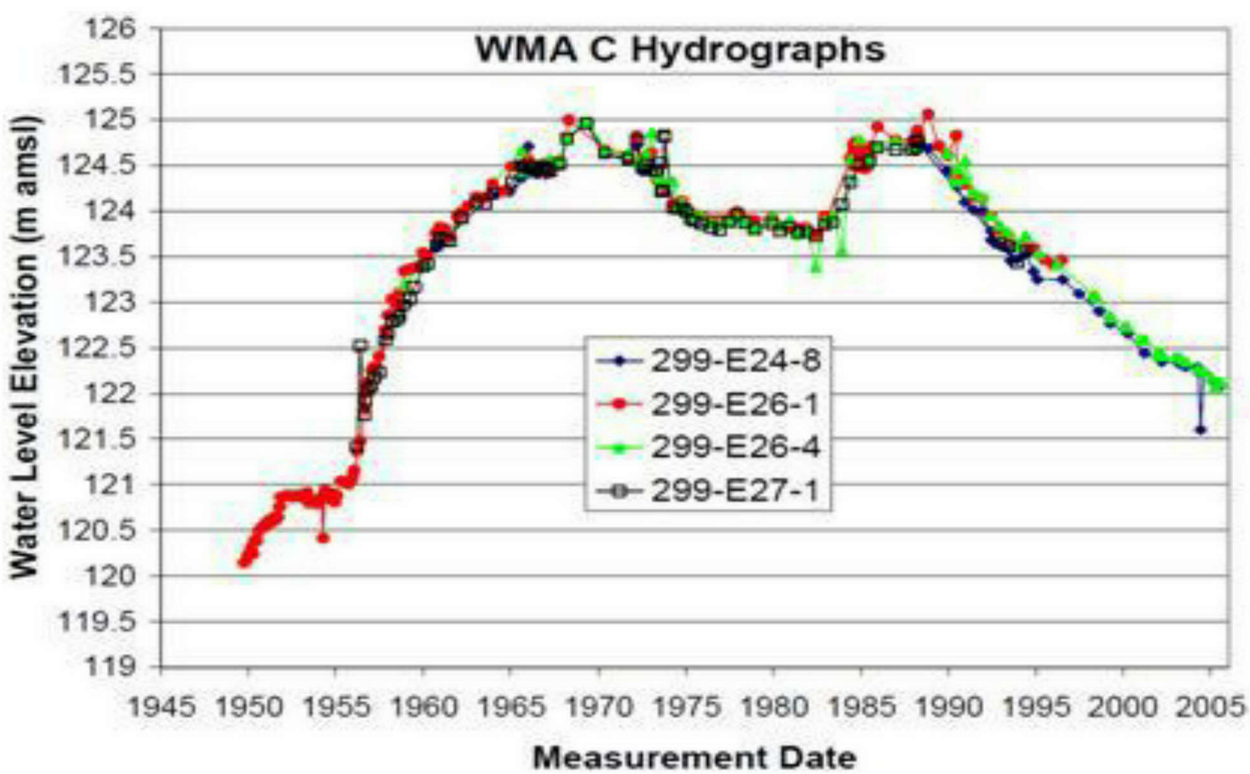
Figure 3-10. Cyanide Concentrations at Groundwater Monitoring Wells 299-E27-7, 299-E27-14 and 299-E27-24



Long-term hydrographs of selected wells in the immediate vicinity of the WMA C show ~5 m rise in the water table between estimated pre-Hanford conditions in the mid-1940s and the early 1970s and late 1980s (see Figure 3-11). These increases are largely the result of waste management operations that discharged an estimated total of 5.8×10^{11} liters at liquid discharge facilities, most notably at B Pond and Gable Mountain pond facilities in 200 East Area and to the north, respectively. In response to cessation of liquid discharges in the early 1990s, water levels in the WMA C area have steadily declined ~3 m from peak levels in the late 1980s and are expected to continue to decline to pre-Hanford conditions in the future. From the 1950s to today, a southwestern trend in groundwater flow exists under WMA C but the general direction of flow is expected to shift to the south and southeast as the water table returns to pre-Hanford conditions.

Groundwater data from wells near the WMA C show groundwater concentrations for several constituents that exceed current maximum contaminant levels (MCLs) and secondary maximum containment levels. Specific constituents that exceed MCLs include ^{99}Tc, iodine-129 (^{129}I) and nitrate. Maximum values of ^{99}Tc, ^{129}I, and nitrate exceed relevant MCLs by factors of approximately 10, 6, and 2, respectively. Other constituents that exceed secondary maximum containment levels include sulfate and aluminum. Other tank waste related contaminants (i.e., cyanide) are present but are found at levels below their respective MCLs. Other than for ^{129}I, the only known source of the tank waste related constituents appears to be tank wastes being managed in the WMA C. Iodine-129 contamination is present throughout the east half of the 200 East Area and are believed to be from liquid waste facilities in the northern portion of the 200-PO-1 OU (DOE/RL-2011-01).

Figure 3-11. Water Table Elevations for Selected Wells near Waste Management Area C from 1945 through 2005



Reference: RPP-RPT-41918, *Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure*.

4.0 SUMMARY OF TANKS ASSESSED

Initial C-Farm leak inventory assessments were performed in 2006 and results reported in Rev. 1 of this report. The initial assessments focused on providing inventory estimates for tanks classified as "assumed leakers" and for three major UPRs in C-Farm. The initial assessment report discusses potential overflows from spare inlets and cascade lines, transfer line leaks and sources of ^{60}Co plumes in the vadose zone, but does not attempt to quantify them and does not include process waste information for tanks classified as "sound". The tanks were re-assessed in 2011 to review additional field characterization data obtained since 2005, to address Nez Perce comments and other input received during WMA C Performance Assessment workshops, and to more closely assess tanks currently classified as "sound" and estimate releases from overflows and pipelines. The re-assessments were incorporated to this report.

The following sections describe the 2006 and 2011 tank farm leak assessments and results summarized in Table 4-1. Additional data and information reviewed for tanks classified as "assumed leakers" are presented in Appendix B. Appendix C shows data and information reviewed for tanks classified as "sound" and Appendix D further describes the rationale and logic used for the 2011 reassessment.

Table 4-1. Waste Releases from and Around Each 241-C Farm Tank (2 sheets)[1]

Tank/UPR	Waste Release Volume, gal	^{60}Co, Ci	^{137}Cs, Ci	^{99}Tc, Ci	Basis
C-101	37,000	0.17	800	0.22	Estimated waste release volume based on an assumed CW waste type and drywell readings. According to surface level measurements there was a waste release of up to ~37,000 gal, likely a combination of a CW release from the spare inlet and condensate (depending on condenser operation).
C-104	28,000	1.3	80	0.03	Cascade line leak next to tank C-104. Tank C-104 was filled to 560,000 gal of CW waste in 1965. No transfer was identified, however, the surface level decreased to the spare inlet elevation of ~532,000 gal resulting in a possible 28,000 gal release.
C-105	2,000	0.08	2,500	0.8	Release range from 40 to 2,000 gal (<2,000 gal) of P1 supernate (PSN). Cascade line release and possible tank leak.
C-108	18,000	0.8	50	0.02	Cascade line leak; tank C-108 filled to 568,000 gal of CW-HS waste in 1965; decreased in surface level to 532,000 gal through a transfer to tank C-102; waste loss assumed to be 18,000 gal based on ^{60}Co and soil moisture determinations. Waste volume based on CW waste composition.
C-110	2,000	0.3	300	0.11	No observed liquid level decrease and less than 1,000 pCi/g ^{137}Cs activity in drywell.
C-111	0				Waste level decrease attributed to evaporation.

Table 4-1. Waste Releases from and Around Each 241-C Farm Tank (2 sheets)[1]

Tank/UPR	Waste Release Volume, gal	^{60}Co, Ci	^{137}Cs, Ci	^{99}Tc, Ci	Basis
C-112	7,000	0.33	20	0.0075	Transfer line leak from 252-C Diversion Box to tank C-112. Line leak likely prior to 1974; waste type in tank C-112 was CW-IX; 7,000 gal based on ^{60}Co plume and 5% soil moisture content above background.
C-201	0				Surface level discrepancy likely due to evaporation.
C-202	0				Surface level discrepancy likely due to evaporation.
C-203	0				Surface level discrepancy likely due to evaporation.
C-204	0				Surface level discrepancy likely due to evaporation.
UPR-81	36,000	0.36	350	0.11	Volume: 36,000 gal ^{137}Cs: 350 Ci
UPR-82	2,600	0.4	5,500	3.0	Volume: 2,600 gal ^{137}Cs is 5,500 Ci (sample concentration times volume). 1969 ^{137}Cs conc. = 4.28 Ci/gal For other analytes, the leak inventory values for radiological constituents are based on the activity per unit leak volume for the analyte in HDW P2 wastes times the ratio of the 1969 concentration for ^{137}Cs to the ^{137}Cs concentration in HDW for P2 waste, times the updated volume.
UPR-86	17,000	0.7	11,500	2.9	Volume: 17,000 gal Maximum, Based on mass balance estimate. Estimate appears to be high based on waste site investigations. ^{137}Cs is 11,500 Ci (1971 sample concentration times the updated volume).

[1]Cesium-137 and ^{60}Co values are approximations decayed to 1/1/2001.

CW = cladding waste, aluminum clad fuel
HDW = Hanford Defined Waste
HS = Hot Semiworks strontium purification waste (1961-1968)
IX = ion exchange
P1 = Plutonium Uranium Extraction (PUREX) high level waste (1956-1962), also referred to as PSN waste type
P2 = PUREX high-level waste (1963-1967)
SGLS = spectral gamma logging system
UPR = unplanned release

Reference: RPP-ENV-33418, *Hanford C-Farm Leak Assessments Report: 241-C-101, 241-C-110, 241-C-111, 241-C-105 and Unplanned Waste Releases*, Rev. 1.

For each release event, the sections include a description of release, release type (point or non-point source), estimated depth of release, estimated time of release, and estimated magnitude of release (volume and inventory). Uncertainties associated with release parameters are also summarized.

Given the limited information available, a conservative approach was used to estimate leak volumes and inventories. Sample data was used when available near the time of release to estimate leak compositions. However, a limited number of constituents were analyzed and composition estimates were largely based on waste types characteristic of the data obtained, total and spectral gamma geophysical logging measurements, and SIM historical process waste estimates.

The HDW and SIM model estimates are described in RPP-19822, *Hanford Defined Waste Model – Revision 5.0* and RPP-26744. These models used Hanford Plant initial radionuclide inventory estimates from the Oak Ridge Isotope Generation and Depletion Code (ORIGIN2) (RPP-13489, *Activity of Fuel Batches Processed Through Hanford Separations Plants, 1944 Through 1989*), tank waste transfer records, and release timing information to estimate waste composition in the SSTs and releases to the vadose zone.

4.1 TANK 241-C-101

4.1.1 Leak Status of Tank 241-C-101

Tank 241-C-101 was classified as a confirmed leaking tank in 1968 with a leak volume of 20,000 gal (HNF-EP-0182). The leak volume estimate appears to be based on a 13.5-in. liquid level decrease between January 1965 and September 1969 and a subsequent radioactivity increase in drywells (30-01-02, 30-01-06 and 30-01-09) around this tank. It appears that a portion of the liquid level decrease was attributed to evaporation. Tank C-101 is fitted with a condensation unit to recycle condensate back into the tank. A 13.5-in. decrease in surface level corresponds to ~37,000 gal. Further evaluations and field investigations indicate that some or all of the liquid level decrease may be attributed to a spare inlet release.

4.1.2 2011 Leak Assessment Considerations

The waste surface level measurements from 1965 through 1969 (when tank C-101 waste was pumped down to a waste depth of ~40 in.) showed an unaccounted surface level measurement decrease of ~13.5 in. (~37,000 gal). Evaporation calculations reported in RPP-ENV-33418, Rev. 1 indicate that given the high heat and high temperature of PUREX high-level (1956-1962) (PSN) waste, up to 85 gal/day of supernate could have evaporated from the tank over this time period, potentially accounting for all of the liquid level decrease over four years. However, if as expected, a condenser was operating during that time, supernate would have condensed back into the tank and the evaporation rate may have been negligible. Some condensers were reported to have leaked and condensate may have been released from the condenser pit to the soils.

Supernate may also have been released through the cascade or spare inlet line. Liquid level measurements indicate that the tank was filled above the cascade outlet with PSN waste from the CR vault from 1965 to 1969. High levels of total gamma activity were detected when the drywells were constructed in 1970. Most of the gamma activity decayed away following a ruthenium-106 (^{106}Ru) decay curve and less than 1,000 pCi/g of ^{137}Cs gamma activity was observed in 1997 SGLS measurements. If 37,000 gal of PSN waste was released, much greater ^{137}Cs activity would be expected compared to what was observed.

It is likely that the waste released was not PSN but was mostly PUREX CW and/or condensate. In March 1965 a 6-in. transfer line (line #8041) failed and permitted coating waste from the PUREX Plant to leak into the encasement between the 152-CR diversion box and tank C-102 and drain to tanks C-101, C-102, and C-103 via the tank pump pits (RL-SEP-405-DEL, *Chemical Processing Department Monthly Report for March, 1965*, p. B-2). As shown in Table 3-2, CW has low ^{137}Cs content and ^{60}Co content. A CW release mixed with condensate would account for the ^{60}Co observed in drywells near tank C-101 and the lower ^{137}Cs levels compared to a PSN release.

In 2011 direct push slant holes under the tank (C8101/2 at site A and C8103/4 at site B) were logged and sampled. Low gamma activity was observed throughout the profile in both holes. Quick-turn-around sample results showed nitrate and ^{99}Tc were not detected except at low concentrations deep in slant hole C8104. The drywell and direct push logging results indicate that if a large volume of waste was released, mobile contaminants may have been flushed below the depth of the direct push hole (~180 ft bgs) to the groundwater.

The SGE results (Figure 3-4) show a low resistivity anomaly extending deep below tank C-101. The resistivity anomaly results may indicate the presence of elevated salts such as nitrate or sodium (indicating a waste source) or may indicate higher moisture regions below the tank.

See Appendix B1.0 for additional tank process information and monitoring data for tank C-101.

4.1.3 Conclusions and Recommendations

An informal assessment of tank C-101 concluded, based on liquid level measurements, evaporation calculations, and low gamma activity in drywells, that the tank probably did not leak, and if it did leak the release point would have been high on the tank wall (See November 2, 2010 Meeting Summary, Appendix A).

4.1.3.1 Release Type. The release may have been from a spare inlet, cascade line or tank leak above 54 in. A reassessment of the tank leak status is recommended per TFC-ENG-CHEM-D-42. Preliminary assessments concluded that if the tank did leak it was probably on the tank wall ~54 in. above the bottom of the tank.

4.1.3.2 Depth of Release. Mobile contaminants may have reached groundwater. The 1975 total gamma drywell data showed high activity starting at about 20 ft bgs in drywells 30-01-01 and 30-01-09. Most of the gamma activity decayed away by 1980 and thereafter decay followed a ^{137}Cs decay line. Drywells 30-01-01 and 30-01-09 show ^{60}Co activity at about 40 ft bgs. Logging results from two slant direct push holes beneath tank C-101 show low gamma levels throughout the well profile and samples from the direct push slant holes indicate little or no NO_3 and ^{99}Tc, but slightly increasing levels with depth, indicating mobile contaminants may have reached groundwater; however, no indication of downward migration was observed in historical drywell total gamma trend plots between 1975 and 1995. The SGE data shows lower resistivity that extends from beneath tank C-101 and moves downward approaching groundwater.

As shown in Figure 4-1, for purposes of estimating the inventory of material released, it was assumed that ^{137}Cs extends from 20 ft bgs (the level of the spare inlets) to 38 ft bgs.

4.1.3.3 Timing of the Release. Based on liquid level decreases and the presence of high levels of ^{106}Ru still in the soil in 1975 a release or releases appear to have occurred beginning in the third quarter of 1965, after the tank received CW from a broken line in the transfer encasement in March 1965 and after the tank was over filled with PSN from the CR vault in the second quarter of 1965. The release continued through 1969 with a decreasing release rate as the liquid level in the tank decreased below the level of the spare inlet and cascade lines.

4.1.3.4 Magnitude of Release. The mass of ^{137}Cs released from tank C-101 was estimated to be less than ~800 Ci. This mass was calculated assuming a release from the spare inlets as shown in Table 4-2 and Figure 4-1. The maximum horizontal radius of ^{137}Cs saturated soils from the release was assumed to be 10 ft (This distance is based on a 13 ft distance between the C-101 spare inlet ports and drywell 30-01-09, less 3 ft for attenuation because the measured ^{137}Cs activity at the drywell was about 1,000 pCi/g, well below the saturation capacity for ^{137}Cs in soils [see Appendix D]). The depth of the saturated soil plume was also assumed to be 10 ft (the approximate depth from the spare inlet port to peak measured activity in the drywell) and a concentration rounded to 10^7 pCi/g was assumed for the ^{137}Cs soil saturation capacity. Assuming the estimated volume of waste released was 37,000 gal (based on a 13.5-in. liquid level decrease), the release concentration for ^{137}Cs would be ~ 0.005 Ci/L (800 Ci / 37,000 gal). If the supernate released was all CW with a ^{137}Cs concentration of 0.000755 Ci/L (based on the HDW, Rev. 5 composition for PUREX CW [1956-1960] [CWP1]), the estimated release volume would be ~175,000 gal. This is unreasonably high based on the observed liquid level decrease and indicates that the waste was more concentrated than CWP1 supernate. Prior to receiving CWP1 waste, tank C-101 received PUREX high-level waste (1956-1962) (P1) that has a much higher cesium concentration than PUREX CW. Ratioing the CWP1 supernate ^{137}Cs waste composition with the P1 supernate ^{137}Cs waste composition results in a means to estimate the mass (concentration) of the other prominent waste constituents contained in the estimated waste release. Table 4-2 displays the estimated waste inventory for the prominent tank C-101 waste release via the spare inlet. Figure 4-1 shows the assumed configuration of the release. Based on an estimated release of 37,000 gal and assuming a 5% increase in moisture content as a result of the release, the release may have spread over a soil volume of ~100,000 ft^3(37,000 gal / 0.05 / 7.48 gal/ft^3), approximately the size of the tank.

4.2 TANK 241-C-105

4.2.1 Leak Status of Tank 241-C-105

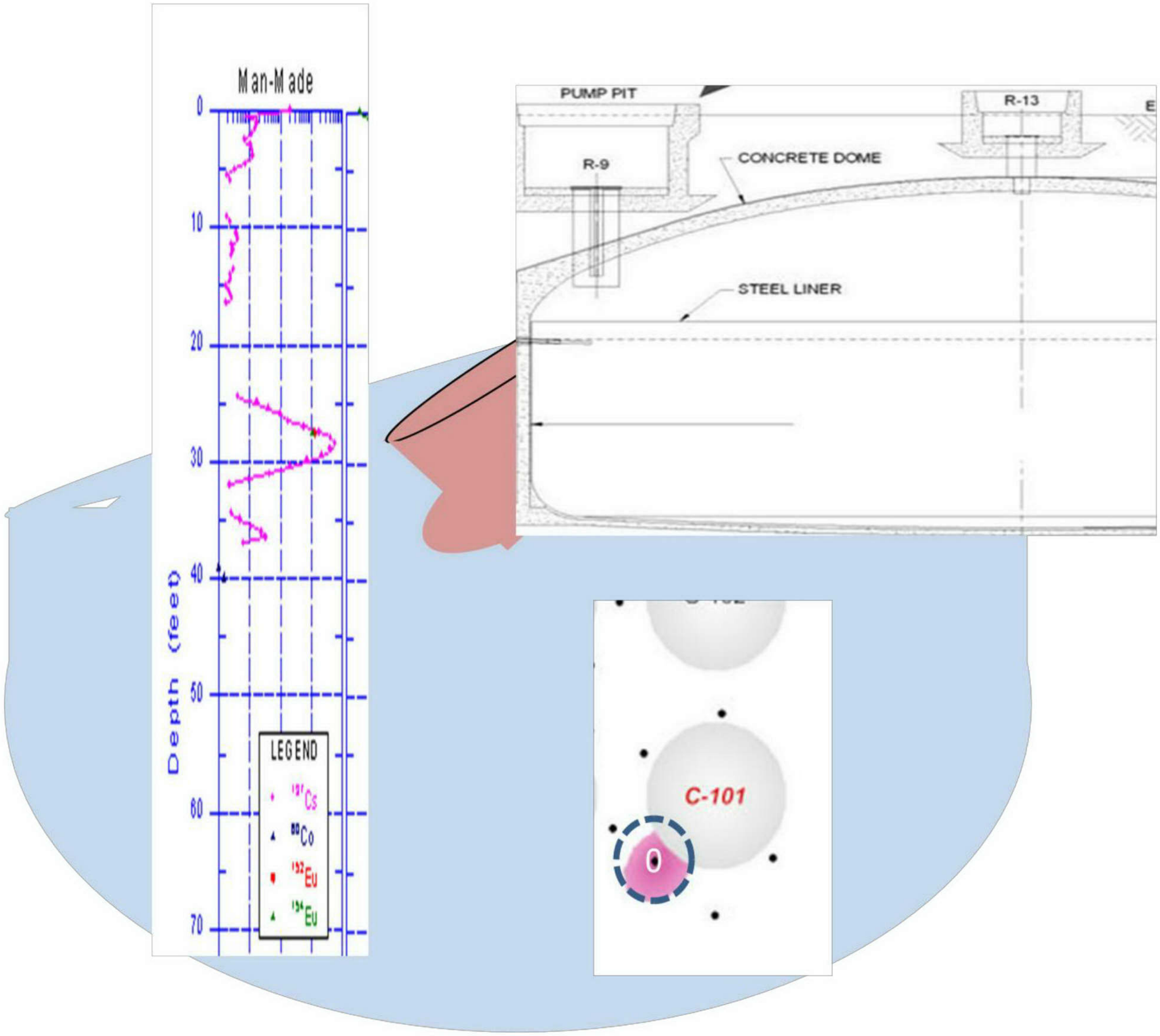
Tank C-105 is was classified as a "sound" tank for many years (HNF-EP-0182). However a high activity ^{137}Cs plume (greater than ~10^7 pCi/g) was observed in drywell 30-05-07 near the base of the tank when it was drilled in 19740. The drywell activity has been attributed to a cascade line leak and potentially a tank leak. After further field investigations and review in 2010 the tank was reclassified as an "assumed leaker" (RPP-ASMT-46452, *Tank 241-C-105 Leak Assessment Completion Report).*

Table 4-2. Tank 241-C-101 Waste Release Inventory Estimate Calculation

	Well	Cesium Plume Cross-Sectional Radius		Cesium Plume Cross-Sectional Area (1/2 circle)		
Cesium Plume Dimensions and Soil Characteristics	30-01-09	10	ft	157	ft^2	
		13 feet from nearest spare inlet – 3 feet assumed attenuation, since measured Cs-137 drywell concentration is well below saturation capacity				
	13 feet from nearest spare inlet					
	Depth of saturated ^{137}Cs plume	Saturated Cs-137 Conc. (pCi/g)		Ft		
	18 - 28	1.00E+07		10		
	Volume	ft^3	Grams of soil	Ci: Cs-137		
		1,570	8.00E+07	8.00E+02		
Waste Release Volume	37,000	gallons				
Waste Type Constants	**CWP1 Waste Type Constants Ci/L Constants in Ci/L (RPP-19822)**	Ci/L	**P1 Waste Type Constants Ci/L Constants in Ci/L (RPP-19822)**	Ci/L	Ratio of CWP1 Waste Type to P1 Waste Type	**Calculated total Ci in the waste release**
	Co-60	1.23E-05		1.23E-05	98%	1.72E+00
	Eu-154	2.73E-07		1.12E-04		3.13E-01
	Cs-137	7.55E-04		0.283		8.00E+02
	Tc-99	2.84E-07		7.46E-05		2.23E-01
Total Wetted Volume of plume	**Release Volume**	**Assuming 5% Soil Moisture increase within the wetted volume (ft^3)**				
	37,000 gal	100,000 ft^3 (37,000/0.05 / 7.48 gal/ft^3)				

CWP1 = Plutonium Uranium Extraction (PUREX) cladding waste, aluminum clad fuel (1956-1960)
P1 = PUREX high-level waste (1956-1962)
Reference: RPP-19822, *Hanford Defined Waste Model – Revision 5.0.*

Figure 4-1. Tank 241-C-101 Conceptual Diagram of Postulated Cesium and Moisture Plume



4.2.2 Leak Assessment Considerations

The radioactivity detected in drywells around SST C-105 and historical information suggests there were several waste loss events near tank C-105:

1. A release from the C-105 spare inlet nozzles,
2. A cascade line leak,
3. Transfer line leaks,
4. A leak near the base of the tank, and
5. Condenser leaks.

See Appendix B2.0 for information on each of these waste loss events and additional tank process information and monitoring data.

4.2.3 Conclusions and Recommendations

It was concluded that the activity around SST C-105 is from several different sources. Probable sources of waste releases to the soil include: releases from the cascade line between tank C-104 and C-105, a leak near the base of tank C-105, releases from spare inlet nozzles, condenser leaks and leaks from Pipeline V103.

Since the initial C-Farm assessment report was written, additional data was collected in support of an integrity assessment for tank C-105 (RPP-ASMT-46452). Based on direct push logging results obtained for the assessment, the integrity assessment panel concluded that the inlet cascade line to C-105 leaked and the tank may have leaked, and the panel recommended that the tank classification be changed to "assumed leaker."

4.2.3.1 Release Type. Multiple releases occurred near tank C-105. Based on drywell and direct push logging results, a cascade line leak appears to have contributed to the high gamma activity in drywell 30-05-07, and based on direct push results near the tank and between drywell 30-05-07 and the cascade line, a tank liner leak near the base of the tank could not be ruled out by the assessment team.

4.2.3.2 Depth of Release. The direct push showed gamma activity starting at about 20 ft bgs (near the cascade line) and increasing in activity to near the base of the tank. In drywell 30-05-07 peak gamma activity was observed at about 40 ft and a smaller peak was observed between 50 and 60 ft bgs. Europium and cobalt gamma activity were observed at ~65 ft bgs. Technetium-99 was observed at peak concentrations of 3 to 6 pCi/g from 130 to 160 ft bgs in borehole C4297, and ^{60}Co concentrations of about 0.5 pCi/g were observed at depths of 40 to 60 ft bgs in borehole C4297 (RPP-35484, *Field Investigation Report for Waste Management Areas C and A-AX*) and from 70 to 110 ft bgs in drywells surrounding tank C-105 (See Figure B4-6). C-105 and C-104 plumes appear to have comingled and deeper ^{60}Co releases are accounted for as part of tank C-104 release estimates.

4.2.3.3 Timing of the Release. Because of transfers of waste in and out of the tank, a liquid level decrease indicating the time of release could not be determined. Gamma activity was first observed when drywell 30-05-07 was installed in 1974. Liquid level decreases between 1963 and 1967 were attributed to evaporation, but a leak may also have contributed to liquid level decreases. A tank leak or cascade line release may also have occurred during the first quarter of 1968 when the tank received PSN waste and was filled above the cascade line.

4.2.3.4 Magnitude of Release. Waste release volume calculations based on drywell logging data range from 40 to 2,000 gal. The waste type is PUREX (PSN-ion exchange [IX] or P1) supernate.

A leak through the cascade line penetration in the tank's sidewall may have occurred when the tank was overfilled between 1954 and 1956. A leak that migrated down the tank sidewall and accumulated on the tank's footing would also explain the observed drywell data. The leak estimate of < 2,000 gal of PUREX supernate appears reasonable for the activity observed in drywell 30-05-07. This estimate assumes that the ^{137}Cs plume is small because it was only detected in one drywell and nearby in direct push hole C7469, and because sorption theory suggests that ^{137}Cs would be expected to migrate about the same horizontal distance in all directions in the soil. This theory seems to be supported by the observation that high activity ^{137}Cs has not been detected to date in any of the other drywells or in borehole C4297 that were installed to investigate the extent of the tank C-105 plume. Another possibility is that a tank leak may have migrated from the point of release below the tank, may be much larger than assumed and may be the source of ^{60}Co activity in drywells between tank C-105 and tank C-103 and northeast of tank C-103. A direct push hole or slant hole from the east/northeast side of tank C-105 extending under the tank could further investigate this concept. However, access near tank C-105 is restricted by retrieval operations; thus, it likely will not be possible to install a direct push hole or borehole in this vicinity before fiscal year 2014.

Other releases from the tank C-105 spare inlet port and transfer line leaks near tank C-105 were assumed to be intermingled with the plume stemming from tank C-104 and are included with tank C-104 release estimates, assumed to be the primary source of ^{60}Co activity between tanks C-104 and C-103; other explanations are possible.

4.2.3.5 Tank Leak Estimate Based on Dry Well Gamma Logging. As noted previously, only the activity 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 drywells. Even in drywell 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 calculation to estimate a potential tank leak.

The measured 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 were calculated as follows:

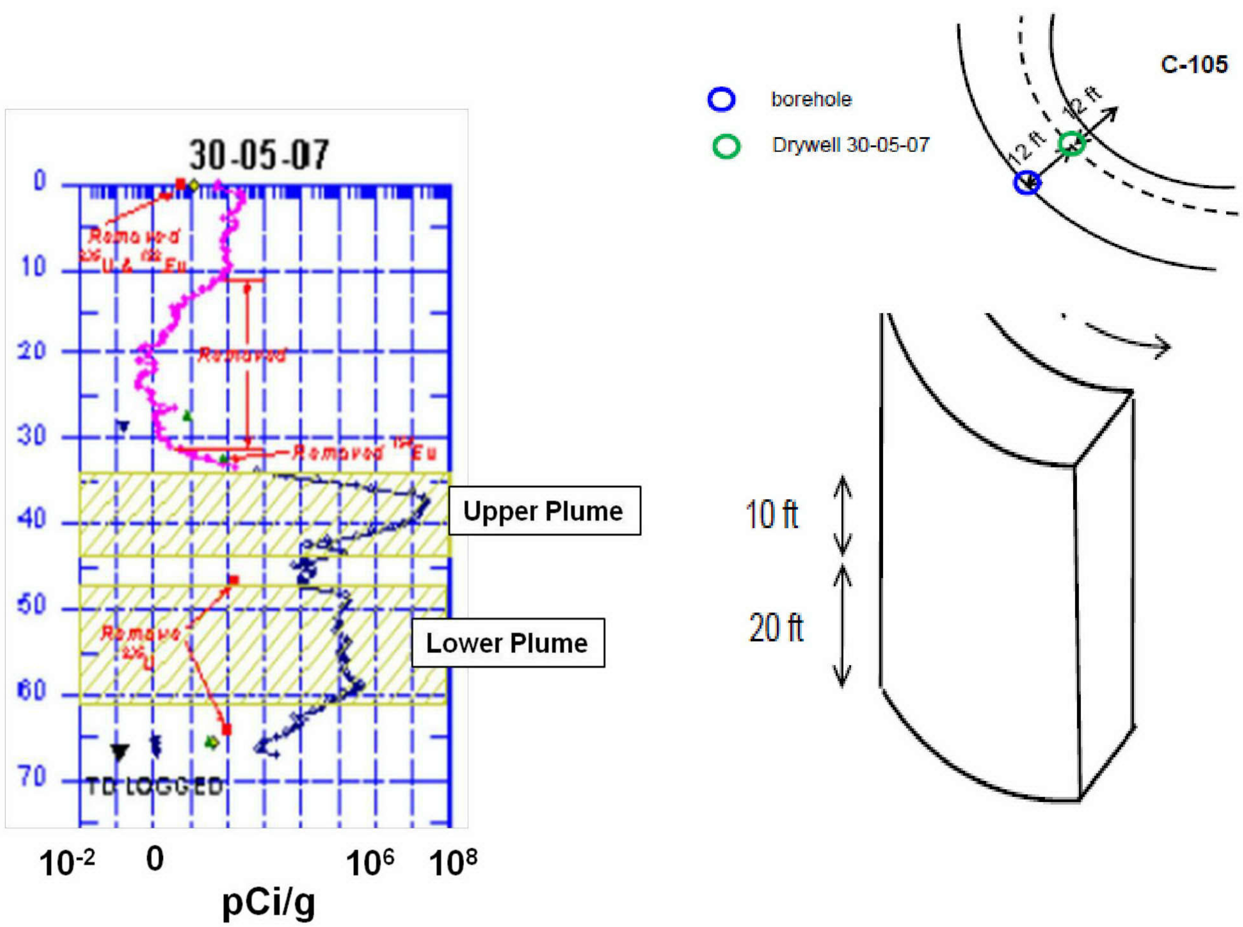
1. For a minimum leak volume, a 30-ft long cylinder (10 ft with ^{137}Cs logged at ~107 pCi/g and 20 ft at ~105 pCi/g), with a point source leak and a 3 ft radius (distance from the tank to drywell 30-05-07) is assumed. The assumption that the potential leak may not have extended much beyond 30-05-07 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 (Appendix D.3). 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 @ 107 pCi/g
   Volume of 3 ft radius and 20 ft long cylinder = 16.2 m^3 @ 105 pCi/g
   8.1 m^3 * 2 g/cm^3 * 107 pCi/g = 162 Ci
   16.2 m^3 *2 g/cm^3 * 105 pCi/g = 3 Ci

165 Ci / 4.3 Ci/gal = 38 gal

2. A maximum potential leak volume was calculated assuming a leak could extend along as much as a quarter of the tank perimeter without being detected (Figure 4-2). 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 drywell C4297] showing no indication of activity comparable to that found in 30-05-07). This forms a plume 30 ft below the base of the tank with an inner and an outer ring (like a rind) with radiuses of 25.5 ft and 49.5 ft respectively. The upper 10 ft of the plume has a concentration of 107 pCi/g ^{137}Cs and the concentration of the lower 20 ft is 105 pCi/g ^{137}Cs.

Figure 4-2. Assumed Tank 241-C-105 Plume Configuration



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 @ 107 pCi/g
400 m^3 * 2 g/cm^3 * 107 pCi/g = 8,000 Ci
Lower Plume Volume = 20*24*59 = 28,280 ft^3 = 800 m^3 @ 105 pCi/g
800 m^3 * 2 g/cm^3 * 105 pCi/g =160 Ci
(8,000 + 160)Ci / 4.3 Ci/gal = 1,900 gal or ~ 2,000 gal

For a plume shape with these X, Y, Z dimensions, but in the shape of an ellipsoid, similar leak mass and volumes were estimated.

4.3 TANK 241-C-110

4.3.1 Leak Status of Tank 241-C-110

Tank C-110 was declared as "questionable integrity" in 1977 following the discovery of unexplained activity in drywell 30-10-09. In 1984 it was declared an "assumed leaker" with an estimated leak volume of 2,000 gal (HNF-EP-0182). Tank C-110 was interim stabilized in June 1995 after repeated saltwell pumping (HNF-SD-RE-TI-178, *Single-Shell tank Interim Stabilization Record*). The drywell activity has since been attributed to a spare inlet nozzle release and in 2008 the tank was reclassified as "sound" (RPP-ASMT-38219, *Tank 241-C-110 Leak Assessment Report).*

4.3.2 Leak Assessment Considerations

There was no liquid level decrease observed for this tank, only an increase of < 250 c/s in 1974 to 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 SGE data. However, there is also no nearby source for the gamma activity other than tank C-110.

The only basis discussed and referenced for a tank C-110 leak was a "Questionable Integrity" designation based on Letter 8901832B R1, "Single-Shell Tank Leak Volumes." 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-in. undetected decrease, which is reasonable for manual tape measurements being used at the time.

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 to 1972. If an overflow occurred during 1971 to 1972 the composition of the supernatant waste stream would have been that measured in 1975 showing ~ 0.32 Ci/gal of ^{137}Cs.

The most probable source determined for a leak from this tank was at the spare inlet 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 to 1972. Although the waste level was not reported as being over the spare inlet ports, an overflow is plausible.

See Appendix B3.0 for additional tank process information and monitoring data.

4.3.3 Conclusions and Recommendations

In 2008 an integrity assessment was conducted for tank C-110 (RPP-ASMT-38219). The assessment concluded that tank C-110 spare inlets were the apparent source for the waste release based on the tank's stable liquid level surface bracketing the period when the drywell gross gamma peak was discovered, the natural decay of the drywell gross gamma peak following discovery, and an interior tank photo showing evidence of waste in and above the tank inlet line penetrations. It was recommended that the tank be reclassified as "sound."

4.3.3.1 Release Type. Liquid level measurements and in-tank photos indicate a spare inlet overflow likely occurred.

4.3.3.2 Depth of Release. The release occurred at the spare inlets about 20 ft bgs.

4.3.3.3 Timing of the Release. Based on fill level histories and ^{106}Ru activity remaining in the drywell in 1974, the release appears to have occurred between 1970 and 1971.

4.3.3.4 Magnitude of Release. No unexplained liquid level decrease was observed in the tank. As a result, a maximum release of 2,000 gal (based on uncertainty in liquid level measurements for the tank) was estimated.

4.4 TANK 241-C-111

4.4.1 Leak Status of Tank 241-C-111

Tank 241-C-111 is currently designated as an "assumed leaker," with a leak volume estimate of 5,500 gal based on a liquid level decrease. The tank was classified as a "leaker" in 1968 and removed from service in the second quarter of 1975. After further investigation the liquid level decrease was attributed to evaporation and in 2008 the tank was reclassified as "sound" (RPP-ASMT-39155, *Tank 241-C-111 Leak Assessment Report).*

4.4.2 Leak Assessment Considerations

Little or no elevated gamma activity was observed in total gamma or SGLS logs for drywells near tank C-111. As a result, drywells showed no sign of a tank leak or other release near tank C-111.

Liquid level decreases from January 1965 to September 1965 were attributed to instrument error. From October 1965 through June 1969, the liquid level decreased by 1,000 to 5,000 gal per quarter for a total level decline of 22,000 gal. The tank waste temperature was reported to be 190°F or higher between 1965 and 1969. At this temperature, measured liquid level decrease rates compared with calculated evaporation rates showed similar trends, confirming that the liquid level decreases can reasonably be attributed to evaporation losses. Calculations showed that a passive breathing rate of about 2.3 ft^3 per minute of 190°F saturated air would account for the loss, when combined with the thermal contraction as the waste began to cool during the latter part of the 1965 through 1969 period. The 2.3 ft^3 per minute passive breathing rate is small compared to SST passive breathing rates measured during the 1990s.

The stable liquid surface level before and after the 1965 to 1969 surface level decrease also indicates that the liquid level decrease was not caused by a tank leak.

See Appendix B4.0 for additional tank process information and monitoring data.

4.4.3 Conclusions and Recommendations

A tank integrity assessment conducted in 2008 concluded that tank C-111 likely did not leak and recommended that the tank C-111 leak integrity status be revised from "Assumed Leaker" to "Sound" (RPP-ASMT-39155). The report concluded that the most probable explanation for the 1965 to 1969 surface level decrease in tank C-111 was evaporation of the thermally hot waste.

4.4.3.1 Release Type. The liquid level decrease was determined to be caused by evaporation. There was no indication of a release to the soils.

4.4.3.2 Depth of Release. No apparent release.

4.4.3.3 Timing of the Release. Evaporation occurred at the time of the liquid level decrease between 1965 and 1969.

4.4.3.4 Magnitude of Release. Based on liquid level decrease, an estimated 22,000 gal evaporated from the tank. There was no indication of a release to the soils.

4.5 241-C-200 Tanks

4.5.1 Leak Status of C-200 Series Tanks

Liquid level decreases based on in-tank measurements and tank photo evaluations were observed in 1984 for tank C-203 and tank photos showed that the liquid level decreased in tank C-201 between 1981 and 1986 and in tanks C-202 and C-204 between 1980 and 1983. Tanks C-201, C-202 and C-204 were filled above the spare inlet level of 55,000 gal several times between 1955 and 1970 when the tanks contained Hot-Semi Works PUREX process waste

4.5.2 Leak Assessment Considerations

In May 1984 a 2-in. liquid level decrease was reported in tank C-203 based on liquid level measurements and in-tank photographs. The report noted a gradual stair-step downward trend from 29.5 to 27.5 inches. In June 1994 a tank leak assessment was performed and the tank was classified as a confirmed leaker. In May 1987 an environmental deviation report was issued for tanks C-201, 202 and 204 as a result of liquid losses observed in the course of update photo evaluations. An engineering investigation was performed to evaluate the tank photos. This photo review was the basis for current estimated leak volumes of 550, 450 and 350 for tanks C-201, 202 and 204 respectively. The photo interpretations and reviews of tank liquid level data confirmed that liquid volume losses occurred. The losses could not be attributed to waste characteristics or evaporation. The simultaneous decrease in liquid level for all three tanks suggested the possibility of an external mechanism, but no credible alternative to a tank leak was identified. In August 1987 a tank integrity evaluation for tanks C-201, -202 and -204 recommended that that all three tanks be classified assumed leakers

An informal review of the C-200 series tanks determined that the liquid level decreases in these four tanks could have been the result of evaporation. Previous tank leak assessments concluded the liquid level decreases had to be due to a tank leak because there was assumed to be no point of air entry into the tanks other than through breather air filters. Previous leak assessments also concluded that intrusions in tank C-203 from 1973 through 1980 may have masked a larger tank leak.

In the 2003 leak assessment it was observed that some of the tanks had higher ventilation rates than those previously estimated by simple barometric pressure vapor space volume calculations. Evaporation calculations indicated that evaporation could account for all of the liquid level decreases in tank s C-201, C-202, C-203 and C-204 (See August 3, 2010 Meeting Summary, Appendix A).

Although tanks C-201, C-202 and C-204 were filled above the spare inlet level of 55,000 gal several times between 1955 and 1970, the liquid level was always near or just above the spare inlet level for all three tanks. When liquid level measurements did exceed 55,000 gal they did not gradually decrease as would be expected for a release from the spare inlet, but remained steady above the 55,000 gallon level for months to years before decreasing or increasing by 1,000 gal and again remaining steady for a similar length of time. This type of behavior suggests either uncertainty in the measurements or that when the tanks were filled above 55,000 gal the spare inlets did not leak or leaks were too small to measure (note: Due to the type of waste, no liquid level decrease criteria was assigned to the C-200 series tanks.). Process records indicate that tank C-203 was never filled above the spare inlet level of 55,000 gal.

See August 3, 2010 Meeting Summary, Appendix A for additional tank process information and monitoring data.

4.5.3 Conclusions and Recommendations

Liquid level decreases in the C-200 tanks were attributed to evaporation. If spare inlet overflows occurred for tank C-201, 202 or 204 the releases were too small to measure. The tanks appear to be sound. However, ^{235}U and ^{238}U was detected in the vadose zone at concentrations of about 2 and 20 pCi/g, respectively at 100 ft bgs in borehole 299-E27-7, approximately 200 ft northeast of the tanks,. Uranium has not been detected at any other location in C Farm but depleted uranium is known to have been stored in the 200 series tanks. As discussed in the April 19 meeting (see Appendix A), transfer lines from the C farm 200 series tanks appear to be the most likely source for uranium and cyanide in well 299-E27-7. Other potential sources discussed were tank leaks, overflows through spare inlets, discharges to French drains, and UPRs north of the well. TFC-ENG-CHEM-D-42 tank integrity assessments are recommended for all four tanks. Ongoing characterization around these tanks may aid in the integrity assessments.

4.5.3.1 Release Type

The observed liquid level decrease in the tanks in the 1980's is attributed primarily to evaporation. Releases from tanks or ancillary equipment may have occurred before 1980.

4.5.3.2 Depth of Release

There are no boreholes in the vicinity to assess potential releases or depths of releases, if any.

4.5.3.3 Timing of the Release

Evaporation occurred at the time of the liquid level decreases. This was in 1984 for tank C-203 and between 1981 and 1986 for tank C-201 and between 1980 and 1983 for tanks C-202 and C-204. Potential releases prior to this time cannot be assessed because of the lack of characterization data. However there is no indication of liquid level decreases before 1980.

4.5.3.4 Magnitude of Release

No basis to estimate releases to the soil from the C-200 series tanks or associated pipelines. Liquid level decreases in the 1980s were accounted for by evaporation estimates for the tanks (See August 3, 2010Meeting Summary, Appendix A). However, as stated above, the tanks or pipelines near the tanks may be the source of low levels of uranium activity detected in borehole 299-E27-7.

4.6 241-C FARM SOUND TANKS

In addition to tanks assumed to have leaked in the past, tanks currently classified as "sound" (HNF-EP-0182) were reviewed. Some of these sound tanks have updated assessments and are summarized above and in more detail in Appendix C. Summary information for the remaining sound tanks is also included in Appendix C. Many of the tanks were overfilled and some tanks show activity in nearby drywells that have been attributed to operations spills, line leaks or leaks from another tank. There was no conclusive evidence of a liner failure for any of these tanks. Estimated inventories for releases near tanks C-104, C-108 and C-112 are included in sections 4.7, 4.8 and 4.9 respectively.

4.7 TANK 241-C-104

4.7.1 Leak Status of Tank 241-C-104

Tank C-104 is currently classified as a "sound" tank (HNF-EP-0182).

4.7.2 Leak Assessment Considerations

Drywell 30-04-03 shows a ^{137}Cs peak at about 23 ft bgs and ^{60}Co readings from 23 to 50 ft bgs. This drywell is close to the cascade line between tanks C-104 and C-105.

The large plume originating between tanks C-104 and C-105 appears to be from the cascade line connecting these two tanks. It is possible that one or both of these tanks may have been the source of the waste release, but the apparent depth and location of the suspected origin of the plume suggest that the most likely source of the released waste is the cascade line. This plume appears to have migrated downward and eastward of tank C-104 to a depth of at least 125 ft. The maximum depth of this plume in the vicinity of its source is questionable because of the limited depth of boreholes in that area.

Transfers during the time the tank was overfilled may have masked liquid level decreases. Releases may also be attributed to a V103 pipeline leak.

See Appendix C3.0 for additional tank process information and monitoring data.

4.7.3 Conclusions and Recommendations

Tank C-104 appears to be "sound" as previously classified. However, drywells show ^{137}Cs near the tank and ^{60}Co plumes that appear to extend from the tank cascade line and migrate outward and downward.

4.7.3.1 Release Type. The observed gamma activity in drywells is attributed primarily to cascade line releases from tank C-104 and may also be attributed to spare inlet overflows from tanks C-104 and C-105 and V103 pipeline leaks.

4.7.3.2 Depth of Release. The ^{137}Cs appears to have migrated from the cascade level to a peak at 23 ft bgs and was assumed to extend downward near the tank to a depth of 50 ft (about 10 ft below the base of the tank). The ^{60}Co plume appears to have migrated downward and eastward from tank C-104 to a depth of at least 125 ft.

4.7.3.3 Timing of the Release. The release was assumed to have occurred around 1965 when the tank was overfilled.

4.7.3.4 Magnitude of Release. Since there is no record of a transfer, the volume of the release due to the overfill was determined from the tank waste surface level decrease reported in WHC-MR-0132, *A History of the 200 Area Tank Farms* in first quarter of 1966 time frame (see Figure C3-2). The volume difference was ~28,000 gal (560,000 gal to 532,000 gal).

For comparison purposes, if an assumed plume volume was described as an increase in the water (wetted) content from a "background" of ~4% to 9% (a 5% increase), this would account for ~23,000 gal (see calculations for a modeled cobalt plume in Table 4-3 and Figure 4-3). Assuming the waste released was CWP1, the mass of ^{137}Cs was estimated to be slightly over 60 Ci at 23,000 gal and 80 Ci for a 28,000-gal release. This mass could be masked next to the tank at the soil cesium saturation concentration of ~10^7 pCi/g. Using CWP1 waste composition would also result in a ~28,000-gal release, and ~1.3 Ci ^{60}Co at the time of the release. It was assumed that the ^{60}Co plume extended past the measured depth in the drywell to 80 ft, thereby resulting in a release that could have been ~28,000 gal.

Table 4-3. C-104 Conceptual Waste Plume Calculations

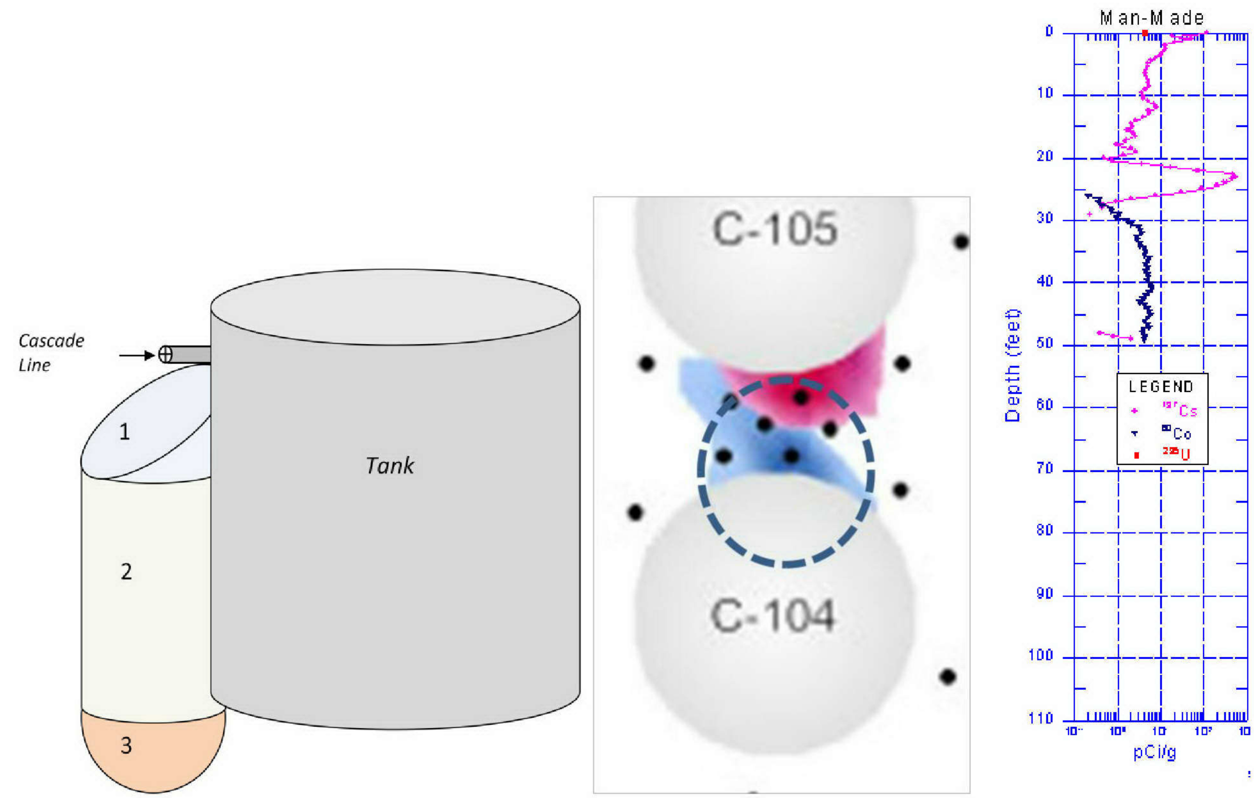
PLUME DIMENSIONS	**Well**	**Plume Cross-Sectional Radius**		**Plume Cross-Sectional Area**		
	30-04-03	20	ft	1256	ft^2	
	Shape	Cylinder; Half Sphere Bottom				
	Segment	**Segment Depth (ft)**	**Segment Height**		**Segment Volume**	
	1	25-30	5	ft	3140	Ft
	2&3	30-70	40	ft	58600	Ft

Inventory Estimates	**CWP1 Waste concentrations Ci/L (RPP-19822)**		**Calculated Ci (Conc*Vol)**
	Co-60	1.23E-05	1.07E+00
	Eu-154	2.73E-07	2.38E-02
	Cs-137	7.55E-04	6.57E+01
	Tc-99	2.84E-07	2.47E-02

CURIES IN MODELED RELEASE VOLUME	**Segment**	**Segment Volume (ft^3) [*(Segment Cross-Sectional Area)x(Segment Height)*]**	**Soil Mass (g)**	**Co60 (Ci) [*(Segment Co60 Mass, g)x (Segment Time-Corrected Co60, pCi/g)*]**
	1	3140	160064640	5.12E-03
	2	50240	2.561E+09	8.20E-02
	3	8400	428198400	1.37E-02
	Totals	6.18E+04	3.15E+09	1.01E-01

OUTPUTS	**Co60 Volume Estimate based on CWP1 [*(Total Curies)x(CWP1 Cs137 Waste Type Constant, Ci/L)x(3.785 gal/L)*]**		2200	gal	
	Total Waste Plume Volume (ft^3)	**Assumed Soil Moisture**	**Total Wetted Volume, Assuming (ft^3)**	**Release (gal) [*(Wetted Volume, ft^3)x (7.48 gal/ft^3)*]**	**Rounded Release Estimate (gal)**
	61780	5%	3089	23000	**23000**

Figure 4-3. Tank 241-C-104 Conceptual Waste Plume Visualizations and Drywell Logging Data



4.8 TANK 241-C-108

4.8.1 Leak Status of Tank 241-C-108

Tank 241-C-108 is classified as a "sound" tank (HNF-EP-0182) and was removed from service in 1976.

4.8.2 Leak Assessment Considerations

Tank C-108 was overfilled in 1965 before waste was transferred to C-102.

At drywell 30-08-02 a ^{137}Cs peak of about 1,000 pCi/g was detected at 20 to 22 bgs, and elevated ^{60}Co activity was detected between 50 and 80 ft bgs. No gamma activity was detected from approximately 25 to 50 ft. This drywell is close to the cascade line for the tank and ^{137}Cs and ^{154}Eu activity detected at 22 ft may be from waste ***inside*** the cascade line. Because some cascade lines are known to have released waste during times when the tanks were overfilled, and because gamma activity was observed starting just at the depth of the cascade line and adjacent to it, it was assumed that the cascade line may be the source of the observed activity at approximately 22 ft. However, the gamma signature for the C-108 cascade line (Figure B4-4) is unlike the gamma signature from the cascade line at tank C-104 (see figure B4-3) where ^{60}Co is observed extending downward from the cascade line, but indicates a hiatus of 30 ft before gamma contamination is again observed at 50 ft near the base of the tank. Additionally historical gamma logs since 1976 and more current SGLS log data indicate continued migration of ^{60}Co in the interval from 50 to 80 ft. Up to four "pulses" of new activity or ^{60}Co movement have been observed in the 34 intervening years. This suggests a source may be continuing to "feed" the plume. A cascade line would have leaked a limited amount and the source would have ceased after the overfill event in 1965.

In August 2007, Tank C-108 waste was retrieved to the limit of the modified sluicing technology used. Hard heel retrieval of the waste involving circulation of liquids in the tank to remove the remaining hard heel is in progress (HNF-EP-0182). During retrieval dry well moisture monitoring and HRR monitoring (see Section 3.6) are performed for leak detection. Although large volumes of supernate and other liquids were introduced to the tank during retrieval operations and liquid is currently being recirculated in the tank to remove the remaining hard heel, no evidence of a leak during retrieval has been detected. This further supports previous evaluations that the tank appears to be sound.

See Appendix C6.0 for additional tank process information and monitoring data.

4.8.3 Conclusions and Recommendations

Tank C-108 appears to be sound, as previously classified. However, drywells show ^{137}Cs near the tank at 22 ft (probably inside the cascade line) and ^{60}Co plumes that appear to extend from the tank bottom and migrate out and downward. Although leak detection monitoring results show no indication of a tank leak or other releases to the soil during retrieval, SGLS drywell logging indicates continued migration of the ^{60}Co in the soil.

4.8.3.1 Release Type. The observed gamma activity in drywells is attributed primarily to cascade line releases from tank C-108. Waste releases from tank spare inlet nozzles or pipeline leaks may have also occurred. Based on HRR results and previous assessments, a tank leak appears unlikely.

4.8.3.2 Depth of Release. The ^{137}Cs appears to have migrated from the cascade level to a peak at 23 ft bgs. Cobalt-60 was detected at 50 ft bgs and extended downward to a depth of 80 ft bgs.

4.8.3.3 Timing of the Release. The release was assumed to have occurred around 1965 when the tank was overfilled with HS and CW waste.

4.8.3.4 Magnitude of Release.

A release volume was estimated based on the size of the wetted plume. A wetted plume size of ~49,000 ft^3 was estimated based on ^{60}Co measurements in drywell 30-08-02. The ^{60}Co extended from 50 to 80 ft bgs and was assumed to spread over a 20 ft radius based on drywell visualizations (Table 4-4 and Figure 4-4).

If the water content of the plume increased from a "background" of ~4% to 9% (a 5% increase based on direct push moisture content measurements in C farm) as a result of the release, an estimated 18,000 gallon of waste would have been released. Assuming the waste overflowed was CWP1 waste (the type of supernate in the tank in 1965) this equates to an estimated 50 Ci of ^{137}Cs and ~0.9 Ci of ^{60}Co that may have been released.

A release volume was also estimated assuming a cascade overflow and based on the distance to drywell 30-08-02 which shows little or no ^{137}Cs in the soil (no activity in the soil if the 137Cs is from waste inside the cascade line). Based on the distance of the drywell from the tank, and gamma activity well below ^{137}Cs saturation capacity, it was assumed that the ^{137}Cs plume is small (about 3 ft radius and 3 ft in depth). Assuming the entire plume is at ^{137}Cs saturation capacity (~10^7 pCi/g), this equates to an estimated ^{137}Cs plume of 43 Ci and an estimated release of 15,000 gal assuming CWP1 waste was released.

Both methods of estimating the release volume show similar release volumes. The larger release volume of 18,000 gal is recommended.

Table 4-4. Tank 241-C-108 Conceptual Waste Plume Visualizations and Drywell Logging Data

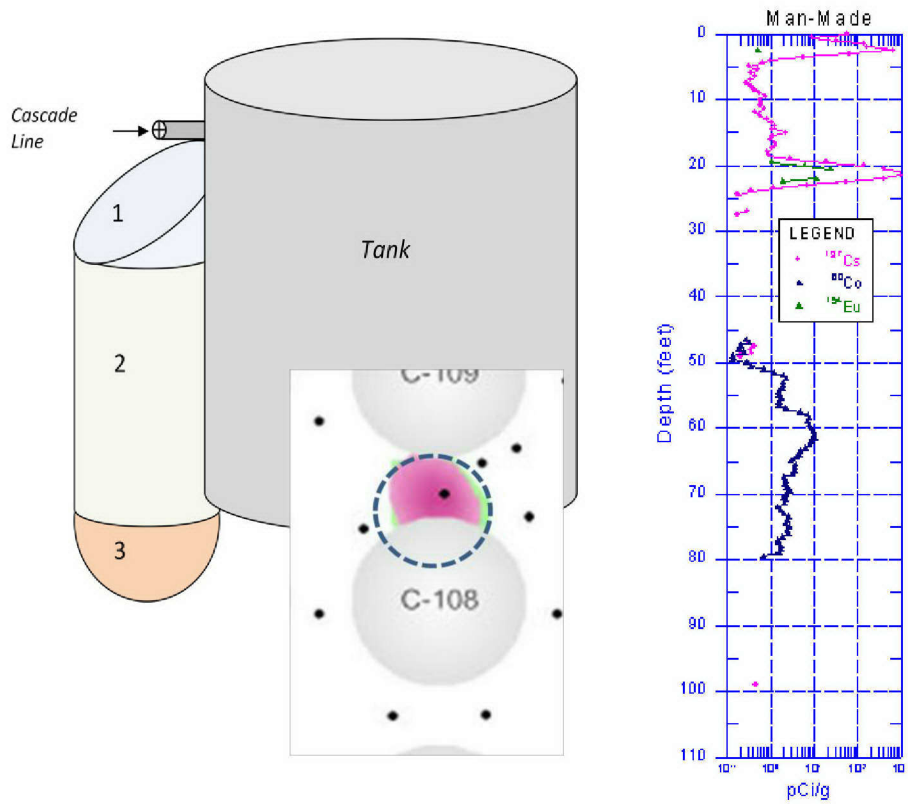
Wetted Plume Dimensions	Well	^{60}Co Plume Radius		Plume Area	
	30-08-02	20	ft	1260	ft^2
	Shape	Cylinder; Half Sphere Bottom			
	Segment	Segment Depth (ft)	Segment Height		
	1	0	0	ft	
	2&3	50-80	30	ft	

Wetted Plume Volume	Segment	Segment Volume (ft^3)
	1	0
	2	37700
	3	11200
	Total	48900

CWP1 Waste Inventory	Composition (Ci/L) (RPP-19822)		Calculated Ci
	Co-60	1.23E-05	0.84
	Eu-154	2.73E-07	0.02
	Cs-137	7.55E-04	51
	Tc-99	2.84E-07	0.02

Estimated Release Volume based on Wetted Plume	Total Waste Plume Volume (ft^3)	Assumed Soil Moisture	Release Volume, (ft^3)	Release Volume (gal)
	48880	5%	2444	18000

Figure 4-4. Tank 241-C-108 Conceptual Waste Plume Visualizations and Drywell Logging Data



4.9 TANK 241-C-112

4.9.1 Leak Status of Tank 241-C-112

Tank C-112 started receiving waste in November 1946. Tank C-112 was suspected of leaking and liquid was pumped to tank C-103 in 1975 and 1976. Later surveillance could not confirm the suspected leak, and the tank is currently considered "sound." Tank C-112 was removed from service in 1976, and in 1983, 5,000 gal of waste (from saltwell pumping) was transferred to DST 241-AN-103. The tank was administratively interim stabilized in September 1990.

4.9.2 Leak Assessment Considerations

At drywells 30-12-01 and 30-12-13 a ^{60}Co peak was detected at 30 to 50 bgs. These drywells are located in proximity to a known release from the salt-well pump pit located on top of the tank and could also be seeing a release from a transfer line leak from 252-C Diversion Box to tank C-112. Using a simple geometric shape as a conceptual model of the waste release plume, an estimated waste volume was determined to be ~7,000 gal.

See Appendix C8.0 for additional tank process information and monitoring data.

4.9.3 Conclusions and Recommendations

In conclusion, a transfer line leak from 252-C Diversion Box to tank C-112 was the likely source of an estimated 7,000 gal release of CW-IX waste.

4.9.3.1 Release Type

Drywell gamma activity near tank C-112 is a attributed to a transfer line leak.

4.9.3.2 Depth of Release

The estimated depth of the release is from 28 to 50 ft bgs based on drywell data.

4.9.3.3 Timing of the Release

The failed transfer line was observed in 1974. The release likely occurred prior to 1974.

4.9.3.4 Magnitude of Release

By using a simple geometric shape as a conceptual model of the waste release plume, an estimated waste volume can be determined. The plume shape was comprised of a sloped halved right 20 ft radius cylinder to represent the plume. The shape extends down the tank side 30 feet with its centerline originating at the tank sidewall and a half sphere at the bottom (Figure 4-5).

Assuming the release resulted in a 5% increase in the water content of the plume (increase from from a "background" of ~4% to 9%) a release of approximately 7,000 gallons may have occurred (Table 4-5).

Table 4-5. C-112 Conceptual Waste Plume Calculations

WETTED PLUME DIMENSIONS	Well	Plume Cross-Sectional Radius		Plume Cross-Sectional Area	
	30-12-01	20	ft	1260	ft^2
	Shape	Diagonal Cut Cylinder, Half Sphere			

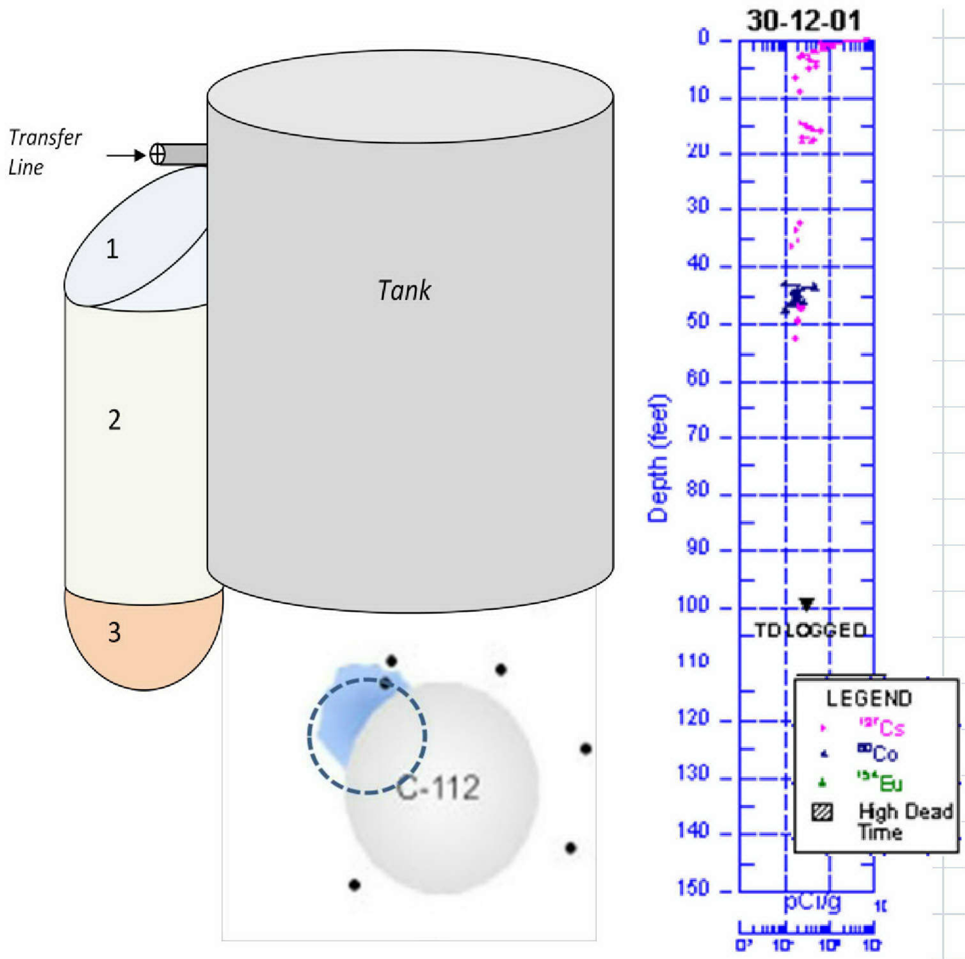
WETTED PLUME DIMENSIONS	Segment	Segment Depth (ft)	^{60}Co Concentration		Segment Height	
	1	28-35	3.20E+01	pCi/g	7	ft
	2&3	40-50	3.20E+01	pCi/g	15	ft

CWP1 WASTE	Concentration (Ci/L) (RPP-19822)		Calculated Ci
	Co-60	1.23E-05	0.33
	Eu-154	2.73E-07	0.007
	Cs-137	7.55E-04	20
	Tc-99	2.84E-07	0.008

MODELED RELEASE VOLUME	Segment	Segment Volume (ft^3)
	1	2200
	2	9400
	3	8400
	Totals	20000

Release Volume Estimate	Wetted Plume Volume (ft^3)	Assumed Soil Moisture	Release Volume (ft^3)	Release *Volume (gal)*
	20000	5%	1000.9	7000

Figure 4-5. C-112 Conceptual Waste Plume Visualizations & Drywell Logging Data



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5.0 WASTE MANAGEMENT AREA C UNPLANNED RELEASES

Information is provided on UPRs of tank wastes from pipelines, diversion boxes, and other structures within the WMA C at the Hanford Site. The WMA C encompasses the C-Farm, which includes the twelve 530,000-gal capacity and four 55,000-gal capacity 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.

Sections 5.1 through 5.4 discuss known UPRs; Section 5.5 provides information on potential tank waste losses from the inlet nozzles on the SSTs; Section 5.6 discusses known waste loss events from pipelines; Section 5.7 discusses waste discharges from the 241-C-801 building; and Section 5.8 presents other potential releases in WMA C.

5.1 IDENTIFIED UNPLANNED RELEASES

DOE/RL-88-30 contains the official listing of UPRs identified at the Hanford Site. The UPRs associated with WMA C are as follows.

- **200-E-153-PL.** Description: Tank Farm Transfer Line V108/812 are 3-in. 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 C-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 devices for the underground structures are visible on the surface. The individual UPRs associated with C-Farm are not separately marked or posted. Occasionally, gamma activity is found adjacent to the outside of the tank farm fence, resulting in an activity 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 activity 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 activity associated with each of the UPRs. Table 5-1 summarizes information on each of UPRs located in the various record documents.

The following sections further describe three major UPRs in WMA C (UPR-200-E-81, UPR-200-E-82 and UPR-200-E86) and inventory estimates for these UPRs

5.2 UPR-200-E-81 RELEASE BACKGROUND AND DESCRIPTION

5.2.1 UPR-200-E-81 Data and Information

RHO-CD-673 identifies UPR 200-E-81 (UN-216-E-9) as a line leak from PUREX plant to tank C-102 near the 241-CR-151 diversion box. The source was determined to be a leak in an underground transfer line from 202-A Building to the 102-C waste storage tank via the 151-CR box. PUREX merged low-level waste flows into the remaining line available which carried organic wash and special run coating waste. On October 15, 1969 a puddle of contaminated liquid (approximately 6 by 40 ft) was discovered a few feet west of the 151-CR diversion box. When the transfer of PUREX coating waste was stopped most of the liquid seeped back into the soil. Radiation levels of 5 R/hr at 20 feet were measured. Backfill was placed over the liquid which reduced the levels to a maximum of 3 R/hr at one foot above about 18 inches of fill dirt.

In November 1969 a stainless steel bypass line was installed around the location of the leak. 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 the carbon steel and stainless steel on one of the lines

The estimated volume of the pipeline leak was 36,000 gal with 720 Ci of ^{137}Cs and 36 Ci of ^{90}Sr in October, 1969 (RHO-CD-673).

5.2.2 Leak Assessment Considerations

RHO-CD-673 provided the only available information to estimate an inventory for UPR-200-E-81.

Based on historical information a number of direct push holes were drilled, logged and sampled in the vicinity of the UPR in 2008 and 2009. Also 3D SGE investigations and analyses were performed in this vicinity in 2008 and 2009. SGE and direct push results are presented in Chapter 5. The SGE results showed wide spread low resistivity between 10 and 30 ft bgs and low levels of nitrate(peak level about 200 ug/g) and ^{99}Tc (peak level about 50 pCi/g) in direct push samples.

5.2.3 Assessment Conclusions and Recommendations

The SGE and direct push results appear to be consistent with the estimated 36,000 gal line leak and a CW release.

5.2.3.1 Release Type
Pipeline failure

5.2.3.2 Depth of Release
The pipeline near the diversion box was at a depth of about 10 ft bgs. The SGE shows resistivity anomalies to about 30 ft bgs. Peak nitrate and 99Tc levels were observed at about 20 and 40 ft bgs in push holes C6392 and C6394 on the South and Southeast side of the 241-CR-151 diversion box

5.2.3.3 Timing of the Release
The pipeline failure was observed in October 1969.

5.2.3.4 Magnitude of Release
Based on historical records the release was estimated to be 36,000 gallon of CW waste with 720 Ci of ^{137}Cs. This estimate appears to be consistent with field investigation results.

5.3 UPR-200-E-82 RELEASE BACKGROUND AND DESCRIPTION

5.3.1 UPR-200-E-82 Data and Information
A Leak in cesium line V122 from 105-C to B Plant was discovered in December 1969 about 35 ft south of the 152-C diversion box. The pipe line leak was characterized in a limited fashion shortly after the leak event in which waste from the pipe migrated to the surface and the site was covered with 2 ft of back fill (ARH-1945). A Gunnite cap was installed over the release site, but not for 20 years after the leak.

Data discussed below is from RHO-CD-673. Tank farm operations staff assumed loss of waste from a joint connecting two pipes at an angle near diversion box 241-C-152 about 11 ft bgs. To assess the magnitude of the leak and spread of contamination, shallow holes were drilled in concentric fashion around the assumed leak location. Each hole was drilled about 20 ft bgs (Figure A-28). Sediments were recovered from each hole at depth intervals of about 2 ft as long as radiation conditions could be handled (e.g., between 5 and 110 rad/hr).

Reported characterization data of these sediments consisted of gamma-emitting radionuclide activity determined in soil samples. Cesium-137 concentrations ranged from about $5(10^7)$ to $< 10^5$ pCi/g between 2 and 17 ft bgs. High concentrations of ^{137}Cs and other shorter-lived contaminants were also present in the well closest to the assumed leak location, but samples were too radioactive to be collected (field readings of 110 rad/hr were identified). Based on soil sample results, an estimated 9,000 to 11,000 Ci of ^{137}Cs were released to the soil and 2,100 to 2,600 gal of PSN waste. Calculation details are presented in the WMA C field investigation report (RPP-35484*)*.

5.3.2 Leak Assessment Considerations
Based on historical information a number of vertical direct push holes were drilled, logged and sampled in the vicinity of the UPR in 2008 and 2009. Three slant holes were also emplaced

around the site of the pipeline leak and electrodes installed in the slant holes in 2006 (RPP-RPT-50052). Three-D SGE investigations and analyses were performed for UPR-200-E-82 in 2011. SGE and direct push results are presented in Chapter 5. Direct push results close to the Gunite cap showed some elevated gamma activity and slightly elevated nitrate (peak levels of 20 ug/g) and ^{99}Tc (peak levels of 4 pCi/g) in the soil. The SGE results showed a general distribution of high electrical resistivity values beneath the UPR-82 release. It was concluded that the pipeline leak was either of low volume and not a source of groundwater contamination for the waste management area, or actions taken to control exposure to the spill have resulted in it being diluted and/or flushed into the underlying groundwater. The size of the release, favors the former interpretation.

Two conceptual models described in RPP-35484 were considered to estimate the size of the release. Both resulted, in similar calculations (2100 and 2600 gal).

5.3.3 Assessment Conclusions and Recommendations

The SGE and direct push results appear to be consistent with a 2,600 gal PSN line leak. Higher gamma activity was expected, but the high activity may be directly under the Gunite cap and direct push holes may have been too deep to detect it.

5.3.3.1 Release Type

Pipeline release as described above.

5.3.3.2 Depth of Release

The majority of the ^{137}Cs concentration appears to be between 2 and 20 ft bgs below the Gunite cap. Low levels of nitrate and 99Tc were detected in direct push holes to 80 ft bgs.

5.3.3.3 Timing of the Release

The pipeline failure was observed in

5.3.3.4 Magnitude of Release

An estimated 9,000 to 11,000 Ci of ^{137}Cs were released to the soil and 2,100 to 2,600 gal of PSN waste.

5.4 UPR-200-E-86 RELEASE BACKGROUND AND DESCRIPTION

5.4.1 UPR-200-E-86 Data and Information

UPR-200-E-86 (also UN-216-E-14) is identified as leakage from the 244-AR Vault to the 151-C diversion box portion of the PSS line to the 106-C tank (**pipeline V108/812),** discovered on February 25, 1971. The line is a 2 inch dirct buried line, about 8 ft below grade. The leak appeared to have occurred at a carbon steel – stainless steel weld.

Eight wells were drilled in the leak area and the apparent boundaries of the contaminated soil were established. The contaminated soil zone was estimated to contain about 1300 ft^3. The contamination did not extend below a depth of 20 feet in any of the test wells. (In RHO-CD-673, letter from Borshiem to Metz dated November 9, 1972). ARH-1895 1, *Chemical Processing*

Division Daily Production Reports January 1971 through March 1971, 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, *Civil Plan and Profile Line No. V113 241-AX-101 to 241-C-151*, H-2-61967, *Civil Plan and Profile 3" PSN LN. No 812* and H-2-61962 show that that a new section of line was installed, bypassing the contaminated area. The damaged portion of the line was blanked off and piping added to by-pass the old line in April 1971 (ARH1895 [2]).

A gunite cap was installed to cover the contaminated soils. According to photos the cap was installed many years after the release occurred.

5.4.2 Leak Assessment Considerations

Based on historical information a number of vertical direct push holes were drilled, logged and sampled in the vicinity of the UPR in 2008 and 2009. Three-D SGE investigations and analyses were performed for UPR-200-E-86 in March 2010 (RPP-RPT-47486).

A conceptual model for the line leak based on vadose zone measurements accounted for only a fraction of the ^{137}Cs reportedly lost based on process records (RPP-14430, *Subsurface Conditions Description of the C and A-AX Waste Management Areas*). A ring of holes were drilled around the gunite cap in 2007 to further investigate the release. The holes were placed at a location defined by the occurrence of surface liquid at the time of the leak. Logging and sampling of the holes showed low levels of activity around the area of the suspected release, inconsistent with a release volume of 17,000 gal of PSN waste (RPP-37625, *Completion Report for UPR-200-E-86 Direct Push Drilling and Sampling*). Future characterization plans (RPP-PLAN-39114) currently call for additional drilling further north of the gunite cap and potentially drilling a hole through the cap. Given the high gamma activity previously measured in soils under the cap, this may result in high exposure to workers that may not be warranted.

UPR 200-E-86 was estimated to have a line loss of 17,385 gal of PSS waste containing 1.35 Ci/gal of 137Cs (decay date of February 1971) (RHO-CD-673). There is no specific mention of the basis for this estimate, but based on references provided in the Borsheim letter, it appears that the estimate may have been based on a mass balance and could be high. The letter also estimates that the contaminated soil contained 1,300 ft^3 and the contamination did not extend below a depth of 20 ft in any of the wells. Assuming 30% soil porosity, the maximum volume the soil would hold is 4,000 gal.

5.4.3 Assessment Conclusions and Recommendations

Although there was no evidence of a large PSN leak in SGE or direct push data, the volume and inventory of 17,000 gal of PSN liquid waste containing 1.35 Ci/gal of ^{137}Cs, estimated in 1971 was determined to provide a bounding estimate for the line leak.

5.4.3.1 Release Type

The release was a 1969 pipeline leak

5.4.3.2 Depth of Release

Waste was released at a depth of 8 ft bgs (depth of the pipeline). Soil samples from 1969 showed contamination extended only to 20 ft bgs.

5.4.3.3 Timing of the Release

The pipeline leak was discovered in December 1969.

5.4.3.4 Magnitude of Release

A maximum of 17,000 gal of PSN supernate with a concentration of 1.35 Ci/gal of ^{137}Cs estimated in 1971 and 11,000 Ci of 137Cs. Direct push and SGE data indicate this estimate is high.

5.5 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 5.5.1, 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 filling the first tank in the cascade, waste then flows to the second; when that is 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 were also submerged when the waste level exceeded the spare inlet level. It appears that when the waste exceeded the operating capacity of the tank, the waste found an outlet over the top of the tank liner, breached a weak spot in the cascade (perhaps where it exits or enters the tank liner), or breached the spare inlet lines. Section B6.0 provides the waste volumes in each of the SSTs in WMA C, as reported by the Tank Farm operator. Events are identified in which the inlet nozzles on an 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.

Table 5-1. Additional Information on Identified Unplanned Releases (6 sheets)

Unplanned Release	Date	Waste Type	Waste Discharged (Gallons)	Event Description	References
UPR-200-E-16	1-1959	PUREX CWP1	~50	"A leak in the over ground 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, p. 18 reports a leak of ~50 gal 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. SST 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, p. 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 100 mrads/hr at the edge of the box."	HW-67459, pp. 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. Activity levels around the vault were on the order of 50 to 100 mrad/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, p. 7

Table 5-1. Additional Information on Identified Unplanned Releases (6 sheets)

Unplanned Release	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.	Radiological Survey Report W304943
UPR-200-E-68	1985	Particulate	no estimate	The activity 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. 20, p. 1383
UPR-200-E-72	1985	Particulate	no estimate	The activity 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. 20, p. 1164
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, pp. 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 ^{137}Cs and 36 Ci ^{90}Sr in 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, pp. 128-129

Table 5-1. Additional Information on Identified Unplanned Releases (6 sheets)

Unplanned Release	Date	Waste Type	Waste Discharged (Gallons)	Event Description	References
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
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."	Radiological Survey Report E300311
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, p. 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."	ARH-1895 1

Table 5-1. Additional Information on Identified Unplanned Releases (6 sheets)

Unplanned Release	Date	Waste Type	Waste Discharged (Gallons)	Event Description	References
UPR-200-E-86 (continued)				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 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."	

Table 5-1. Additional Information on Identified Unplanned Releases (6 sheets)

Unplanned Release	Date	Waste Type	Waste Discharged (Gallons)	Event Description	References
UPR-200-E-86 (continued)				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 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 ^{137}Cs content of leak (~25,000 Ci 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 gal 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 2 in. was observed on ground contamination. HW-26486 p. 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, p. 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. 20, p. 1393

Table 5-1. Additional Information on Identified Unplanned Releases (6 sheets)

Unplanned Release	Date	Waste Type	Waste Discharged (Gallons)	Event Description	References

CWP1 = Plutonium Uranium Extraction (PUREX) cladding waste, aluminum clad fuel (1956-1960)
CWP2 = PUREX cladding waste, aluminum clad fuel (1961-1972)
P2 = PUREX high-level waste (1963-1967)
PSS = PUREX sludge supernate
SST = single-shell tank
TBP = Tributyl phosphate process waste (1952-1958)
UPR = unplanned release

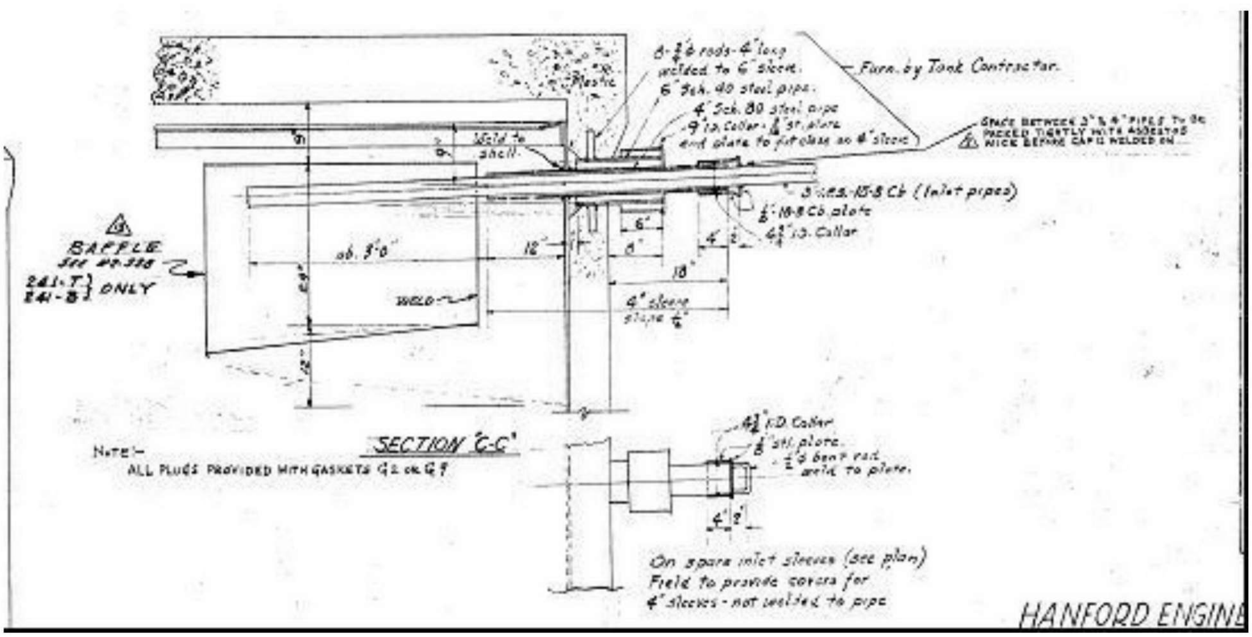
References:

ARH-1895-1, *Chemical Processing Division Daily Production Reports January 1971 through March 1971.*
ARH-1895-2, *Chemical Processing Division Daily Production Reports April 1971 through June 1971*.
ARH-1945, *B Plant Ion Exchange Feed Line Leak*.
DOE/RL-88-30, *Hanford Site Waste Management Units Report*.
HW-26486, *Manufacturing Department – Radiation Hazards Incident Investigation*.
HW-60807, *Unconfined Underground Radioactive Waste and Contamination in the 200 Areas–1959*.
HW-67459, *Chemical Processing Department Monthly Report for November 1960*.
HW-84619, *Summary of Environmental Contamination Incidents at Hanford, 1958 – 1964*.
Radiological Survey Report E300311, *Radiation/Contamination Survey of 241C, 244CR, 271CR*.
Radiological Survey Report W304943, *Radiological Survey to Downpost Area 244 CR Vault Area from CA to an Underground Radioactive Material Area. This is 9500 sq.f. SE of 271 CR*.
RHO-CD-673, *Handbook 200 Areas Waste Sites*.
RPP-RPT-29191, *Supplemental Information Hanford Tank Waste Leaks*.

5.5.1 Description of Single-Shell Tank Inlet Nozzles

The SSTs in the C-Farm are each equipped with four horizontal inlet nozzles, as shown in Figure 5-1 (see drawings W-72742, *Hanford Engineer Works 20'-0" Dia. Storage Tanks Arrangement Bldg# 241-T, 241-U, 241-B, 241-C* and W-72743, *Hanford Engineer Works– B'l'd. #241 75'-0" Dia. Storage Tanks T-U-B & C Arrangement*). While Figure 5-1 depicts 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-in. diameter schedule 80 steel pipe with an outer 6-in. diameter schedule 40 steel pipe. The outer 6-in. diameter steel pipe is embedded in the concrete sidewall of the SST, attached to the exterior of the carbon steel sidewall using mastic and protrudes ~8 in. from the exterior of the tank wall. The 4-in. diameter steel pipe is inserted through the 6-in. diameter steel pipe, protrudes ~12 in. inside the SST and ~18 in. beyond the exterior of the concrete sidewall of the SST. The 4-in. diameter steel pipe is welded to the sidewall of the carbon steel tank. An 8-in. diameter steel collar is tightly fitted around the 6-in. diameter steel pipe where the 4-in. diameter steel pipe exits this outer pipe. Process waste lines, which are 3-in. inner diameter, 11 gauge 18-8Cb (i.e., early form of stainless steel) tubing, are inserted through the 4-in. diameter steel pipe and extend ~4 ft inside the SST.

Figure 5-1. 20-Foot Diameter Single-Shell Tank Detail Showing Inlet Nozzles



The elevation of the four inlet nozzles for the 100-series SSTs is 17 ft 4 in. from the center of the tank bottom (see drawing H-2-1744, *Tank Farm Riser & Nozzle Elev.*). The elevation of the four inlet nozzles for the 200-series SSTs is 24 ft 7 in. from the center of the tank bottom (see drawing H-2-1744). All inlet nozzles on the 100-series SSTs in 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 position 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, *Hanford Engineer Works Building No. 241-T-U-B & C Concrete Details of Pipe Supports*; H-2-616, *Details of Pipe Supports Bld'g. 241-BX Concrete, Hanford Engineer Works*; and H-2-2929, *Waste Fill Lines & Clean Outs 1st Cycle Waste 241-C Tank Farm*). The concrete support beams are 30 in. tall and 32 in. wide, except for those in tank C-101, which are only 26 in. wide. The concrete support beams have a 4-in. tall shoulder, resulting in a 24-in.- (only 18-in.- for tank C-101) wide trough running down the center of the beam.

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, *Hanford Engineering Works Building No. 241 T-U-B & -C Concrete Details of Pipe Supports (20' Dia. Tanks)*]. 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 in. tall and 20 in. wide. The concrete support beams have a 4-in. tall shoulder, resulting in a 12-in. 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 that a 4.5-in. diameter cover was to be placed over the 4-in. diameter spare inlet nozzles (see Figure 5-1). It is known that some of the spare inlet nozzles are poorly sealed. Single-shell tank 241-BX-102 (BX-102) was overfilled in February 1951 and waste was lost to the ground through the spare inlet nozzles (HW-20742, *Loss of Depleted Metal Waste Supernatant to Soil*). 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 tapered wooden plugs driven in the spare nozzle covered by a cap and sealed with waterproofing, and some have caps covered with a waterproofing membrane and then sealed in cement" (see HW-20742, p. 5).

Based on the SST BX-102 waste loss investigation, waste may have been similarly lost to the ground in C-Farm if SSTs were filled above the height of the spare inlet nozzles; 17 ft 4 in. (~547,500 gal) for the 100-series and 24 ft 7 in. (~55,900 gal) 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.

5.5.2 Potential Waste Loss through Inlet Nozzles of Cascade Lines

The waste volumes in all SSTs were 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. Table B6-1 shows reported waste volumes from January 1945 through December 1980for the 16 SSTs in C-Farm. Single-shell tanks were removed from service in January 1981 and no waste additions were allowed after this date. Table 5-2 shows dates when the SSTs were filled with waste above the elevation of the spare inlet nozzles. Based on waste level records and visual inspections, only one C-Farm tank, tank 241-C-203, was not overfilled at least once.

Table 5-2. Potential Waste Losses Through Spare Inlet Ports on Waste Management Area C Tanks

Tank	Date	Waste Type Present in Tank
C-101	June 1965 – December 1967	Received waste from CR Vault. Tank contains CR Vault waste (28 kgal), PUREX P2 (452 kgal), and Coating Waste (CWP2) (94 kgal).
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 gal of unknown waste type (likely PUREX CWP2 based on RL-SEP-332-DEL, *Chemical Processing Department Monthly Report for February, 1965*, 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 high-level waste supernate
C-109	June 1961 – December 1961	PUREX CWP2
	June 1965 – March 1968	Tank received 19,000 gal from 201-C Strontium Semiworks (HS). Tank contains 112,000 gal of evaporator bottoms (BT-SltCk), 300,000 gal of PUREX CWP2, and 142,000 gal of Strontium 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.

Waste types:
1C = Bismuth phosphate first cycle decontamination waste
CWP1 = Plutonium Uranium Extraction (PUREX) CW (1956-1960)
P2 = PUREX high-level waste (1963-1967)
CW = Cladding waste, aluminum clad fuel
CWP2 = PUREX CW (1961-1972)

Two additional events when SSTs in WMA C were potentially filled with waste above the spare inlet nozzles and cascade lines are reported in RPP-RPT-29191.

- "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, p. 143).

- 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 *[S-222]* Laboratory". November 1967, "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" (RPP-RPT-29191, p. 58).

5.6 SUSPECT PIPELINE WASTE LOSS EVENTS

Several pipelines in the WMA C are known to have failed while transferring tank wastes. Table 5-3 identifies pipelines in WMA C that are known or suspected to have failed, pipelines that plugged and other potential releases in WMA C. The date the failure was detected, the waste type and the volume of waste that was leaked to the soil (if known), and a description of the event are listed in the table. Unplanned releases (UPRs) are specifically identified in WIDS (DOE/RL-88-30) for some of the failed pipelines listed in Table 3-15, others are not specifically mentioned in WIDS except for referring to previous revisions of this report for other soil losses in the C farm. 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 how much waste leaked from these concrete structures.

Table 5-3. Other Releases and Occurrences in WMA C (7 sheets)

Table 5-3. Other Releases and Occurrences in WMA C				
Date	**Source**	**Waste Discharged**	**Event Description**	**References**
11-20-1951	Tank 241-C-106 Spare inlet nozzle	Overflow, Possible release	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. The stubbed inlet lines are only covered with a loose fitting cap, as shown on drawing W-72743. No record was located that indicated the liquid level in tank 106-C was purposefully reduced to below the elevation of the stubbed inlet lines. Tank liquid levels were not reported again until April 1952 (HW-27838). However, as of April 31, 1952, the liquid level in tank 106-C was reported as 519,000 gallons, which is well below the elevation of the stubbed inlet lines.	HW-23140, page 45 RPP-RPT-29191 p 146
11-1952	Diversion box 241-ER-151	Plugged line, possible overflow	Recent evidence of a plugged line on the waste service between 241-WR and 110-C tank farm was investigated. The line plug was isolated in a jumper in the 151-ER diversion box. This jumper contained a Patter flow meter and the solids being carriers by the waste built up on the flow element causing ultimate plugging. This jumper has been replaced with a standard diversion box jumper and the Patter flow meter has been eliminated in this service.	HW-26376, page E-7 HW-37331, page 11
11-1952	Tank 241-C-110	TBP waste	TBP waste was being directed to the first tank (110-CR) of a three-tank cascade series for storage. The tank on filling failed to cascade indicating that the overflow line to the next tank was plugged.	HW-27627 RPP-25113
1-1953	Between 153-ER and Tank 241-C-108	Plugged line, Possible overflow	The cross country line between the 153 ER diversion station and Tank 108-C plugged with waste on 1-27-53. Maintenance cleared the line and returned it to service on 1-28-53. While filling the line with waste, it either plugged again or was not completely cleared. Attempts are now being made to free the line.	HW-36979-A, page 95
1-1953	241-C-101 to 001-CR	Plugged line, Possible overflow	A plug in the line from 101-C to the 001-CR has delayed sluicing operations 48 hours.	HW-36979-A, page 95
2-1953	Tanks 241-C-101 and 241-C-103	Plugged line, Possible overflow	Some rocks and concrete were removed from the 103-C to 101-C transfer line	HW-36979-A, page 88
4-1953	241-ER-153 Tank 241-C-108	Plugged line, Possible overflow	The waste line to 108-C plugged on 4-5-53 in a flexible jumper in the 153-ER diversion box. The jumper was flushed with water and returned to service on 4-7-53.	HW-36979-A, page 75
1-1957	Tank 241-C-	Plugged line,	The coating waste and organic waste transfer line [from PUREX Plant] to the 104-C tank in the	HW-48132, page 16

Table 5-3. Other Releases and Occurrences in WMA C (7 sheets)

Table 5-3. Other Releases and Occurrences in WMA C				
Date	**Source**	**Waste Discharged**	**Event Description**	**References**
	104	Possible overflow	241-C area plugged completely and necessitated transfer of coating waste to the 111-C tank. Until the line is unplugged and returned to service, each transfer of organic waste to the tank farm will require a diversion box jumper change. The coating waste transfer **line was unplugged** in April 1957	HW-50089; page C-2 HW-47654, page 7. HW-47654, page 65.
4-1957	241-CR Vault Tank 241-C-104	Plugged line, Possible overflow	Waste routing to the 241-C underground waste storage farm were returned to normal following unplugging of the coating waste line between 241-CR vault and the 104-C tank.	HW-50089, page C-2
5-1957	Tank 241-C-104	Plugged line, Possible overflow	A plugged line to the 104-C tank (Purex coating waste) and several jumper changes accounted for approximately 190 manhours charged to the Purex Operation.	HW-50584, page D-7
9-1957	Tank 241-C-104 241-CR-153	Plugged line, Possible overflow	On September 17, the coating waste line to tank 241-C-104 plugged between 153-CR diversion box and the tank, necessitating the transfer of coating waste to tank 241- A-103 on a temporary basis. On September 26, jumper changes were completed to route coating waste to tank 241-C-105 and solvent wash solution to tank 241-A-103.	HW-52864, page C-2 HW-47654, page 167 and 168.
11-1960	Tank 241-C-112	Plugged line, Possible overflow	Coating waste was diverted from the 112-C to the 102-C tank when the delivery manifold to the former tank plugged.	HW-67459, page B-2
5-1961	Tanks 241-C-107 and 241-C-108	Plugged line, Possible overflow	The installation of a pump and an over-ground piping system was completed for pumping coating waste from 107-C to 108-C tanks. This work was initiated when the overflow line between these tanks became plugged.	HW-69803, page B-3
6-1962	Tank 241-C-101	Plugged line, Possible overflow	A new policy which requires sampling of all waste streams leaving the Purex Plant forced a flowsheet change in the handling of the coating removal waste solutions. Instead of transferring the waste and rinse water to underground storage separately, the two are combined, made 1M in NaOH, and sampled prior to transfer. Despite the extra caustic addition, a layer of solids has built up in the collection tank, and difficulties have been encountered with plugging in the transfer line.	HW-74151, page G-5 HW-71990, page 126.
12-1962	Tank 241-C-102	Plugged line, Possible overflow	The coating waste line from Purex to 102-C waste tank became plugged on 12-5-62. An alternate route using the strontium line was used until the **lines were unplugged** on 12-20-62. The combining of coating waste and rinse water which caused the plugging in the coating waste line to underground storage during the month has been discontinued and extra caustic is being added so that precipitation of solids can be minimized. The alternate strontium line refers to a transfer line from the 202-A Purex Plant to the 244-CR Vault.	HW-75702, pages B-1 and G-1 HW-71990, page 232.
1-1963	202-A	Plugged line,	Dissolving was started on non-representative metal on Jan. 28, 1963. The first coating waste	HW-76912, page 3

Table 5-3. Other Releases and Occurrences in WMA C (7 sheets)

Date	Source	Waste Discharged	Event Description	References
	PUREX to Tank 241-C-102	Possible overflow	through the line to UGS either plugged the line or an old plug still existed. The UGS line was flushed both ways from the 152-A diversion box with water at a rate as high as 180 gpm; a **plug appeared to be removed**. At the end of the reporting period, coating wastes were jetting well. This appears to have been a reoccurring problem with 25wt% caustic flushes and air blowing used to remove residual waste from the transfer line noted periodically in this reference.	
6-1964	**Line V172** Diversion box 241-C-252 to Tank 241-C-112	Pipeline Semi-works leak	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 pipeline from the 241-C-252 diversion box to tank 241-C-112 was used to transfer waste from the 201-C Strontium Semi-Works. This is line V172 according to drawing H-2-36835, *PIPING DIV BOXES 241C-153 & 241C-252 ARRGT PLANS*	HW-82526, page B-2
11-1964	Pipeline 801-C to tank C-103	Cesium Depleted PUREX HLW Supernate (P1)	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	244-CR Vault	PUREX CWP2	"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."	RL-SEP-332, page H-2 RPP-RPT-29191, page 116
3-1965	Pipeline between 152-CR and tank C-102	Failed line, possible release of PUREX CWP2	"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 5-3. Other Releases and Occurrences in WMA C (7 sheets)

Date	Source	Waste Discharged	Event Description	References
			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	Tank 241-C-103	Plugged line, Possible overflow	The plugging of the cesium feed pot dip leg screen in TK-103C was determined to be due to precipitation in the feed cooler. The feed screen and cooler were given a 1,000-gallon hot water flush and hot feed (60°C) was circulated through the cooler (cooling water off) and allowed to overflow from the feed pot. After apparently 18 hours circulating hot feed was jetted at 5 GPM to the load-out building [801-C] with no screen plugging problems. Cooling water was tuned on to adjust the feed temperature to 100°F (as indicated on the instrument in the 801-C control room). No plugging problems were noted at this temperature during a 6-hour period. Cooling water flow was increased to bring the feed temperature to 95°F however, plugging was encountered when the feed temperature reached 98°F. The screen was easily cleaned by stopping the cooling water flow to allow hot feed to dissolve the precipitate from the screen	RPP-RPT-29191, page 120 ISO-75 RD, page 7[illegible] ISO-265 RD page 7[illegible]
5-1966	Jumper in 152-CR diversion box	PUREX CWP2	"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
10-1967	Tank 241-C-105 Spare inlet nozzle	Spare inlet release	**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. 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.	ISO-651 RD, page 288 RPP-RPT-29191 p 161

Table 5-3. Other Releases and Occurrences in WMA C (7 sheets)

Table 5-3. Other Releases and Occurrences in WMA C				
Date	**Source**	**Waste Discharged**	**Event Description**	**References**
1-1968	Plugged line Waste discharge to ground Tanks 241-AX-102 and 241-C-102	Possible C Farm release	Attempted to unplug the 102-AX to 102-C line with hot water and using pressure from Fire Department truck. **Liquid noticed coming from underground near 103-AX pump pit**. Flushing discontinued. Opened 101-AX pump-out pit and pumped two Fire Department tank trucks of water thru line to "C" farm. Line open from this point. Still plugged from 102-AX to 101-AX. Line from 102-AX to 102-C now appears to be unplugged. No pressure build-up noted. Line was flushed with 750 gallons of hot water.	ARH-258, page 85 ARH-258, page 89 ARH-258, page 93
12-1968	Tank 241-C-105 to 221-B Plant (tank 17-2)	Plugged line possible release	IX Ion Exchange – Shut down on 8-4 shift on 12/12/68 to flush 105-C pump and transfer line to B Plant. Line still plugged as of 0800 this morning, 12/13/68. 12-17-1968, B-Plant IX Ion Exchange – Down. Working on plugged line from 105-C to 17-2 (aged cesium supernate feed). 12-19-1968, B-Plant IX Ion Exchange – Down. **Original line from 105-C to 17-2 plugged**. Now working on alternate routing.	RPP-RPT-29191 p. 128 ARH-818, pages 137 - 145
-1969	Tank 241-C-105 to B Plant tank 17-2	Plugged line, possible release	7/10/69, Page 13: Line from 105-C to 17-2 cesium supernatant receiver tank was flushed with hot water in an attempt to improve pumping rate. Not yet checked out. 7/13/69, Page 15: Pumping from 105-C feed tank is still slow (about 10-gpm).	ARH-1023-3-DEL
3-1970	Diversion box 241-C-151 Tanks 241-A-102 and 241-C-105	Plugged line possible release	Page 124 (3-13-70) IX Ion Exchange: Down. Line from 102A to 105C found plugged between A farm and 151C diversion box. Hot water and high pressure has no effect. Page 126 (3-16-70) IX Ion Exchange: Routed PSN feed from 102A to 105C via 244AR (normal route plugged). Started loading cesium run 166 at 0545 on 3-15-70. Page 128 (3-17-70) Miscellaneous: Line from 102A to 105C via 151C diversion box still plugged, although applied water pressure at 250 lbs.	ARH-1526-1, pages 124, 126, 128 ARH-1503 page G1-5
8-7-1970	Diversion box 241-CR-	Plugged line possible	8-7-1970 Miscellaneous	ARH-1526-3, page 65

Table 5-3. Other Releases and Occurrences in WMA C (7 sheets)

Table 5-3. Other Releases and Occurrences in WMA C				
Date	**Source**	**Waste Discharged**	**Event Description**	**References**
	151	release	151CR: Snaking out the diversion box drain line to 002-CR tank sump. Line apparently still plugged. 8-11-1970 Miscellaneous 151CR: Diversion box drain line to 002CR tank sump still plugged.	ARH-1526-3, page 69
8-1974	B Plant to Tank 241-C-106	Plugged line possible release	Three process outages occurred. The first, a 22-hour outage on August 6, was caused by the pluggage of the waste transfer line between B Plant and 106-C Tank in the 241-C Tank Farm.	ARH-3067 RD, page 42
10-1975	Overground line between tank C-108 and C-103	Line leak, One cup	Leak in Overground Transfer Line. A leak occurred in an overground transfer line and contaminated an area of soil approximately 18 inches square, to a depth of one inch. The **leak volume was estimated at one cup** and the soil had a maximum radiation of two rads per hour at contact. The leak was located at a point where the above-ground pump is joined to the line with a vertical nozzle and connector head. The transfer had been running about nine hours when the connection developed a very slow leak.	ARH-LD-210 B, page 10 OR-75-115
7-1979	Raw water valve leak	5,000 gal Raw water	At 6:00 PM on July 22, 1979 water was discovered coming from the ground at the southwest corner of C farm. The water ran downhill to the tank area. A 75' X 200' puddle was formed at the west side of tanks 111C and 112C. The puddle partially covered the tanks. The cause of the occurrence was failure of a "stop and waste" valve in the 4 inch raw water line supplying water to C farm.	OR-79-73
Pre-1988	V-103 pipeline	PUREX P2 supernate	**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°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	Environmental Protection Deviation Report 87-10, page 4

Table 5-3. Other Releases and Occurrences in WMA C				
Date	Source	Waste Discharged	Event Description	References
			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	Pipeline V-112	unknown	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
5-1993	Raw water line to tank C-110	250 gal Raw water	On 5/10/93 Maintenance was being performed in 110-C instrument cabinet. This work required raw water to supply system pressure to test a broken water line which had been repaired. Water was supplied from the 244-CR vault through a water service pit at 107-C, to a quick disconnect located at the 110-C instrument cabinet. No actual use of raw water was intended, as the line being repaired was simply to be pressure tested. However, an investigation found that the raw water line leaked 250 gal to the ground in C-farm.	RL-WHC-TANKFARM-1993-0047

Waste types:
CW = Cladding waste, aluminum clad fuel
CWP2 = Plutonium Uranium Extraction (PUREX) CW (1961-1972)
HS = Hot Semiworks strontium purification waste (1961-1968)
P1 = PUREX high level waste (HLW) (1956-1962)
P2 = PUREX HLW (1963-1967)
PSN = PUREX supernate

References:
DOE/RL-88-30, *Hanford Site Waste Management Units Report*, Rev. 20.
H-2-2338, *Diversion Box 241-CR-152 Nozzle Information*.
H-2-4574, *Process & Service Piping Tanks to Loadout Station*.
H-2-44501, *Area Map 200 East "A" Plant Facilities*.
Internal memo 13331-88-088, "Environmental Protection Deviation Report 87-10, Radiation Level Increase In Drywell 30-03-09."
RPP-25113, *Residual Waste Inventories in the Plugged and Abandoned Pipelines at the Hanford Site*.
RPP-RPT-29191, *Supplemental Information Hanford Tank Waste Leaks*.

5.7 241-C-801 CONTAMINATED DRYWELL

Waste discharged to the contaminated drywell associated with the 241-C-801 building is technically not a UPR. 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 [Interoffice memo 7G400-03-SMM-003, "Shipments of Cesium-137 and Strontium-90 from the Hanford Site (1961 through 1977)"]. 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 [1963-1967 high-level waste]) was transferred from SST C-103 through underground piping to a valve pit located inside the 241-C-801 building. 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, *Engineering Flow Diagram, C-Farm Cesium Loadout Facility* and H-2-4554, *Plot Plan – Roads Drawing Schedule, Cesium Loadout Facility*). This drywell is located ~23 m (75 ft) north of the 241-C-801 building; outside the tank farm fence (DOE/RL-88-30, Rev. 20, page 1158).

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 may have been discharged to this drywell as a result of operations conducted at the 241-C-801 building.

5.8 OTHER POTENTIAL LOSSES

In addition to the suspect pipeline failures and waste loss events documented in this report, other pipe line failures or liquid losses likely occurred. A 1984 BWIP water balance study (Internal letter 65633-128, "Status of the BWIP Water Balance Study") showed that between 1977 and 1984, between 15% and 41% (24% average) of the 8E9 L of water discharged to East Area general raw water lines was unaccounted for, suggesting either error in process measurements or significant losses in the water lines. While raw water losses do not increase the inventory of waste lost to the soil, they provide a substantial driving force to move mobile contaminants toward groundwater and these raw water loss estimates give an indication of other potential losses from waste process lines. Table 5-3 shows documented raw water line failures and losses that were found. There were likely additional releases in the farms that were not documented or for which information is not available.

Figure 5-2 shows cross section visualizations of near surface gamma activity in C Farm. based on SGLS drywell logging data. The figures show low levels (< 10 pCi/g) of ^{137}Cs activity at 2 ft bgs across the farm. Higher levels of ^{137}Cs and ^{154}Eu observed at 2 ft bgs in drywell 30-07-11 are attributed to contamination within a transfer lines adjacent to the drywell. Subsurface gamma logging data and discussion of the logging data is presented in Appendices B, C and D. Figure 5-3shows surface radioactivity survey results for C Farm and identifies locations of surface hot spots.

In general the highest gamma activity levels were observed near tanks or where an inventory has been determined. This suggests that other, undocumented leaks may have been smaller, contaminants have been flushed or the waste lost contained lower levels of non-mobile gamma activity (i.e., ^{137}Cs). Additional investigations are in process per the WMA C work plan (RPP-PLAN-39114) to better quantify releases and to provide inventory estimates for corrective measures studies.

Figure 5-2. Near Surface Spectral Gamma Activity in C Farm

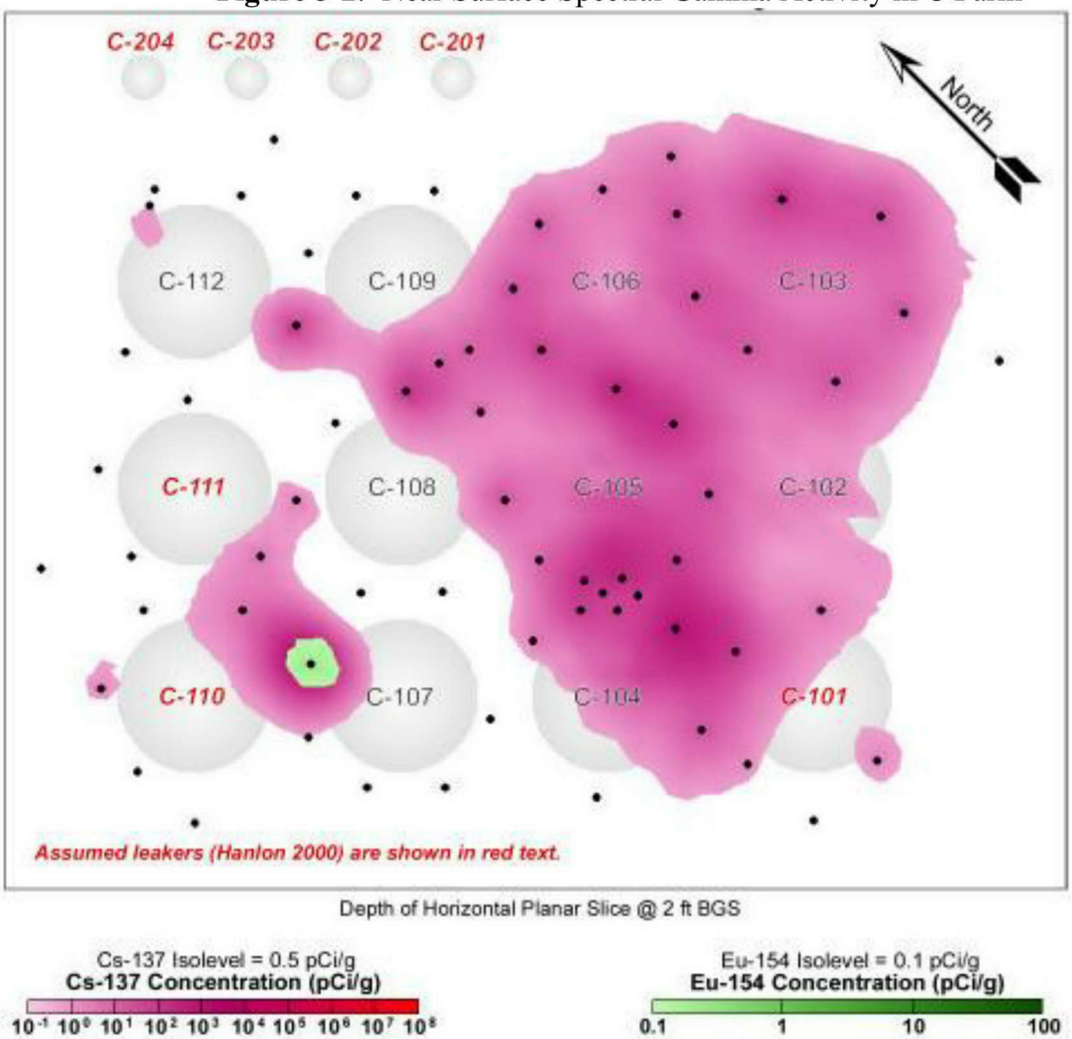
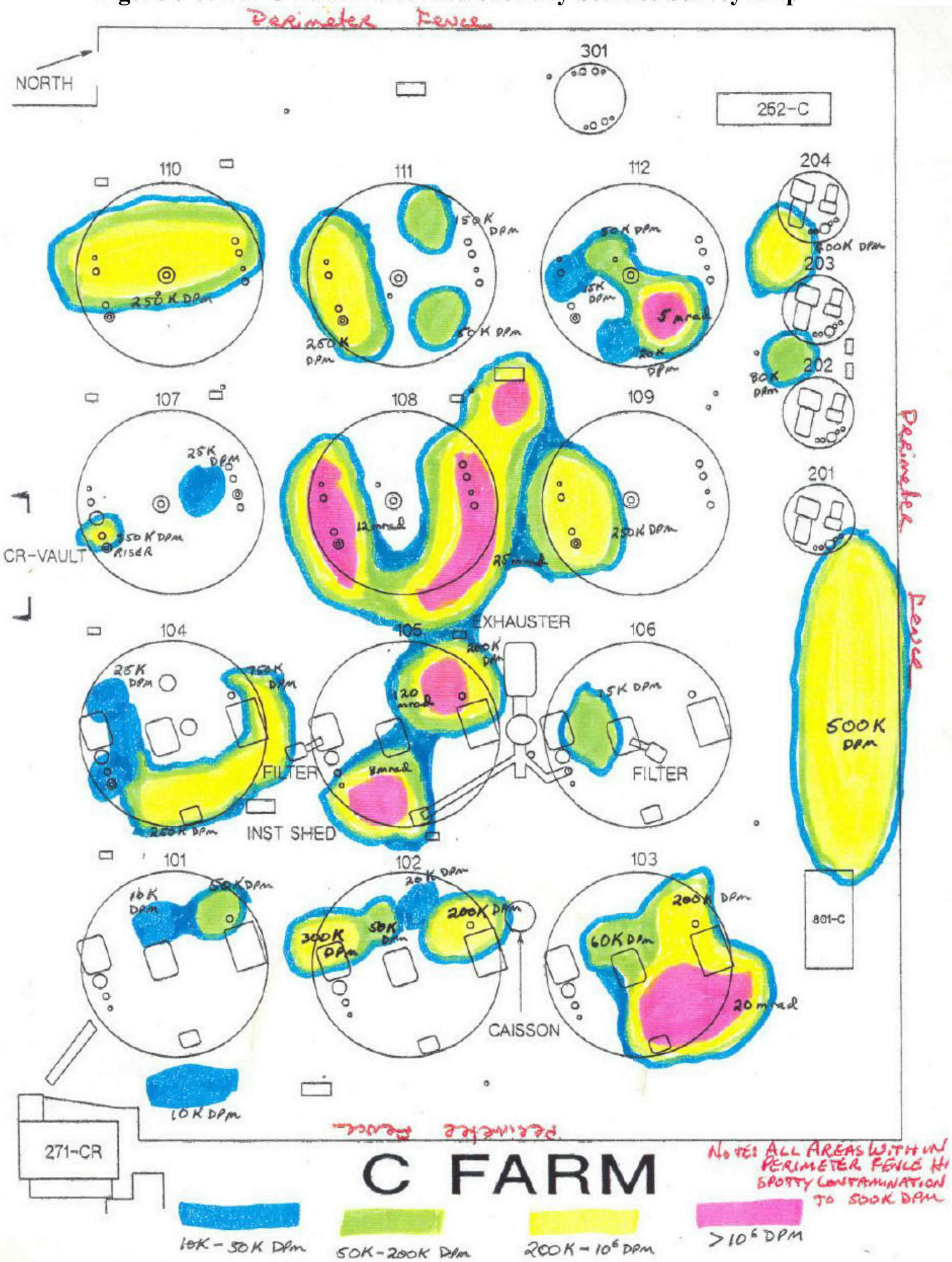


Figure 5-3. 241-C Tank Farm Radioactivity Surface Survey Map [1]



[1]This C Farm surface survey status map is a sketch showing results of weekly radioactivity survey reports as of January 2010. The sketch is posted at the 241-C Farm entrance for worker protection.

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APPENDIX A

MEETING SUMMARIES

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MEETING SUMMARY

CH2MHILL
Hanford Group, Inc.

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

CH2MHILL
Hanford Group, Inc.

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.

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 CH2MHILL Hanford Group, Inc.

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 erCi/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 erCi/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.

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.

Tank C-111 Leak Information Summary					
Item	**When**	**Estimated Leak Volume (gallons)**	**Range of Leak Volume (gallons)**	**Possible Sources**	**Comments**
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).**
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

Tank C-111 Leak Information Summary					
Item	**When**	**Estimated Leak Volume (gallons)**	**Range of Leak Volume (gallons)**	**Possible Sources**	**Comments**
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			

MEETING SUMMARY

CH2MHILL
Hanford Group, Inc.

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.

MEETING SUMMARY

CH2MHILL
Hanford Group, Inc.

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.

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.

MEETING SUMMARY

CH2MHILL
Hanford Group, Inc.

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).

MEETING SUMMARY

CH2MHILL
Hanford Group, Inc.

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.

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.

Attachment 1

6.1.1 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 drywell 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

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 = $2\pi r/4 = 2\pi(37.5)/4 = 59\ ft$
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*

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.

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.

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.

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.

MEETING SUMMARY

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: June 16, 2010
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Mike Barnes, ECOLOGY
Joe Caggiano, ECOLOGY
Mike Connelly, WRPS
Jim Field, WRPS
Les Fort, WRPS
Brendan Hedel, WRPS
Paul Henwood, S.M. Stoller
Jeff Lyon. ECOLOGY
Beth Rochette, ECOLOGY
Marc Wood, CHPRC

PURPOSE:
Present TFC-ENG-CHEM-D-42 tank 241-C-105 leak evaluation results and discuss spare inlet and cascade line leak conceptual models.

Review of Previous Meeting Summary
The June 2, 2010 meeting summary was reviewed and approved.

C-105 leak Evaluation Results
Dennis Washenfelder presented the results of the assessment. Results were previously presented to the WRPS Executive Safety Review Board (ESRB) and to ORP; with the recommendation that the tank be reclassified to "assumed leaker." The source of activity in drywell 30-05-07 in C-farm has long been attributed solely to a cascade line leak with very low probability of a tank leak.

Discussions with ECOLOGY resulting in a decision in the Tank Waste Retrieval Work plan to treat C-105 "as if it leaked," Additional field investigations and evaluations documented in the A-AX and C Field Investigation Report and Tank Waste C-farm leak inventory evaluations concluded that the new data indicates that the tank may have leaked and should be re-evaluated. After initial evaluation, the "D-42" leak assessment team recommended logging a hole to be placed between borehole 30-05-07 and the cascade line and as near to the point where the cascade line enters tank C-105 as possible. If the cascade line leak was the source of activity in

30-05-07 it was expected that the new hole would show high activity at the level of the cascade line extending down to the base of the tank.

A hole (C7469) was pushed and logged in October 2009. The log showed activity starting at the cascade line level (~20 ft bgs) and gradually increasing to ~28 ft bgs. The activity decreased to ~32 ft then rapidly increased consistent with the activity in drywell 30-05-07 (about the level of the waste currently in tank C-105). Losses from both the spare inlet and cascade lines were apparent based on photos showing a waste beach line above the spare inlet level in tank C-105, high activity measured in soils near the spare inlet, and tank drawings showing the spare inlet caps were loosely fitted and showing a leak path for cascade lines. The cascade line leak likely contributed to the peak in 30-05-07 but a tank leak could not be ruled out. This conclusion was based partly on the observed double peak in the C7469 direct push log, suggesting the possibility of two separate leak events, and partly based on the lack of activity near the spare inlets in drywell 30-05-08. The potential opening on the spare inlets was larger and the leak path more direct compared to the leak path for the cascade line. If the activity at the base of the tank in 30-05-07 and C7469 was only from the cascade line similar or higher levels of activity would be expected near the base of the tank in drywell 30-05-08 (near the spare inlet), yet no such activity was observed.

Drawings show a concrete beam supports the cascade line with adjacent tank pillar supports on both ends. One concept discussed was that this infrastructure could have impacted the ability to compact soils near the cascade line and permit the possibility for a preferential flow path next to the tank resulting in a cascade spill running down the side of the tank and pooling at the tank footing.

Mike Connelly demonstrated a 3-D model under development that illustrates pipeline locations, concrete structures and locations of activity. The model is being further developed to include geometric and other features.

Discussion of Results

Depending on the interpretation of the data there is still uncertainty associated with the integrity classification of SST C-105. The conclusion drawn by the Leak Assessment Expert Panel was that "it does not seem credible that a leak through the cascade line penetration can be the sole source of the radiation peak at observed at the base of the tank." The Leak Assessment Expert Panel elicitations indicated that there was still uncertainty in the tank leak probability determination. Recognizing the implications and potential cost and schedule impact to retrieve the tank, Jeff Lyon inquired as to what, if any, additional data could be obtained or evaluated to show the tank was sound or had truly leaked. Additional pushes and samples may be helpful and again may not. The direct push (C7469) was undertaken to answer such a question. The direct push showed the cascade line had leaked, but also raised more questions. WRPS will look into other data that may help to resolve the question of whether the tank leaked.

The question of risk vs. benefit was also discussed. It was suggested that given the large number of drywells near C-105 and particularly near drywell 30-05-07 HRR leak detection would be more reliable than at locations with fewer wells. If the tank leaked in the past, the leak was either high on the tank wall or self sealed; because drywell activity gradually decreased after

1974 and there was no liquid level decrease observed in the tank (WHC-SD-EN-TI-185, *Assessment of Unsaturated Zone Radionuclide Contamination around Single-Shell tanks 241-C-105 and 241-C-106*).

Because of the still significant uncertainty as to the true status of tank C-105, Jeff Lyon indicated that, it may be justifiable to sluice C-105 and rely on the current protocols and procedures for retrieval tank leak monitoring (HRR and drywell monitoring). Jeff Lyon noted that open discussions about the tank leaks through the ongoing leak assessment processes were instrumental to understanding the uncertainties in current tank leak classifications and reconsidering alternatives such as risk/benefit of sluicing the tanks. WRPS took an action to forward the information discussed to the Leak Assessment Expert Panel lead and retrieval management.

MEETING SUMMARY

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: August 3, 2010
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Mike Barnes, ECOLOGY
Joe Caggiano, ECOLOGY
Jim Field, WRPS
Les Fort, WRPS
Paul Henwood, S.M. Stoller
Jeff Lyon, ECOLOGY
Marc Wood, CHPRC

PURPOSE:
Discuss C-200 series tanks

Review of Previous Meeting Summary
The July 13, 2010 meeting summary was reviewed and approved with comments.

Review of C-200 Tanks
ECOLOGY requested that the team review the C-200 series tanks to:
1. Review the locations for direct push logs and samples near the tanks.
2. Verify whether or not the C-200 tanks leaked during retrieval
3. Assess whether releases from the C-200 tanks could account for Uranium in the groundwater near C-farm.

The current WMA-C work plan (RPP-PLAN-39114) identifies direct push sampling to be done near the spare inlets for each of the C-200 tanks. Based on tank waste process history it was believed that these were locations where organics might be detected and C-200 tank spare inlet overflows were identified as potential sources for Uranium in groundwater well 299-E27-7 North East of the C-200 series tanks.

Jim Field presented historical process and tank leak assessment information for the C-200 series tanks (see Attached). Process measurements indicate that Tanks C-201, C-202 and C-204 were filled above the spare inlet level of 55,000 gal several times between 1955 and 1970 when the tanks contained Hot-Semi Works PUREX process waste; suggesting the possibility of a release through the spare inlets. However, the liquid level was always near or just above the spare inlet level for all three tanks. When liquid level measurements did exceed 55,000 gal they did not gradually decrease as would be expected for a spare inlet leak, but remained steady above the 55,000 gallon level for months to years before decreasing or increasing by 1,000 gal and again remaining steady for a similar length of time. This type of behavior suggests either uncertainty in the measurements or that when the tanks were filled above 55,000 gal the spare inlets did not leak or leaks were too small to measure (note: due to the nature of the waste there was no liquid level decrease criteria for the C-200 series tanks. The increase criteria was + 2 inches (SD-WM-TI-356)). Process records indicate that Tank C-203 was never filled above the spare inlet level of 55,000 gal. As a result, the team concluded that spare inlet leaks from the C-200 series tanks are probably not the source of uranium and cyanide observed in groundwater well 299-E27-7.

The C-200 series tanks were interim stabilized in 1981 and 1982. Liquid level decreases based on in-tank measurements and tank photo evaluations were observed in 1984 for tank C-203 and tank photos showed that the liquid level decreased in tank C-201 between 1981 and 1986 and in tanks C-202 and C-204 between 1980 and 1983. Previous tank leak assessments concluded the liquid level decreases had to be due to a tank leak because there was assumed to be no point of air entry into the tanks other than through breather air filters. Previous leak assessments also concluded that intrusions in tank C-203 from 1973 through 1980 may have masked a larger tank leak. However, recent evaluations have shown some tanks are ventilated at a rate greater than those rates estimated by simple barometric pressure vapor space volume calculations. If this was the case for the C-200 series tanks the liquid level decreases could have been due to evaporation. Calculations, attached, show that evaporation through the vent filters could account for the liquid level decreases observed.

The uncertainties associated with whether or not the C-200 series liquid level decreases were from the spare inlet or the tank system, resulted in the team recommending that characterization continue and be focused about the C-200 series tanks. The focus of such an effort is to investigate whether tanks leaked during retrieval and to investigate potential leaking pipelines as a potential source for uranium in groundwater well 299-E27-7. The findings from the UPR-81 3-Dimensional Surface Geophysics Exploration appear promising as a tool to investigate potential C-200 series tank system leaks.

The team recommended that the WMA C work plan be revised as needed to optimize the available direct pushes around the C-200 series tanks for 3-D SGE investigations and pipeline leak investigations. ECOLOGY will discuss this investigative approach as part of WMA-C work plan comments.

ATTACHMENT: SUMMARY OF C-200 TANKS

C-200 Tank Waste History

These tanks were originally constructed as part of the Manhattan Project from 1944 to 1945. Single-shell tanks 241-C-201 through 241-C-204 sat unused until November 1947 when they were activated to store MW (HLW) from operation of the bismuth phosphate process in the 221-B Separations building. These tanks were filled with metal waste by January 1948 (RPP-15408, *Origin of Wastes C-200 Series Single-Shell Tanks*).

Metal waste was hydraulically mined from these tanks from March 1953 through January 1955. The MW sludge and supernatant was dissolved in acid in the 244-BXR vault and then transferred to the 221-U building where uranium was recovered from these wastes using a tributyl phosphate-based solvent extraction process. After completing the removal of MW, each tank was visually inspected and determined to be empty. However, given the inspection method, periscope optics, residual MW could have been left in each tank (RPP-15408).

Tanks 241-C-203 (C-203) and C-204 received cold uranium (i.e., uranium that had not been irradiated in a reactor) waste from PUREX startup testing in November 1955. The cold uranium waste was removed from tanks C-203 and C-204 in December 1955. HW-40763 notes that the waste was sent to "open ditch (A-19)" and states that "the ditch will be for disposal of the remaining depleted uranium." Tanks C-201 through C-204 were then used from May 1955 through October 1956 to receive and store waste originating from research and development activities conducted at the 201-C Hot Semiworks facility in the 200 East Area of the Hanford Site. The cold uranium waste was removed from tanks C-203 and C-204 before transfers of Hot Semiworks waste into these tanks was conducted (RPP-15408).

Tanks C-201 through C-204 were not used to receive waste after being filled with waste from the Hot Semiworks. The liquid in tanks C-201, C-202 (C-202), and C-204 was transferred to SST C-104 in 1970. The liquid in tank C-204 was transferred to SSTs C-104 and C-109 in 1970. Residual liquids were subsequently transferred from these tanks into SST C-106 in 1980 (RPP-15408).

Table 1 provides the history of waste transferred to and from the C-200 tanks from 1947 through 1956. Table 2 provides the history after that time period to 1980.

Stabilization and Current Status

The C-200 tanks were interim stabilized in 1981 and 1982; no pumpable liquid remained in the tanks. Tank waste was retrieval was completed from the C-200 series tanks in 2005 and 2006 (HNF-EP-0182) As required in the Tank Waste Retrieval Work Plan for the C-200 SSTs (RPP-16525, *C-200-Series Tanks Retrieval Functions and Requirements*) water additions were mitigated by using a vacuum extraction retrieval method. In-tank video monitoring and daily mass balance information did not indicate the presence of a leak or spill during retrieval, but were also insufficient to conclude no leakage occurred. Tanks C-201, 202, 203 and 204 all currently contain less than 150 gal of Hot Semiworks waste (RPP-RPT-43040, -43041, -43042 and -43043)

Previous C-200 Tank Leak Assessments

In May 1984 a 2-in. liquid level decrease was reported in tank C-203 based on liquid level measurements and in-tank photographs (Environmental Protection Deviation Report 84-03, *Tank 203-C Liquid Level Decrease*). The report noted a gradual stair-step downward trend from 29.5 to 27.5 inches. In June 1994 a tank leak assessment was performed. All of the team members concluded that the tank should be classified as a confirmed leaker (Memo 65000-WWS-84-10, Classification of Tank 241-C-203).

In May 1987 an environmental deviation report was issued for tanks C-201, 202 and 204 as a result of liquid losses observed in the course of update photo evaluations. An engineering investigation was performed to evaluate the tank photos. This photo review was the basis for current estimated leak volumes of 550, 450 and 350 for tanks C-201, 202 and 204 respectively (Memo 65950-87-517, Liquid level losses in tanks 241-C-201, -202 and -204). The photo interpretations and reviews of tank liquid level data confirmed that liquid volume losses occurred. The losses could not be attributed to waste characteristics or evaporation. The simultaneous decrease in liquid level for all three tanks suggested the possibility of an external mechanism, but no credible alternative to a tank leak was identified (Memo 65950-87-587, Quarterly trend analysis of surveillance data). In August 1987 a tank integrity evaluation for tanks C-201, -202 and -204 recommended that that all three tanks be classified assumed leakers (Memo 35500-87-133, Waste tank integrity evaluation). No record was found of a peer review that was requested to confirm the leak classification (Memo TFS&O-87-00189, Waste Tank Integrity Evaluation).

Figures 1-3 show tank surface level measurements and tank structure.

Potential Spare Inlet Losses

In addition to potential tank leaks after 1983, Table 3 shows that SSTs C-201, C-202, and C-204 were filled with waste above the elevation of the spare inlet nozzles and cascade lines (greater than 55,000 gal) on several occasions between 1955and 1970 when the tanks contained Hot-Semi Works PUREX process waste, suggesting the possibility of a release through the spare inlets. There is no indication from the process records that C-203 was filled above the spare inlet lines. Waste may have been lost to the ground from these SSTs as a result of overfilling these tanks. However, the liquid level of the tanks was always near or just above the spare inlet level for all three tanks. When liquid level measurements did exceed 55,000 gal they did not gradually decrease as would be expected for a spare inlet leak, but remained steady above the 55,000 gallon level for months to years before decreasing or increasing by 1,000 gal and again remaining steady for a similar length of time. This type of behavior suggests either uncertainty in the measurements, or that when the tanks were filled above 55,000 gal the spare inlets did not leak, or leaks were too small to measure. All of these possibilities suggest that spare inlet leaks from tanks C-201, 202 and 204 are not likely the source of Uranium in the groundwater.

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 4.

Table 1. Waste Processing History – 200-Series Single-Shell Tank Wastes (1946 to 1956)

Time	241-C-201	241-C-202	241-C-203	241-C-204	COMMENTS
November 1947 to December 1948	Fill all tanks with Metal Waste – Addition from B Plant				
December 1953	Removal of Metal Waste Supernate to C-106				
November 1954	None	None	None	Metal Waste Supernate	7,000 gallons to C-104
February1954 to February 1955	Metal Waste Sluicing to CR Vault 2/15/1954 – 3/17/1954	Metal Waste Sluicing to CR Vault 1/9/1954 – 1/14/1954	Metal Waste Sluicing to CR Vault 1/15/1954 – 1/28/1954	Metal Waste Sluicing to CR Vault 1/1955 – 2/1955	C-104 pump failed in 2/54, delaying sluicing. All 4 tanks reported as empty by periscope optics
May 1955 to November 1956	Hot Semi-Works PUREX process waste 5/1955 – 11/1955	Hot Semi-Works PUREX process waste 11/1955 – 5/1956	Hot Semi-Works PUREX process waste 12/1955 – 11/1956	Hot Semi-Works PUREX process waste 12/1955 – 11/1956	C-201 and C-202 filled to 54,500-gallons.
April 1954 to November 1956			Process equipment and facility flushes for modifications		C-203 and C-204 filled to 34,500-gallons.

Table 2. Waste Processing History – 200-Series Single-Shell Tank Wastes (1957 to 2006)

Time	241-C-201	241-C-202	241-C-203	241-C-204
January to March 1970			Supernate Removal. Transferred 19,000 gal to Tank C-109	
April to June 1970	Supernate Removal. Transferred 54,000, 55,000, 12,000, and 14,000 gallons of supernate from C-201, C-202, C-203, and C-204 to unspecified tank.			
July 1977				Supernate Removal to unspecified tank
October 1980	Supernate Removal of all tanks to Tank C-109			
January 1983 – April 1987				
January 2005 – December 2006	C-201 thru C-204 Retrieved using Vacuum Retrieval Systems			

Table 3. C-200 Series Tank Waste Liquid Levels					
Reference*	**Date**	**241-C-201**	**241-C-202**	**241-C-203**	**241-C-204**
HW-27838	Apr-52	54.5	54.5	54.5	52.5
	May-52	54.5	54.5	54.5	52.5
	Jun-52	54.5	54.5	54.5	54.5
HW-27839	Jul-52	54.5	54.5	54.5	54.5
	Aug-52	54.5	54.5	54.5	54.5
	Sep-52	54.5	54.5	54.5	54.5
HW-27840	Oct-52	52.5	54.5	54.5	54.5
	Nov-52	52.5	54.5	54.5	54.5
	Dec-52	52.5	54.5	54.5	54.5
HW-27841	Jan-53	52.5	54.5	54.5	54.5
HW-27842	Feb-53	52.5	54.5	54.5	54.5
HW-27775	Mar-53	52.5	54.5	54.5	54.5
HW-28043	Apr-53	54.5	8	54.5	54.5
HW-28377	May-53	54.5	8	54.5	54.5
HW-28712	Jun-53	54.5	8	54.5	54.5
HW-29054	Jul-53	54.5	8	54.5	54.5
HW-29242	Aug-53	54.5	8	54.5	54.5
HW-29624	Sep-53	54.5	8	54.5	54.5
HW-29905	Oct-53	54.5	8	54.5	54.5
HW-30250	Nov-53	54.5	8	54.5	54.5
HW-30498	Dec-53	15.7	43.7	14.8	15.2
HW-30851	Jan-54	15.7	0	0	39.2
HW-31126	Feb-54	10	0	0	51
HW-31374	Mar-54	0	0	0	51
HW-31811	Apr-54	0	0	0	51
HW-32110	May-54	0	0	0	51
HW-32389	Jun-54	0	0	0	51
HW-32697	Jul-54	0	0	0	51
HW-33002	Aug-54	0	0	0	51
HW-33396	Sep-54	0	0	0	51
HW-33544	Oct-54	0	0	0	51
HW-33904	Nov-54	0	0	0	47
HW-34412	Dec-54	0	0	0	47
HW-35022	Jan-55	0	0	0	0
HW-35628	Feb-55	0	0	0	0
HW-36001	Mar-55	0	0	0	0

Table 3. C-200 Series Tank Waste Liquid Levels					
Reference*	**Date**	**241-C-201**	**241-C-202**	**241-C-203**	**241-C-204**
HW-36553	Apr-55	0	0	0	0
HW-37143	May-55	2	0	0	0
HW-38000	Jun-55	13	0	0	0
HW-38401	Jul-55	24.5	0	0	0
HW-38926	Aug-55	25	0	0	0
HW-39216	Sep-55	30	0	0	0
HW-39850	Oct-55	43	0	0	0
HW-40208	Nov-55	54.5	5.5	51.5	45.5
HW-40816	Dec-55	57	6	5	5
HW-41038	Jan-56	57	9	5	5
HW-41812	Feb-56	54.5	23.5	5	5
HW-42394	Mar-56	54.5	23.5	5	5
HW-42993	Apr-56	54.5	42.5	5	5
HW-43490	May-56	54.5	54.5	5	34
HW-43895	Jun-56	54.5	54.5	5	34
HW-44860	Jul-56	54.5	54.5	5	34
HW-45140	Aug-56	54.5	54.5	20	34
HW-45738	Sep-56	54.5	54.5	22	34
HW-46382	Oct-56	54.5	54.5	39.5	9.5
HW-47052	Nov-56	54.5	54.5	34.5	34
HW-47640	Dec-56	54.5	54.5	34.5	34.5
HW-48144	Jan-57	54	56	36	34
HW-48846	Feb-57	54	56	36	34
HW-49523	Mar-57	54	56	36	54
HW-50127	Apr-57	54	55	35	33
HW-50617	May-57	54	55	35	33
HW-51348	Jun-57	54	56	35	33
HW-51858	Jul-57	55	56	35	32
HW-52414	Aug-57	55	56	35	32
HW-52932	Sep-57	55	56	35	32
HW-53573	Oct-57	55	56	35	32
HW-54067	Nov-57	55	56	35	32
HW-54519	Dec-57	55	56	35	32
HW-54916	Jan-58	55	56	35	32
HW-55264	Feb-58	55	56	36	34
HW-55630	Mar-58	55	56	36	34

Table 3. C-200 Series Tank Waste Liquid Levels

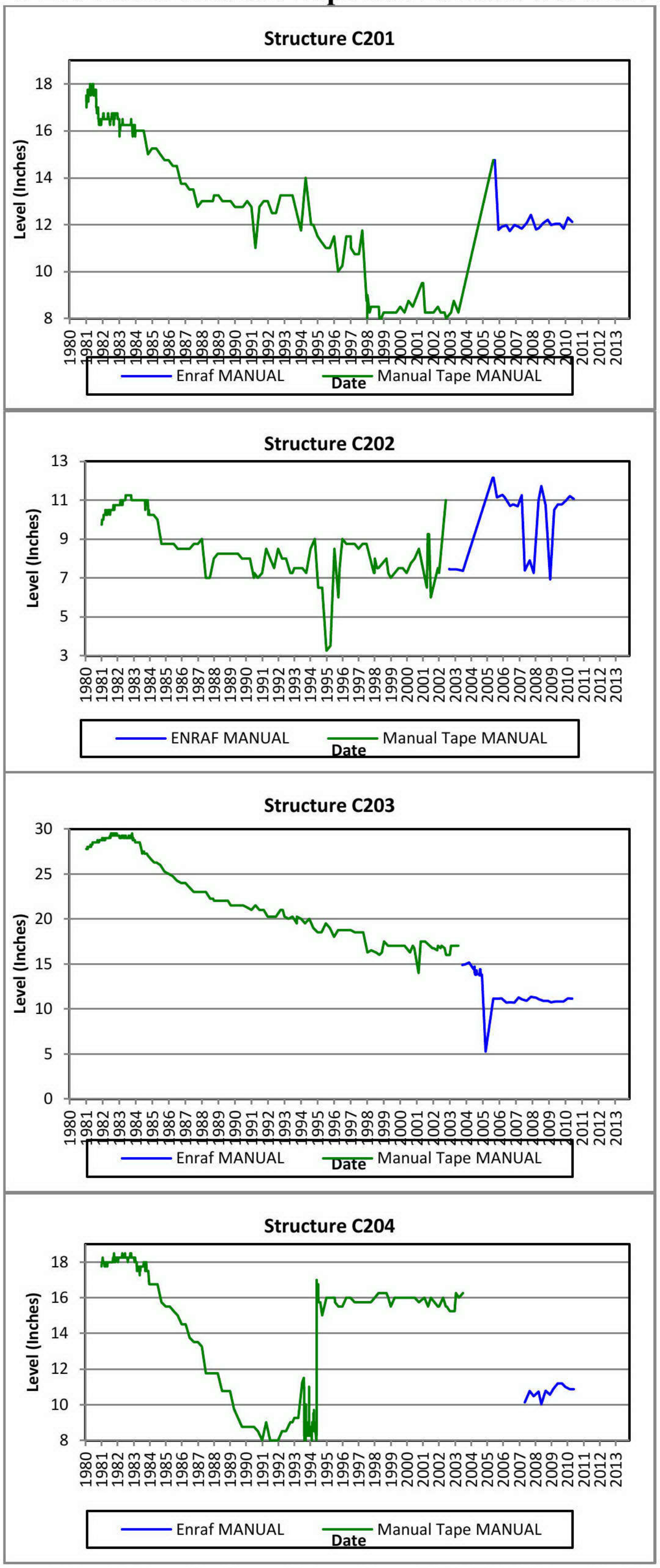
Reference*	Date	241-C-201	241-C-202	241-C-203	241-C-204
HW-55997	Apr-58	55	56	36	34
HW-56357	May-58	55	56	36	34
HW-56761	Jun-58	55	56	36	34
HW-57122	Jul-58	55	56	36	34
HW-57550	Aug-58	55	56	36	34
HW-57711	Sep-58	55	56	36	34
HW-58201	Oct-58	55	56	36	34
HW-58579	Nov-58	55	55	36	34
HW-58831	Dec-58	55	55	35	34
HW-59204	Jan-59	55	55	35	34
HW-59586	Feb-59	55	55	35	34
HW-60065	Mar-59	54	55	34	33
HW-60419	Apr-59	54	55	34	33
HW-60738	May-59	54	55	34	33
HW-61095	Jun-59	54	55	34	33
HW-61582	Jul-59	54	55	34	33
HW-61952	Aug-59	54	55	34	33
HW-62421	Sep-59	54	55	34	33
HW-62723	Oct-59	55	55	34	36
HW-63083	Nov-59	55	55	34	36
HW-63559	Dec-59	55	55	34	36
HW-63896	Jan-60	55	55	34	36
HW-64373	Feb-60	55	55	34	36
HW-64810	Mar-60	55	55	34	36
Hw-65272	Apr-60	55	55	34	36
HW-65643	May-60	55	55	34	36
HW-66187	Jun-60	55	55	34	36
HW-66557	Jul-60	55	55	34	36
HW-66827	Aug-60	55	55	34	36
HW-67696	Sep-60	55	55	34	36
HW-67705	Oct-60	55	55	34	36
HW-68291	Nov-60	55	55	34	36
HW-68292	Dec-60	55	55	34	36
HW-71610	Jun-61	56	56	34	37
HW-72625	Dec-61	56	56	34	37
HW-74647	Jun-62	56	56	34	37

Table 3. C-200 Series Tank Waste Liquid Levels					
Reference*	**Date**	**241-C-201**	**241-C-202**	**241-C-203**	**241-C-204**
HW-76223	Dec-62	56	56	34	37
HW-78279	Jun-63	56	56	34	37
HW-80379	Dec-63	54	57	35	36
HW-83308	Jun-64	54	55	35	36
RL-SEP-260	Dec-64	54	55	35	36
RL-SEP-659	Jun-65	54	55	33	36
RL-SEP-821	Sep-65	54	55	33	36
RL-SEP-923	Dec-65	52	55	33	36
ISO-226	Mar-66	52	55	33	36
ISO-404	Jun-66	52	55	33	36
ISO-538	Sep-66	52	55	33	36
ISO-674	Dec-66	52	55	33	36
ISO-806	Mar-67	55	55	34	36
ISO-967	Jun-67	55	55	34	36
ARH-95	Sep-67	55	55	34	36
ARH-326	Dec-67	55	55	34	57
ARH-534	Mar-68	55	55	34	57
ARH-721	Jun-68	55	55	34	57
ARH-871	Sep-68	55	55	34	57
ARH-1061	Dec-68	55	55	34	57
ARH-1200A	Mar-69	55	55	34	57
ARH-1200B	Jun-69	55	55	34	57
ARH1200C	Sep-69	55	55	34	57
ARH1-1200D	Dec-69	55	55	34	57
ARH-1666A	Mar-70	55	55	18	57
ARH-1666B	Jun-70	1	0	6	43
ARH-1666C	Sep-70	1	0	6	42
ARH-1666D	Dec-70	1	0	6	42
ARH-2074A	Mar-71	1	0	6	42
ARH-2074B	Jun-71	1	0	6	42
ARH-2074C	Sep-71	1	0	6	42
ARH-2074D	Dec-71	1	0	6	42

Table 4. Potential Waste Losses Through Spare Inlets

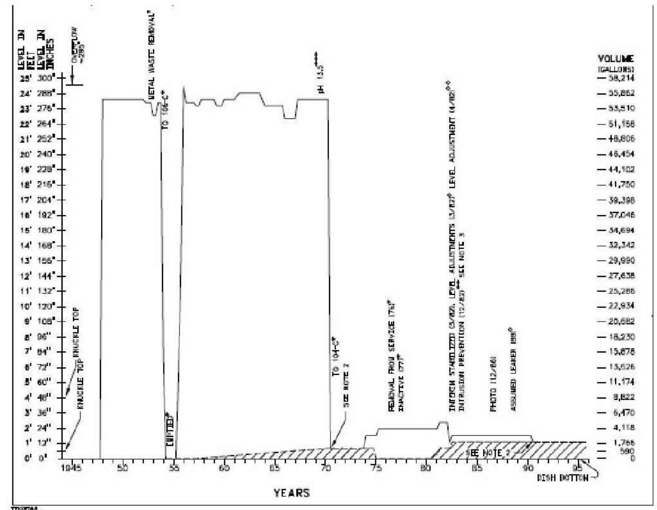
Tank	Date	Waste Type Present in Tank
241-C-201	December 1955 – January 1956 June 1961 – June 1963	201-C Hot Semi-works waste from PUREX flowsheet tests (Note: this is not waste type HS).
241-C-202	January 1957 – March 1957 June 1957 – October 1958 June 1961 – December 1963	201-C Hot Semi-works waste from PUREX flowsheet tests (Note: this is not waste type HS). Last waste transferred into tank was 201-C building flush solutions.
241-C-204	March 1968 – March 1970	201-C Hot Semi-works waste from PUREX flowsheet tests (Note: this is not waste type HS) and 201-C building flush solutions.

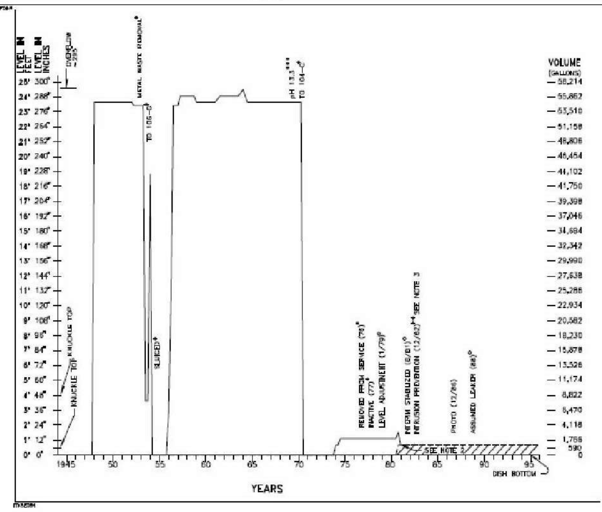
Figure 1: C-200 Series Manual Tape and ENRAF Surface Level Data



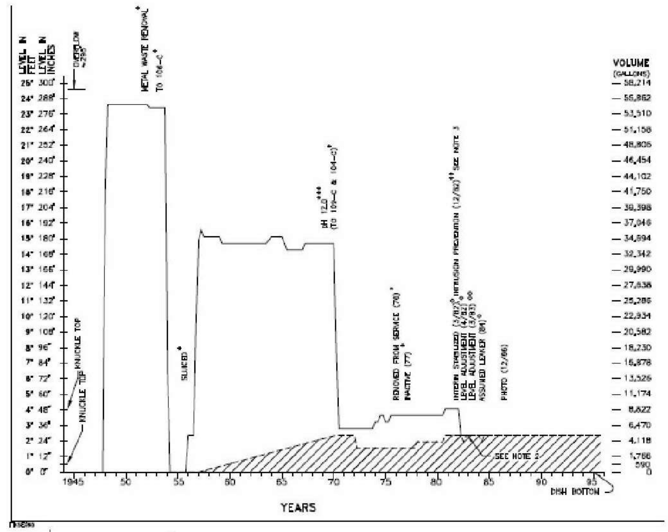
Manual Tape Liquid levels from Riser 5 and ENRAF levels from Riser 8

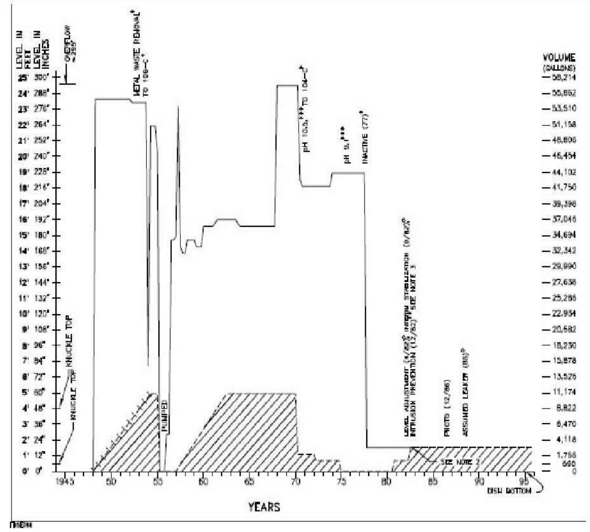
Figure 2. Surface Level History





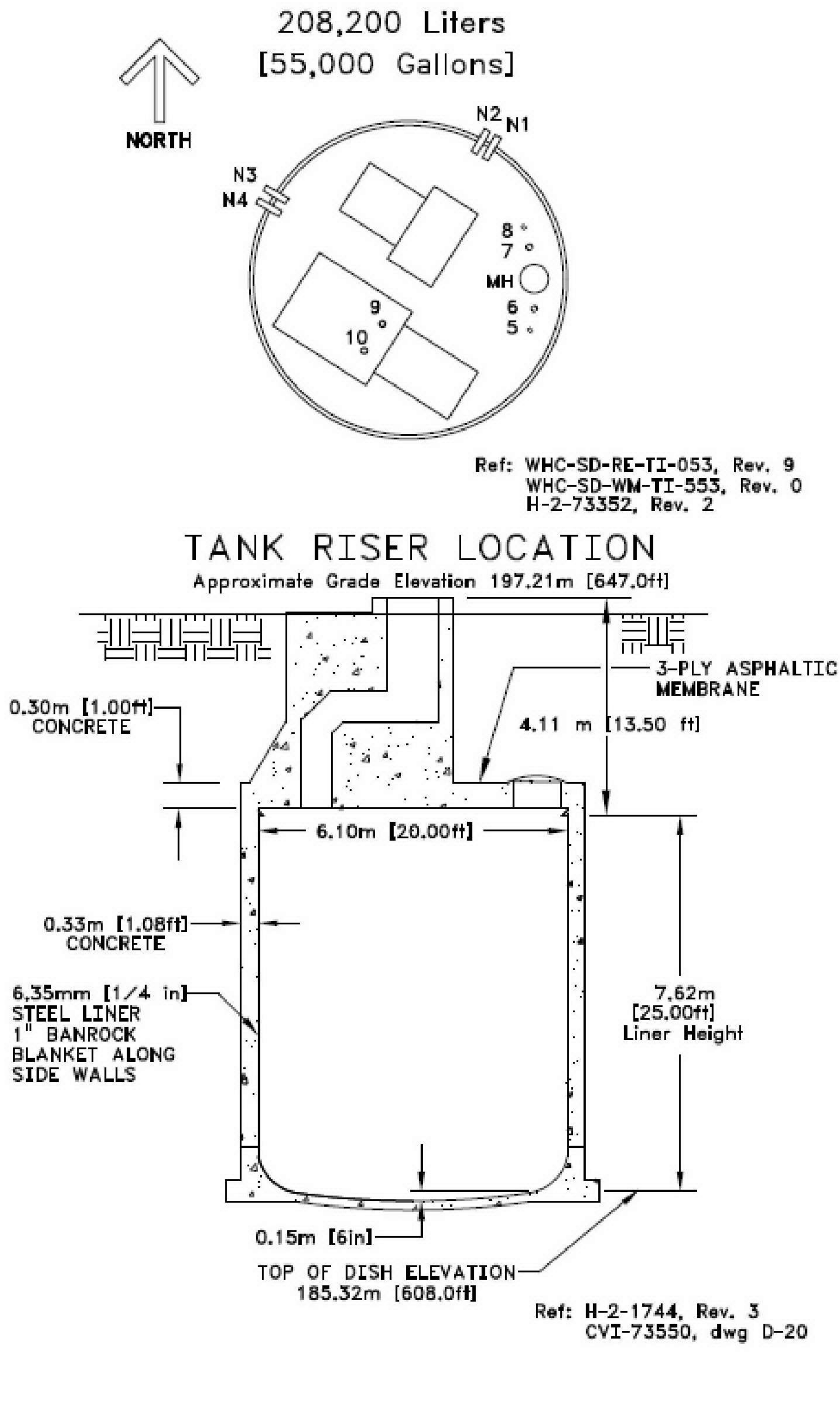
C-201 C-202


LEVEL IN FEET
LEVEL IN INCHES
OVERFLOW
KNUCKLE TOP
METAL WASTE REMOVAL
TO 106-C
SLUICED
pH 12.0
(TO 109-C & 104-C)
REMOVED FROM SERVICE (76)
INACTIVE (77)
INTERIM STABILIZED (3/82)
INTRUSION PREVENTION (12/82)
SEE NOTE 3
LEVEL ADJUSTMENT (4/82)
LEVEL ADJUSTMENT (3/83)
ASSUMED LEAKER (84)
PHOTO (12/86)
SEE NOTE 2
VOLUME (GALLONS)
YEARS
DISH BOTTOM


LEVEL IN FEET
LEVEL IN INCHES
OVERFLOW
KNUCKLE TOP
METAL WASTE REMOVAL
TO 106-C
PUMPED
pH 10.5
TO 104-C
pH 9.1
INACTIVE (77)
LEVEL ADJUSTMENT (4/82)
INTERIM STABILIZATION (9/82)
INTRUSION PREVENTION (12/82)
SEE NOTE 3
PHOTO (12/86)
ASSUMED LEAKER (88)
SEE NOTE 2
VOLUME (GALLONS)
YEARS
DISH BOTTOM

C-203 C-204

Figure 3. 200-Series Tank Construction Drawing



Evaporation Estimates

There is a strong possibility that the volume loss identified at the C-200 series tank was due to evaporation.

An extensive meteorological monitoring program is conducted at the Hanford Site at the Hanford Meteorological Station (HMS), including temperature, relative humidity, precipitation, atmospheric pressure, solar radiation, cloud cover, visibility, and subsurface temperature. Information is taken from PNNL-14616, *Hanford Site Climatological Data Summary 2003 with Historical Data.*

Table 5: Monthly Averages and Extreme Relative Humidity Data, 1950 to 2003

Category	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Dry Bulb	31.4	37.6	45.2	53.2	62.1	69.9	77.3	75.7	66.5	53	40.1	32.6	53.7
Wet Bulb	29	34	39	44	50	55	58	58	53	45	37	31	44
Relative Humidity	77.5	70.4	56.6	47.5	42.9	39.5	33.3	35.6	42.1	56.1	73.6	80.4	54.6
Dew Point	24.8	27.8	29	31.8	37	41.6	43.8	44.1	40.4	36	31.5	26.7	34.5

Simple Evaporation Estimate

Using the annual average Hanford Site climatic information and standard Combustion Engineering, Inc. Steam Tables it was determined that for 54°F air the partial pressure of water is 0.42 in. Hg; and at 55% humidity it would be ~ 0.23 in. of Hg; leaving 0.19 in. Hg difference to saturation. Determining the mass of water to saturation for one cubic foot of this air was determined to be ~2.6E-4 lb_{H_2O}/ft^3.

Standard Hanford tank farm breathing filters have a flow rate range from 5 to 25 cfm. Therefore, the annual potential evaporation volume for this range, for the averaged conditions, is 80 to 400 gallons. The C-200 tanks have a volume measurement of ~195 gallon per inch. Evaporation could account for the 2 inches of liquid loss identified. For reference, at a year and half and 25 cfm, at the conditions specified, evaporation could account of at least 3 inches of liquid loss in a C-200 tank.

Detailed Evaluation of Liquid Volume Losses and Evaporation Estimates

Liquid Volume Losses

Figures 1 through 4 show waste level plots for the C-200 series tanks for the period December 1980 to December 2003. The plots for Tanks 241-C-201, 241-C-202 and 241-C-203 show a similar decrease pattern where the waste level drops at one rate, then at a slower rate, then finally levels off. The plot for Tank 241-C-204 shows only one drop rate until leveling off. It is assumed the first period occurs when the waste has at least a partial liquid surface. The second period (for Tanks 241-C-201, 241-C-202 and 241-C-203) is assumed to occur when the level probe is sitting on the waste surface or in a depression and the liquid in the tank continues to evaporate or leak. The final stage is when further liquid removal has no effect on the solid surface.

The volume loss in any of these tanks cannot be calculated directly from a change in waste level because solids were present at the waste surface for the majority of the time the levels were decreasing. One point, designated Point A, was selected on each plot (except for Tank 241-C-204) to be an assumed 100 percent liquid surface. A second point, designated Point B, was selected for the level at which the liquid surface is assumed to have disappeared. Designated Point C is the level at which the waste surface is assumed to level out. There is no Point C for Tank 241-C-204 since the level stops decreasing at Point B. Designated Points 1, 2 etc. shown on the plots are the estimated percent solids present on the waste surface as stated in 65950-87-517 and EPDR 84-03.

For this document, the volume loss for the first period is based upon an average gal. of free liquid per inch, assuming the waste surface goes from 100 percent free liquid at Point A (except for Tank 241-C-204) to zero percent free liquid at Point B. The gallons of liquid per inch at Point A was estimated from RPP-13019, *Determination of Hanford Waste Tank Volumes,* by subtracting the calculated tank volume at 0.5 inches below Point A from the value calculated at 0.5 inches above Point A. The results of the calculation are shown below each figure.
For Tank 241-C-204 photos in 1980 and 1983 indicated the waste surface was 50 percent liquid at a waste height of 17.75 inches. Point A for Tank 241-C-204 is 18 inches, so engineering judgment was used to assume the waste surface was a conservative 60 percent liquid as the waste height increased by 0.25 inches.

For the second period a maximum and minimum liquid loss was estimated. The maximum volume loss for the second period (excluding Tank 241-C-204) is bounded by conservatively assuming the whole waste surface recedes as liquid is lost from the tank, i.e., the maximum change in volume for the second period is calculated as if all the volume between Points B and C disappeared. The minimum volume loss for the second period is bounded by assuming: 1) the level plummet is sitting in a depression measuring the interstitial liquid level; 2) the solid waste surface level doesn't change, all the observed decrease is due to interstitial liquid loss; 3) there is conservatively no capillary liquid holdup; and 4) the waste porosity is 35 volume percent. Past experience with saltwell pumping indicates most saltcake porosities are in the 22-35 volume percent range and most sludge porosities are in the 6-12 percent range. Assuming 35 percent porosity for the waste in the 241-C-200 Series tanks will result in a conservative estimate for the minimum liquid lost between B and C.

The details of the observed liquid loss calculations are provided at the bottom of the level plot for each tank. Using the above assumptions Tank 241-C-201 lost an estimated 625 to 1,040 gal. of liquid between June 1981 and March 1998. Of this, 400 gal. disappeared between June 1981 and December 1987 and 225 to 640 gal from December 1987 to March 1998.

Tank 241-C-202 lost an estimated 225 to 310 gal. of liquid between June 1983 and June 1990. Of this, 180 gal. disappeared between June 1983 and June 1986 and 45 to 130 gal. from June 1986 to June 1990.

Tank 241-C-203 lost an estimated 1,015 to 1,520 gal. of liquid between December 1982 and June 1999. Of this, 715 gal. disappeared between December 1982 and October 1988 and 300 to 855 gal. from October 1988 to June 1999.

The Tank 241-C-204 level data shows a fairly steady decrease from about 18 inches to about eight inches between October 1982 and June 1991, with the reading subsequently getting erratic and then rising to 16 inches when the tape was replaced in June 1994. A photo in December 1986 shows the tape plummet resting on solids with the waste level at 13.3 inches and a ten percent liquid surface. The reason for the eight inch increase in the waste surface reading with the manual tape change is unknown but there are three potential explanations:

- the readings with the new manual tape are high by eight inches after 1994 due to a different reference elevation, or
- the readings with the old manual tape were low by eight inches before 1994 due to a different reference elevation, or
- before 1994 the tape was in a deep crack or depression, and the new plummet rested on a higher surface when the tape was replaced in 1994

Assuming the new manual tape data are high by eight inches after the old tape was replaced, Tank 241-C-204 lost an estimated 500 gal. of liquid between December 1982 and June 1991. Assuming the old manual tape data are low by eight inches before the replacement, Tank 241-C-204 lost an estimated 550 gal. of liquid between the same dates. To estimate the loss associated with the third bullet the liquid loss between December 1982 and the December 1986 photo was calculated in a similar fashion as for the other three tanks from Point A to Point B, except here the waste level was assumed to be 60 percent liquid at Point A and 10 percent liquid at Point 3 based upon photo data reported in 65950-87-517. The loss between Point 3 and Point B was calculated the same as for the other three tanks from Point B to Point C, except the loss was assumed to be just interstitial liquid at a 35 percent waste porosity. Using this methodology, Tank 241-C-204 lost an estimated 560 gal. of liquid between December 1982 and June 1990. Of this, 300 gal. disappeared between December 1982 and December 1986 and 260 disappeared from December 1986 to June 1991. The range of estimated liquid lost from Tank 241-C-204 between December 1982 and June 1991 is thus 500 to 560 gal, depending upon assumptions used for interpretation of the manual tape data.

These volume decreases do not take into account water loss due to evaporation. Evaporation is discussed in the following section.

Detailed Evaporation Estimates

1980s Evaporation Estimate

Letter 65950-87-517 states that evaporation could not account for all the liquid loss in Tanks 241-C-201, 241-C-202, and 241-C-204. No reference for any Tank 241-C-201, 241-C-202, and 241-C-204 evaporation calculations is stated. However, 65950-87-517 references ARH-CD-256, *Anticipated Natural Air Breathing Rate for Underground Tanks,* for tank breathing rates. This 1975 document provided the basis used for tank breathing rate estimates in the 1980s. No discussion was found of an evaporation analysis for Tank 241-C-203 as a follow up to EPDR 84-03. Using the tank breathing rates calculated from a formula in ARH-CD-256 a maximum evaporation rate of 3 gal/day was estimated, accounting for less than 5 percent of the liquid losses observed in the tanks.

However, The 1980s breathing rate formula only considered the daily change in atmospheric pressure. In reality, the pressure may vary several times per day resulting in more air exchange between the tank and the ambient air than would be predicted by looking at only the daily maximum and minimum pressure readings. Diffusion of gases through openings also will result in vapor exchange with the atmosphere without pressure differences. The 1980s breathing rate formula thus predicts lower than actual passive tank ventilation rates.

Revised Evaporation Estimates
In 1997 and 1998 14 breathing rate tests were performed in 13 100 Series SSTs. These tests involved injection of He or He + SF_6 tracer gases (HNF-3588, *Organic Complexant Topical Report*) into the tanks with periodic sampling afterward. Table 2 Column 2 shows the measured ventilation rates for these tanks taken from Appendix D of HNF-3588. Column 3 shows the headspace volume calculated using RPP-13019. Column 4 shows the ventilation rate calculated using the formula from ARH-CD-256 and the headspace volumes from Column 3.

Column 5 of Table 2 shows the ratio of measured to calculated passive ventilation rates. The numbers for Tank 241-C-104 can be ignored because this tank is connected by a cascade line to Tank 241-C-105, which was also connected to Tank 241-C-106 when the ventilation rate study was done (Tank 241-C-106 was actively ventilated). From the remaining tanks it can be seen that the measured ventilation rate ranged from 3.0 to 43 times higher than the rate calculated using ARH-CD-256.

No 200 series tank had its tank breathing rate measured. To estimate a ventilation rate for the 241-C-200 Series tanks, the tank headspace volume for each tank in Table 2 (excluding Tank 241-C-104 and U-103) was divided by its measured breathing rate to give an estimate of the number of days needed to change out one tank headspace volume of air for that tank. These data are given in Column 6. Since the volume of air released from an enclosure due to a pressure change is proportional to the volume of the enclosure it was assumed that a 200 series tank would have a similar range of headspace air change out times as the 100 series tanks. The range of values for the 13 100 series tanks is 3.43 to 50.2 days. Dividing the average headspace volume of the 241-C-200 Series tanks (8,488 ft.^{3}) by 50.2 gives a minimum estimated breathing rate for the 241-C-200 Series tanks of 169 ft^3/day. Dividing by 3.43 gives a maximum estimated breathing rate for the 241-C-200 Series tanks of 2474 ft^3/day. The estimated 241-C-200 Series tank breathing rate range was thus assumed to be 170-2500 ft.^{3}/day.
HNF-3588, Table D-4, provides an estimated 1.7 m^3/hour ventilation rate for the 241-C-200 Series tanks. HNF-3588 explains that this estimate is based on an estimated ventilation rate of 1 ft.^{3}/min (1,440 ft.^{3}/day).

The evaporation rate for the 241-C-200 Series tanks was estimated for this document assuming a tank breathing rate range of 170 to 2,500 ft.^{3}/day, with a „best estimate' breathing rate value of 1,440 ft.^{3}/day.

Hanford Meteorological Data were used for ambient air conditions. Table 3 Rows 1 to 8 present average monthly temperature data for the period 1980 to 1987. Row 9 provides an average monthly temperature. Rows 10 through 17 provide the average monthly relative humidity data. Row 18 provides the average monthly relative humidity data.

In-tank temperature data from nearby tanks with the lowest in-tank temperatures (Tanks 241-C-109 and 241-C-111) were used to approximate 241-C-200 Series tank conditions because no in-tank temperature data have been available for the 241-C-200 Series tanks since the 1970s. Tanks 241-C-109 and 241-C-112 are the closest tanks to the 241-C-200 Series tanks. However, Tank 241-C-112 had elevated tank headspace temperatures and using these temperatures could overestimate the 241-C-200 Series tank evaporation rates. The headspace temperatures for Tanks 241-C-109 and 241-C-111 for the period 1980-1987 are not readily available, but the headspace temperatures for 1996 to 2003 are available from the Surveillance Analysis Computer System. These temperatures should be the same or lower than those from 1980 to 1987 (and thus conservative) because of less radioactive decay heat. Each tank has eight tank headspace thermocouple points available. The daily temperature data for these two tanks for 1996 to 2003 was downloaded, and the average of all eight points was calculated to provide a monthly average tank headspace temperature. These data are provided in Table 4. The average of these two readings is given in Row 3 of Table 4 and was used as the tank headspace temperature for the 241-C-200 Series tanks.

Table 5, Rows 1 and 2, restate the ambient air temperature and assumed 241-C-200 Series tank headspace temperatures from Tables 3 and 4. Table 5 Rows 3 and 4 provide water vapor pressure data for these temperatures obtained from *Perry's Chemical Engineering Handbook*, 4th Edition, 1963. Row 6 provides the water vapor content calculated for the ambient air from the vapor pressure data and the ambient relative humidity. Rows 6 through 9 provide the tank headspace water vapor content at 100, 90, 80, and 70 percent relative humidity.

An example of how the concentration of water vapor in the tank headspace was calculated is shown for January for 100 percent relative humidity:

$$\frac{(20.1 \text{ mm Hg})\ (459{+}32°\text{R})\ (18 \text{ g } H_2O/\text{g mole})\ (454 \text{ g mole/lb mole})}{(359 \text{ ft.}^3/\text{lb mole @ STP})\ (760 \text{ mm Hg})\ (459{+}72°\text{R}).} = 0.558 \text{ g } H_2O/\text{ft.}^3$$

STP = standard temperature and pressure.

The daily evaporation for a 241-C-200 Series tank in January with a 170 ft.^{3}/day ventilation rate and assuming the tank headspace was at 100 percent relative humidity would have been:
170 ft.^{3}/day × (0.558 – 0.104 g H_2O/ft.^{3}) = 77 g H_2O /day.

Where: 0.104 g H_2O/ft.^{3} is the water content in the ambient air entering the tank in January, from Table 5, Row 5, Column 1.

The daily evaporation for a 241-C-200 Series tank in the 1980s in January with a 2,500 $ft.^3$/day ventilation rate and assuming the tank headspace was at 100 percent relative humidity would have been:

$$2{,}500\ ft.^3/day \times (0.558 - .104\ g\ H_2O/ft.^3) = 1{,}135\ g\ H_2O\ /day.$$

The relative humidity in the 241-C-200 Series tanks in 1980 to 1987 is unknown. With a partial liquid surface and no active ventilation, engineering judgment was used to assume the relative humidity in the tank headspace should have been more than 70 percent and could have approached 100 percent. The daily evaporation loss for each month was calculated for 100, 90, 80, and 70 percent relative humidity in the tank headspace. This calculated daily evaporation loss was multiplied by the number of days in the month, the total loss for the year added up, divided by 365, and the result converted to a gallons of water per day loss rate. Table 6 gives the results.

From Table 6 it can be seen that the minimum assumed breathing rate of 170 $ft.^3$/day would have resulted in an evaporation rate of 0.011 to 0.019 gal/day. The maximum assumed breathing rate of 2,500 $ft.^3$/day would have resulted in an evaporation rate of 0.16 to 0.28 gal./day. For this document a daily tank evaporation range of 0.011 to 0.28 gal./day was assumed. At the „best estimate' 1,440 $ft.^3$/day breathing rate the evaporation loss would have been 0.09 to 0.16 gal./day. The „best estimate' of a daily tank evaporation rate was assumed to be 0.14 gal./day based upon the 1,440 $ft.^3$/day breathing rate at a 90 percent tank headspace relative humidity.

Comparison of Evaporation Estimates and Liquid Losses

Tank 241-C-201 evaporated an estimated 67 to 1,700 gal. of water between June 1981 and March 1998. The „best estimate' of the evaporation during the same period is 840 gal. The minimum value was calculated by multiplying 0.011 gal/day by 16.75 yr, and that value by 365 days per year. The maximum and „best estimate' values were determined in a similar fashion. An estimated 26 to 660 gal were evaporated up to December 1987 and 41 to 1,040 gal from then until March 1998.

Tank 241-C-202 evaporated an estimated 28 to 710 gal. of water between June 1983 and June 1990. The „best estimate' of the evaporation during the same period is 350 gal. An estimated 12 to 300 gal were evaporated up to June 1986 and 16 to 410 gal from then until June 1990.

Tank 241-C-203 evaporated an estimated 67 to 1670 gal. of water between December 1982 and June 1999. The „best estimate' of the evaporation during the same period is 830 gal. An estimated 23 to 580 gal were evaporated up to October 1988 and 43 to 1,090 gal from then until June 1999.

Tank 241-C-204 evaporated an estimated 31 to 790 gal. of water due to evaporation between October 1982 and June 1991. The „best estimate' of the evaporation during the same period is 390 gal.

Figure 6 shows a comparison of the estimated range of liquid volume losses from Section 4.0 and estimated evaporation ranges. For Tank 241-C-201 the estimated liquid loss range falls in the middle of the estimated evaporation range, with the „best estimate' of evaporation in the middle of the liquid loss range. Tank 241-C-202 shows a similar pattern except the estimated liquid loss range is slightly below the „best estimate' of evaporation. Tank 241-C-204 shows the estimated liquid loss range within the estimated evaporation range, but slightly above the „best estimate' for evaporation. For Tank 241-C-203 the estimated liquid loss range is bounded by the estimated evaporation range but the midpoint of the observed liquid loss range is above the „best estimate' of evaporation.

Table 6. 241-C-200 Series Tank Data

Tank	Waste Volume from TWINS [L (gal.)]	Headspace Volume Based upon RPP-13019 (ft.^{3})	Tank Breathing Rate Based upon ARH-CD-256 (ft.^{3}/day)
241-C-201	4,000 (1,100)	8,576	57
241-C-202	3,000 (800)	8,611	57
241-C-203	10,000 (2,600)	8,364	56
241-C-204	9,000 (2,400)	8,399	56

ARH-CD-256, 1975, *Anticipated Natural Air Breathing Rate for Underground Tanks*, Atlantic Richfield Hanford Company, Richland, Washington.

RPP-13019, 2003, *Determination of Hanford Waste Tank Volumes*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

Tank Waste Information Network System (TWINS) database, at http://twins.pnl.gov/twins.htm.

Table 7. Measured vs. Calculated Ventilation Rates for Selected Tanks

Tank	Avg. Ventilation Rate from HNF-3588 Rev 1 [ft.^{3}/min (ft.^{3}/day)]	Tank Headspace Volume Calculated from RPP-13019 (ft.^{3})	Calculated Tank Ventilation Rate Based on ARH-CD-256 (ft.^{3}/day)	Ratio of Measured to Calculated Ventilation Rates Based on ARH-CD-256	Ratio of Headspace Volume to Avg. Ventilation Rate (day/tank)
A-101	10 (14,000)	122,820	820	18	8.77
AX-102	16 (23,000)	174,174	1,200	20	7.57
AX-103	25 (36,000)	163,747	1,100	33	4.55
BY-105	16 (23,000)	78,860	530	43	3.43
C-104	67 (96,000)	78,929	530	180	-
C-107	1.1 (1,600)	80,399	540	3.0	50.2
S-102	2.2 (3,200)	81,676	540	5.8	25.5
TX-104	3.5 (5,000)	130,996	870	5.7	26.2
U-102	2.1 (3,000)	69,839	470	6.6	23.3
U-103 He	1.7 (2,500)	57,807	390	6.3	-
U-103 He+SF_6	2.3 (3,300)	57,807	390	8.5	17.5
U-105	5.0 (7,200)	66,363	440	16	9.22
U-106	1.3 (1,900)	90,599	600	3.1	47.7
U-111	1.9 (2,700)	79,464	530	5.1	29.4

HNF-3588, 2003, *Organic Complexant Topical Report*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13019, 2003, *Determination of Hanford Waste Tank Volumes*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

ARH-CD-256, 1975, *Anticipated Natural Air Breathing Rate for Underground Tanks*, Atlantic Richfield Hanford Company, Richland, Washington.

Table 8. Selected Hanford Site Ambient Air Meteorological Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980 °F	23.7	34.6	44.5	55.2	61.4	64.7	74.7	71.2	66.0	52.6	41.0	36.6
1981 °F	38.0	39.7	48.7	54.0	60.5	66.0	73.9	79.0	66.3	52.0	42.7	32.8
1982 °F	29.8	38.1	45.9	49.4	60.4	73.1	74.9	75.8	65.4	51.4	36.9	32.0
1983 °F	37.5	40.9	48.5	51.1	63.8	65.4	71.3	74.4	61.7	52.6	43.6	21.2
1984 °F	31.6	38.7	47.2	50.5	56.0	65.7	76.1	74.0	62.1	47.9	39.4	23.6
1985 °F	25.0	29.9	44.0	55.5	63.2	70.2	82.2	70.5	58.8	49.8	24.8	21.0
1986 °F	34.0	39.1	48.6	50.9	62.3	73.0	70.6	79.2	62.2	54.7	42.3	32.4
1987 °F	30.7	40.1	48.3	58.0	66.2	73.4	74.3	76.6	69.9	55.5	43.6	31.5
Avg °F	31.3	37.6	47.0	53.1	61.7	68.9	74.8	75.1	64.1	52.1	39.3	28.9
1980 RH	75.5	72.5	57.4	49.9	50.8	48.3	35.8	35.7	47.3	60.3	78.2	84.4
1981 RH	84.5	71.0	57.8	46.6	46.5	46.6	37.0	27.5	38.2	53.2	75.4	79.0
1982 RH	73.7	58.8	52.6	43.6	38.0	37.1	35.7	35.2	50.1	64.4	75.0	76.9
1983 RH	81.7	83.5	67.9	50.9	34.8	36.6	37.3	37.9	41.6	52.1	68.1	75.3
1984 RH	74.6	66.0	58.1	49.6	44.4	42.5	32.4	35.1	44.0	51.7	72.2	71.6
1985 RH	78.4	68.0	52.1	42.8	40.4	37.4	30.1	38.3	51.9	60.2	78.6	87.9
1986 RH	85.4	75.6	66.9	45.7	42.6	34.6	39.1	30.7	53.6	61.7	69.0	88.6
1987 RH	81.5	71.5	60.2	42.5	39.7	34.2	41.3	32.9	35.9	45.1	73.5	81.8
Avg RH	79.4	70.9	59.1	46.5	42.2	39.7	36.1	34.2	45.3	56.1	73.8	80.7

RH = relative humidity.

Table 9. Tanks 241-C-109 and 241-C-111 Headspace Temperature Data.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
241-C-109 °F	70.7	68.7	67.6	67.6	68.6	70.3	72.5	75.1	76.9	77.2	75.8	73.6
241-C-111°F	73.3	71.5	70.4	70.2	70.9	72.4	74.3	76.8	78.4	78.6	77.6	75.6
Average (assumed 241-C-200 Series tank headspace temperature) °F	72.0	70.1	69.0	68.9	69.7	71.4	73.4	76.0	77.7	77.9	76.7	74.6

Table 10. Temperature and Water Vapor Data and Calculated Water Vapor Concentrations.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ambient °F	31.2	37.6	45.2	53.2	62.2	69.8	77.2	75.7	66.5	53	40.1	32.5
Assumed 241-C-200 Series headspace °F	72.0	70.1	69.0	68.9	69.7	71.4	73.4	76.0	77.7	77.9	76.7	74.6
VP of H_2O at ambient temp mm Hg	4.4	5.7	7.7	10.4	14.3	18.7	23.9	22.8	16.7	10.3	6.3	4.7
VP of H_2O at Tank Temp mm Hg	20.1	18.9	18.2	18.1	18.7	19.7	21.1	22.9	24.3	24.5	23.5	22.0
H_2O in ambient air at avg RH g/ft.^{3}	0.104	0.120	0.127	0.142	0.174	0.206	0.220	0.224	0.198	0.167	0.138	0.113
H_2O in tank HS at 100% RH g/ft.^{3}	0.558	0.526	0.508	0.505	0.520	0.548	0.584	0.632	0.669	0.672	0.647	0.608
H_2O in tank HS at 90% RH g/ft.^{3}	0.502	0.474	0.458	0.455	0.468	0.493	0.525	0.569	0.602	0.605	0.582	0.547
H_2O in tank HS at 80% RH g/ft.^{3}	0.446	0.421	0.407	0.404	0.416	0.439	0.467	0.506	0.535	0.538	0.517	0.486
H_2O in tank HS at 70% RH g/ft.^{3}	0.390	0.369	0.356	0.354	0.364	0.384	0.409	0.443	0.468	0.471	0.453	0.425

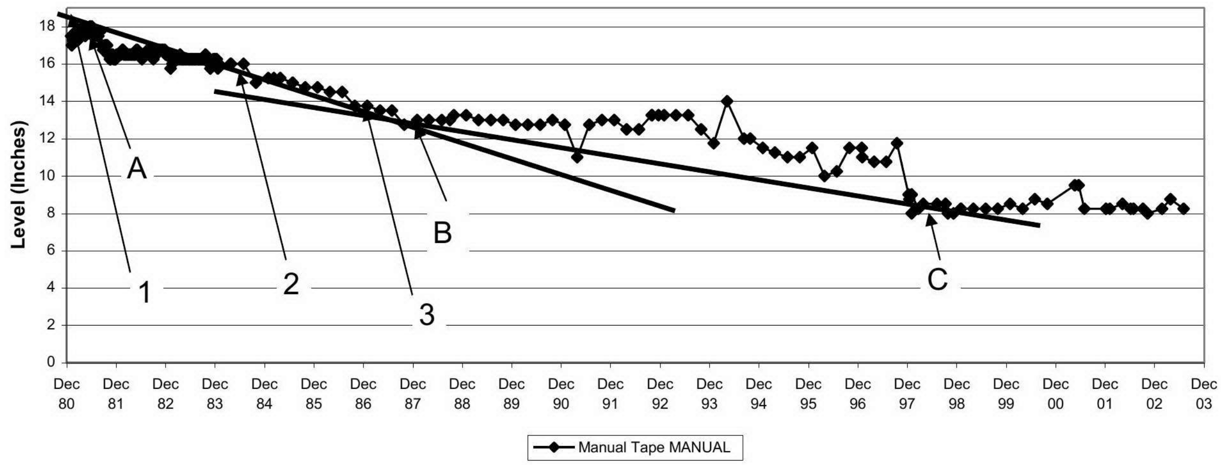
HS = head space.
RH = relative humidity.
VP = vapor pressure.

Table 11. Estimated Daily Evaporation Rates for 241-C-200 Series Tanks in 1980 - 1987.

	Loss @ 70% RH in Tank Headspace	Loss @ 80% RH in Tank Headspace	Loss @ 90% RH in Tank Headspace	Loss @ 100% RH in Tank Headspace
Water loss rate at 170 ft.^{3}/day (gal./day)	0.011	0.014	0.016	0.019
Water loss rate at 1,440 ft.^{3}/day (gal./day)	0.093	0.12	0.14	0.16
Water loss rate at 2,500 ft.^{3}/day (gal./day)	0.16	0.20	0.24	0.28

RH = relative humidity.

Figure 4: Tank 241-C-201 Waste Level



Point A – Assume 100% liquid surface @~17.75 inches in ~June 1981
Point B – Assume 0% liquid surface @~13.0 inches in ~ December 1987
Point C – Assume level drop ceases @~8.5 inches in ~ March 1998
Point 1 – Per 65950-87-517, 80% liquid surface @~17.25 inches in January 1981; Point 2 – 10% liquid surface @~15.5 inches in June 1984; Point 3 – 0% liquid surface, dry and cracked @~13.25 inches in December 1986
Per RPP-13019, 17.75 inches = 167 gal/in., 13.0 inches = 152 gal/in. → (167 x 1.0 + 152 x 0) † 2 = 84 gal free liquid/in. from A to B,

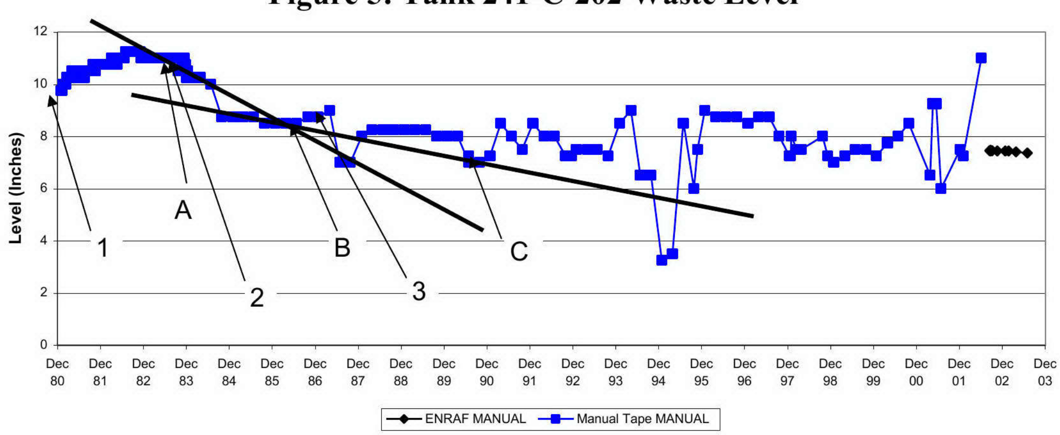
Volume lost between A and B = (17.75 – 13.0) x 84 ≈ 400 gal

Per RPP-13019, 13.0 inches = 1264 gal, 8.5 inches = 624 gal

Max volume lost between B and C = 1264 – 624 = 640 gal
Min volume lost between B and C = 640 x 0.35 ≈ 225 gal

Total volume lost between A and C = 400 + (225 to 640) = 625 to 1040 gal

Figure 5: Tank 241-C-202 Waste Level



Point A – Assume 100% liquid surface @~11.0 inches in ~June 1983
Point B – Assume 0% liquid surface @~8.5 inches in ~ June 1986
Point C – Assume level drop ceases @~7.5 inches in ~ June 1990

Point 1 – Per 65950-87-517, 50% liquid surface @~9.5 inches in December 1980; Point 2 – 90% liquid surface @~11 inches in August 1983; Point 3 – 0% liquid surface, dry and cracked @ 8.75 inches, December 1986

Per RPP-13019, 11.0 inches = 143 gal/in., 8.5 inches = 130 gal/in. → (143 x 1.0 + 130 x 0) † 2 = 72 gal free liquid/in. from A to B,

Volume lost between A and B = (11.0 – 8.5) x 72 = 180 gal

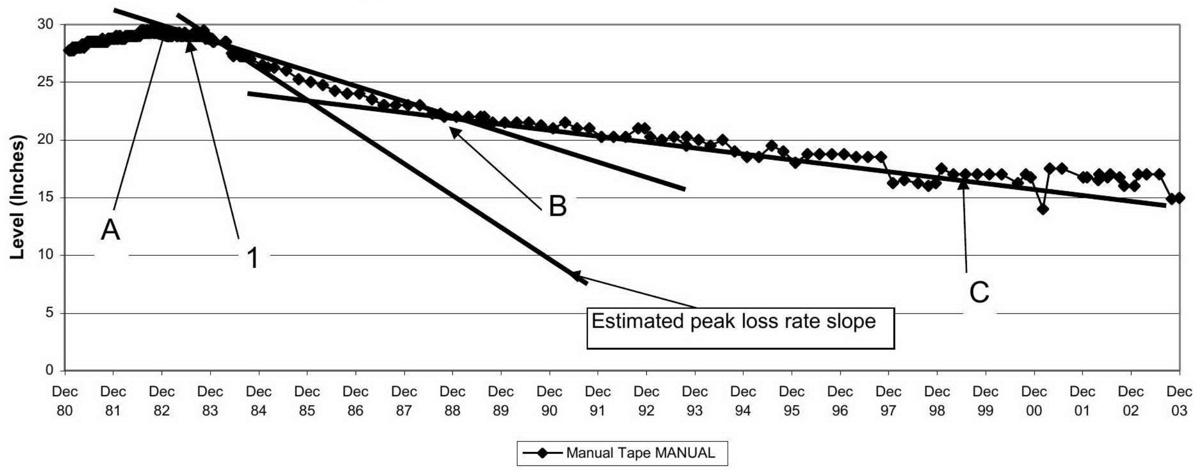
Per RPP-13019, 8.5 inches = 624 gal, 7.5 inches = 497 gal

Max volume lost between B and C = 624 – 497 ≈ 130 gal

Min volume lost between B and C = 130 x 0.35 ≈ 45 gal

Total volume lost between A and C = 180 + (45 to 130) = 225 to 310 gal

Figure 6: Tank 241-C-203 Waste Level



Point A – Assume 100% liquid surface @~29.5 inches in ~December 1982

Point B – Assume 0% liquid surface @~22 inches in ~ October 1988

Point C – Assume level drop ceases @~17 inches in ~ June 1999

Point 1 – Per EPDR 84-03, 100% liquid surface @ ~29 inches in August 1983

Per RPP-13019, 29.5 inches = 189 gal/in., 22 inches = 177 gal/in. → (189 x 1.0 + 177 x 0) † 2 = 95 gal free liquid/in. from A to B,

Volume lost between A and B = (29.5 – 22) x 95 = 715 gal

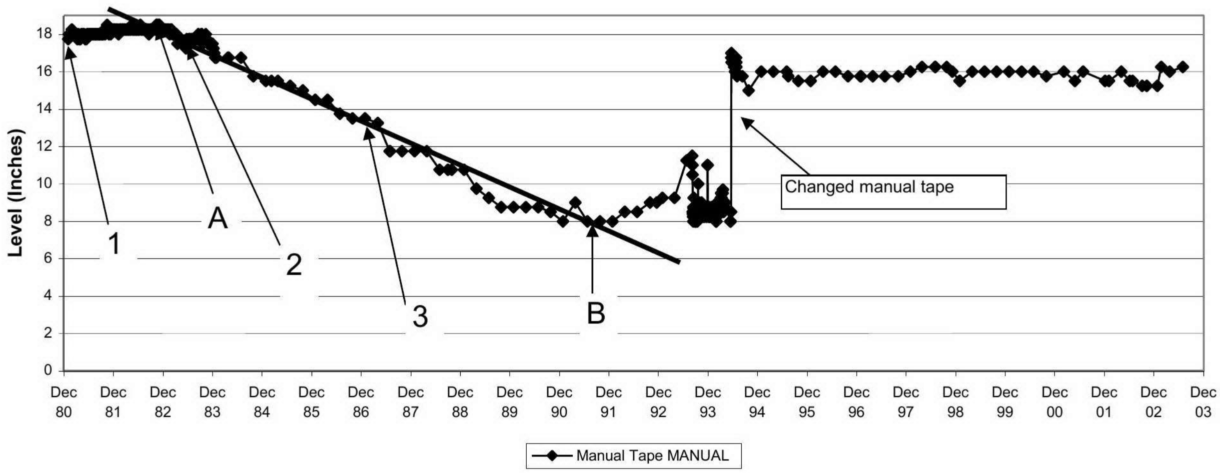
Per RPP-13019, 22 inches = 2756 gal, 17 inches = 1899 gal

Max volume lost between B and C = 2756 – 1899 ≈ 855 gal

Min volume lost between B and C = 855 x 0.35 ≈ 300 gal

Total volume lost between A and C = 715 + (300 to 855) = 1015 to 1570 gal

Figure 7: Tank 241-C-204 Waste Level



Point A – Assume 60% liquid surface @~18 inches in ~December 1982
Point B – Assume 0% liquid surface @~8 inches in ~ June 1991
Point 1 – Per 65950-87-517, 50% liquid surface @ ~17.75 inches in December 1980, Point 2 – 50% liquid surface @ ~17.75 inches in August 1983, Point 3 – 10% liquid surface @ ~13.3 inches in December 1986, with plummet contacting solid surface

- If readings with new manual tape are high by 8 inches, data before 1994 are assumed accurate and per RPP-13019, 18 inches = 167 gal/in., 8 inches = 127 gal/in. → (167 x 0.6 + 127 x 0) ÷ 2 = 50 gal free liquid/in. from A to B. Volume lost between A and B = (18 – 8) x 50 = 500 gal
- If readings with old manual tape are low by 8 inches, per RPP-13019, 26 (8 + 18) inches = 184 gal/in., 16 (8 + 8) inches = 162 gal/in → (184 x 0.6 + 162 x 0) † 2 = 55 gal free liquid/in. from A to B. Volume lost between A and B = (26 – 16) x 55 = 550 gal
- If assume lose surface liquid between A and 3 and interstitial liquid between Point 3 and B, per RPP-13019, 13.3 inches = 153 gal/in, → (184 x 0.6 + 153 x 0.1) † 2 = 63 gal free liquid/in. from A to 3, volume lost between A and 3 = (18 – 13.3) x 63 = 296 gal, volume @ 13.3 in. = 1307 gal, volume @ 8 in. = 560 gal, interstitial liquid lost between 3 and B = (1307 – 560) x 0.35 = 261 gal. Total liquid lost between A and B = 296 + 261 ≈ 560 gal

Therefore, total liquid lost = 500 to 560 gal

Figure 8: C-200 Tanks Waste Sources

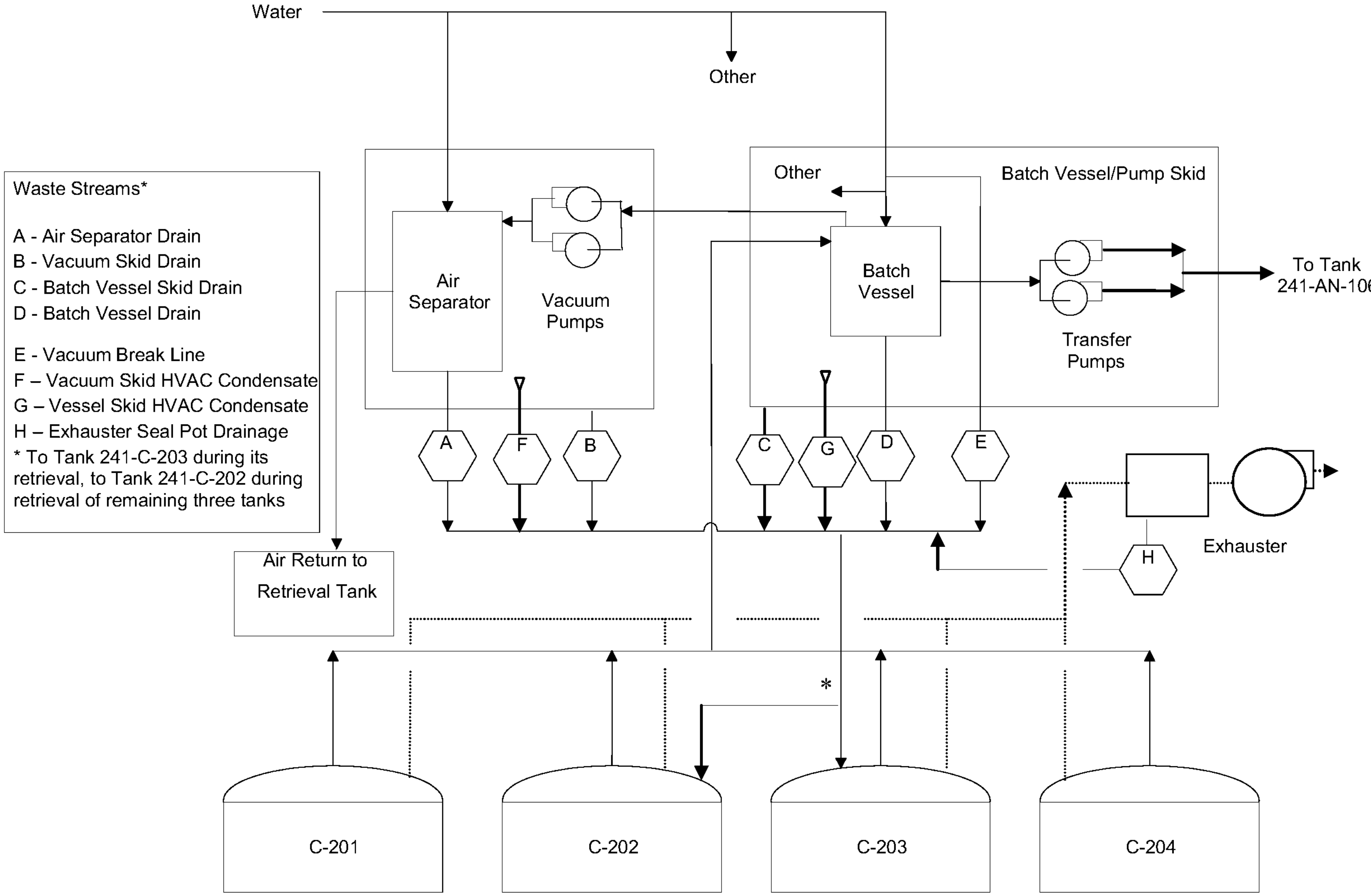
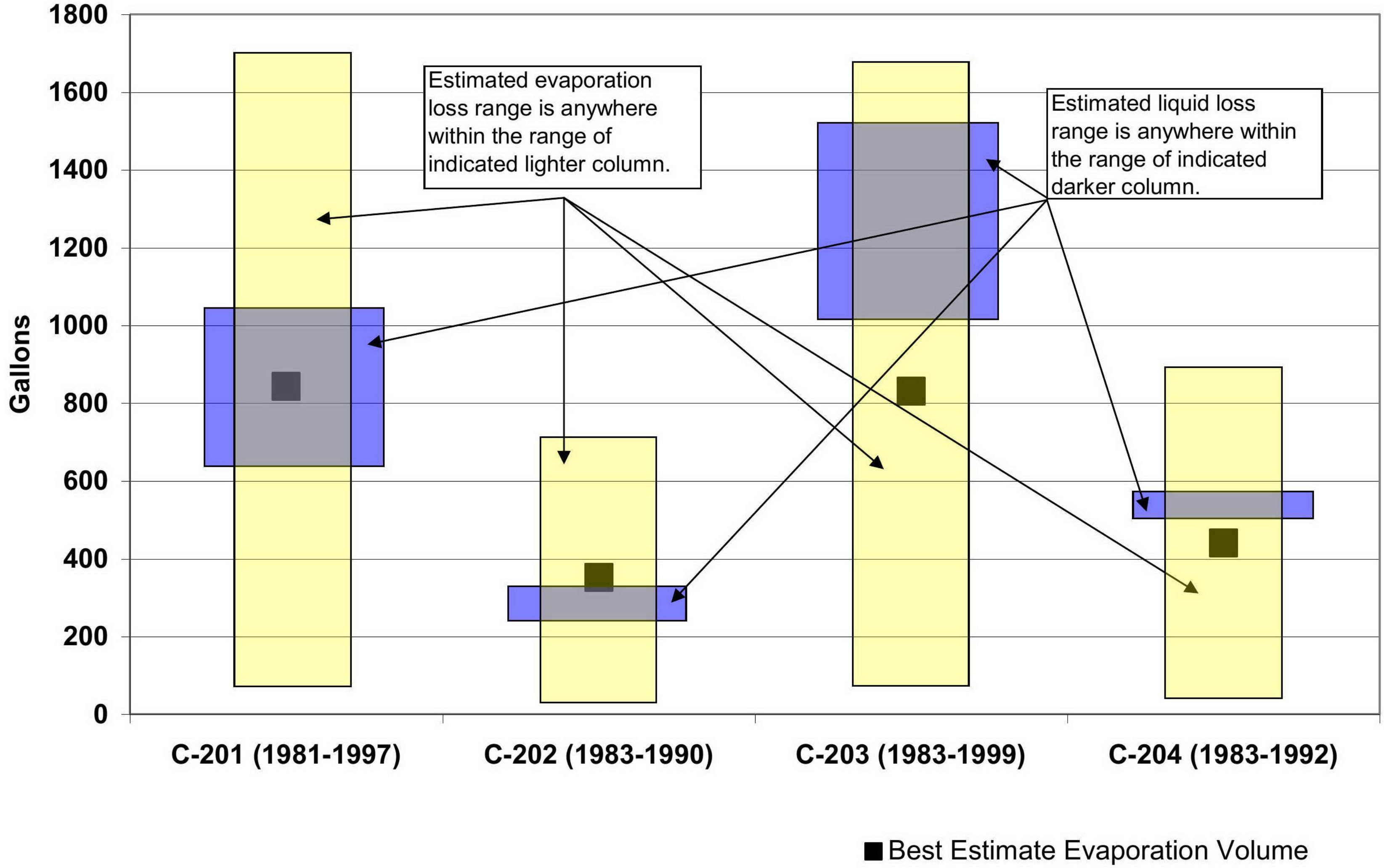


Figure 9: Comparison of Observed Volume Decreases in 241-C-200 Series Tanks With Estimated Evaporation Volume Ranges and Best Estimate of Evaporation Volume



MEETING SUMMARY

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: August 11, 2010
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Mike Barnes, ECOLOGY
Joe Caggiano, ECOLOGY
Les Fort, WRPS
Paul Henwood, S.M. Stoller
Bob Lober, ORP
Marc Wood, CHPRC

PURPOSE:
Review and assess the approach proposed by the SST Retrieval & Closure organization to compile evidence for a pending 241-C-101 leak evaluation based on spare inlet leak/release conceptual models in accordance with procedure TFC-ENG-CHEM-D-42.

Review of Previous Meeting Summary:
Previous meeting summaries were not available for review.

Tank 241-C-101 Leak Conceptual Model – spare inlets
Tank C-101 waste volume and other monitoring information was discussed. The information presented was part of various reports, including C-Farm Leak Assessment Report RPP-ENV-33418. The tank was classified as questionable integrity in 1969 based on a 4-inch liquid level decrease from 194.5 to 190.5 inches between approximately January 1968 and December 1969. Tank 101-C was reclassified as a Confirmed Leaker in 1980 after a leak assessment performed by four separate groups (RHO-CD-896). The review groups concluded that 17,000 to 24,000 gallons of waste had leaked from tank 241-C-101. The C-Farm Leak Assessment Report (RPP-ENV-33418) determined that 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 based on liquid level decreases. 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. 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.

Review of the basis for the 1980 Tank C-101 leak evaluation showed that the 4 inch waste level decrease was above the spare-inlet elevation of 191.5 inches. Drywell 30-01-09 is close to the spare inlets and could be detecting an overflow of waste from the tank. An informal working group composed of Technical Integration and Closure & Corrective Measures technical staff has been reviewing the possible outcomes of the tank C-101 leak assessment. They stated they have not found historical information that, by itself, could be used as a basis to change tank C-101 designated status to a sound tank. They looked at the tank contents and fission product inventory to see whether or not evaporation could account for the 36,000 gallon loss during the 1965 – 1969 time period, and determined that it can account for some, but not all of the loss. They identified locations for three direct pushes, and a possible soil sample push, that is hoped will provide the best chance for supporting a final decision on the tank's leak integrity status. They also suggested re-logging the existing drywells around the tank with the Spectral Gamma Logging System (SGLS) to update the soil contamination profile baseline. These drywells have not been logged since 1997.

These are described below.

1. Re-log drywells in the Vicinity of Tank C-101. Also through techniques such as ground penetrating radar – global positioning survey ground scans confirm location of at-grade and below-grade structures using global positioning and ground penetrating radar before commencing direct pushes.
2. Conduct a direct push near Drywell 30-01-09.
3. Conduct two additional Direct Pushes.
    a. near Drywell 30-01-06 between existing Drywell 30-01-06 and line 8107 from 241-CR-152-L8 connecting to V844 and 241-CR-151-L8 that lies south and east of the drywell, as close to the line as feasible. Complete radiation and moisture logs, and install an electrode string before resealing.
    b. between existing Drywell 30-01-06 and the East side of Tank C-101 where no drywells exist.

Response from the Closure and Corrective Measures organization to the three points stated above was as follows:

1. Logging drywells and the GPR/GPS scans are within the existing work scope of the organization. Stoller is currently logging in C farm.
2. The first direct push (near drywell 30-01-09) is in scope for FY11.
3. The other 2 direct push/log locations are not in the current baseline. These will require a Budget Change Request to add them, and perform them early next FY.

There was some discussion as to the charter of the group. This group is to assess the nature and extent of tank farm releases and to that end assess data gaps and/refine waste release data/information. The goal is to establish a waste contaminate release inventory. With that in mind the group recommended performing items 1, 2, and 3b. The group also recommended extending the re-logging scope of the drywells to incorporate moisture logging and that they be involved in the sampling and direct push planning efforts.

MEETING SUMMARY

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: November 2, 2010
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Mike Barnes, ECOLOGY
Joe Caggiano, ECOLOGY
Jim Field, WRPS
Les Fort, WRPS
Paul Henwood, S.M. Stoller
Bob Lober, ORP
Marcus, Wood, CHPRC

PURPOSE:
Review additional data for Tank C-101 and U Farm "Sound" Tanks

Review of Previous Meeting Summaries:
The meeting summary for October 19, 2010 was reviewed and approved with minor changes. Responses were provided to Ecology comments on the BY Farm leak inventory assessment report. Ecology will review the responses and provide feedback. Ecology also provided comments on the BX Farm leak inventory assessment report. WRPS will review the comments and provide responses.

Tank 241-C-101
On October 7, 2010 a meeting was held to discuss a recommendation to sluice tank 241-C-101 (C-101). The basis for the recommendation was the observation that the liquid surface level in tank C-101 appeared to be stable at 54 inches above the bottom center of the tank. Ecology concurred with a revision to RPP-22520, "*241-C-101 and 241-C105 Tanks Waste Retrieval Work Plan",* to accommodate modified sluicing of tank C-101 contingent upon the following:

a. Two direct push hole pairs will be installed near tank C-101. These holes will be logged and sampled as specified in the WMA-C work plan (RPP-PLAN-39114). One of the direct push holes will be positioned near tank C-101 spare inlets.

   Additional direct push holes will be drilled as needed for complete HRR coverage during retrieval. Gamma and neutron logging will be performed and an electrode string will be placed in these holes. The electrodes will be placed to an approximate depth of 80 ft, near the high moisture zone in this area. Additional pushes for sampling near the HRR system holes will be contingent on logging results and determined jointly by ORP and Ecology.

b. Tank C-101 liquid/waste level will be limited and maintained below ~54 inches in depth during all retrieval activities.

Pre-1975 strip chart logs for drywells near tank C-101 were reviewed and discussed. The strip charts were attached to a letter re. Rockwell International Study on Questionable Integrity Tank Analysis (TRAC-1308) released October 2010. The Questionable integrity study referring to the dry well data as being reviewed previously as part of C-101 leak evaluations, but the strip chart log data before 1975 was not available. The 1970 log data shows high total gamma activity (10^6 counts per second) starting at about 22 ft bgs in drywell 30-01-09 that decayed to 10,000 cps by 1979 and was at 1,000 pCi/g in 1987 SGLS data. This data supports earlier suppositions of a spare inlet overflow or a leak close to the elevation of the spare inlets. However, the data also shows a 1971 spike of ~50,000 cps between 30 and 45 ft, near the base of the tank at drywell 30-01-01. The spike at drywell 30-01-01 was not present in 1970 and decayed to ~100 cps by 1979. By 1979, less than 1 pCi/g ^{137}Cs and ~0.1 pCi/g Cobalt were observed.

It was concluded that the new data does not change the October 7, 2010 agreement that tank C-101 could be retrieved using modified sluicing contingent on the results of the additional direct push logging and maintaining a liquid level below 54 inches in the tank. However, the 1971 activity spike at drywell 30-01-01 raises additional questions and increases the importance of complete coverage during leak detection monitoring and of additional logging on the North/Northwest side of this tank. The group will re-evaluate tank C-101 and inventory the waste that has been released after the new data is obtained. This action will also support the final Tank Waste Retrieval Work Plan and recommendations for future integrity evaluations for tank C-101 per TFC-ENG-CHEM-D-42. The C Farm leak assessment report will be revised as necessary to incorporate new data and additional leak inventory evaluations.

U Farm "Sound" Tanks

Process information, liquid level measurements and drywell data was presented for U farm tanks currently designated as "sound" in HNF-EP-0182 (Tanks 241-U-101, -102, -103, -105, -106, -107, -108, -109, -111, -201,-202, -203 and -204). This information will be included in the U Farm assessment report. . Photographs indicate that some of these tanks were filled above the spare inlet level, many of the tanks were also on the flammable gas watch list and contained as much as 20% in retained gas. The gradual buildup and release of retained gas contributed to uncertainty in liquid level measurements. Drywell activity was attributed to other tanks or near surface releases. It was concluded that there is no evidence of a leak or release from any of these tanks and no further review is required.

It was noted that there are no drywells near the 200 series tanks. Additional drywells and/or direct push logging near these tanks is recommended in support of future U farm corrective actions and closure activities.

MEETING SUMMARY

washington river protection solutions

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: March 1, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:

Mike Barnes, ECOLOGY
Joe Caggiano; ECOLOGY
Jim Field; WRPS
Jordan Follett; WRPS
Les Fort, WRPS
Crystal Girardot; WRPS
Don Harlow, WRPS
Michelle Hendrickson, ECOLOGY
Paul Henwood, S.M. Stoller
Bob Lober, ORP
Pam McCann, ORP
Ted Venetz, WRPS
Dennis Washenfelder, WRPS
Marcus, Wood, CHPRC

PURPOSE:
The purpose of this meeting was to:
1) Discuss a communication strategy on how the leak assessment reports and revisions will be relayed to the tribes and stakeholders, specifically revisions and response to alternate C Farm leak inventory estimates;
2) Discuss the approach undertaken to assess C farm sound tanks and unplanned release estimates (Part 1);
3) Begin tank integrity waste leak location and cause assessments relative to tank 241-SX-108 (Part 2).

Review of Previous Meeting Summaries and Actions:
The meeting summary for February 1, 2011 was reviewed and approved.

- this week A disk containing the draft S Farm leak assessment report was given to Ecology for review.
- Michelle Hendrickson reported that the TPA Change Request to modify due dates of M-45-91F milestones status remains as "in progress."
- The final draft page from the pending revision of document RPP-32681 incorporating additional details to reflect tank leak location and cause workscope was distributed for final sanction. The revision will be released this week.

Part 1: Tank Farm Leak Inventory Assessments

C Farm Leak Loss Communications
Participants discussed the current strategy and stake holder involvement as described in RPP-23681. ORP communications is preparing a fact sheet describing the current tank farm leak assessment process. The focus of the discussion was on approaches to discuss the process with tribes and stakeholders. The timing to revisit C Farm was discussed relative to ongoing characterization efforts and the new information that lends itself to an update, of C farm inventory estimates. Participants agreed that it would be beneficial to discuss plans and approach to further assess C farm now, but estimates of releases in some locations (e.g. C-104 and C-101) should be deferred until the current slant push data underneath these tanks is available. An action was taken to look into when the C-104 and C-101 data will be available and if the data can be delivered and released in a timely manner to support assessments and a revised C Farm leak assessment report. Ecology also noted that issues with ^{99}Tc and ^{106}Ru laboratory interferences and implications to current soil analyses will need to be addressed. It was also noted that UPR-82 and UPR-86 release estimates should be reassessed based on direct push results to date.

C Farm Inventory Approach
An approach was presented, similar to the Nez Perce approach, fully considering the drywell data and visualizations in the Addendum to the C Tank Farm Report (GJO-98-39-TARA), but also considering different waste type compositions consistent with the data. One of the criticisms of the initial assessment and estimates in RPP-ENV-33418 was that they do not account for ^{60}Co releases. The current approach attempts to better quantify and account for these unplanned releases.

GJO-98-39-TARA estimated the total volume of contaminated soils and total activity based on spectral gamma and high rate logging drywell data for ^{137}Cs, ^{60}Co, and ^{154}Eu. Although these estimates are numerical interpretations, they help to understand the magnitude of the waste releases. Knowledge of different gamma contaminants in the soil, an idea of the type of waste released, and consideration of the maximum release that could occur based on soil water content allows for the consideration of alternative conceptual models to estimate a volume and mass of waste that may have been released. An example was presented and discussed. The approach and example will be described in the revised C farm assessment report.

Participants agreed that the approach presented should be pursued. Limitations of the approach and potential modifications will be discussed in the next meeting. While the approach results in greater release estimates, the estimates still do not explain measured ^{99}Tc in ground water wells; this will continue to be an issue and source of public criticism. The C farm work plan was designed largely to look for the ^{99}Tc plume source. ORP noted that investigations are continuing in C farm and investigation strategies will be modified, as needed, as additional information is obtained. A participant suggested sampling soils near the bottom of ^{60}Co plume visualizations shown in the addendum report. It was noted that this may be useful, but would be inconsistent with the location of boreholes where the highest ^{99}Tc was observed in ground water samples.

MEETING SUMMARY

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: March 16, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:

Mike Barnes, ECOLOGY
Joe Caggiano; ECOLOGY
Jim Field; WRPS
Les Fort, WRPS
Crystal Girardot; WRPS
Don Harlow, WRPS

Michelle Hendrickson, ECOLOGY
Paul Henwood, S.M. Stoller
Jeremy Johnson, ORP
Bob Lober, ORP
Ted Venetz, WRPS

PURPOSE:
The purpose of this meeting was to:
1) Continue discussing a new approach to assess C farm sound tanks and unplanned release estimates and assess releases near tanks 241-C-101 and 241-C-102 (Part 1);
2) Discuss tank leak location and cause of liner integrity issues at tank 241-SX-109 (Part 2).

Review Previous Meeting Summaries and Actions:
The meeting summary for March 1, 2011 was reviewed and approved.
Bob Lober discussed response to a Nez Perce letter regarding C farm contaminated soil inventory estimates and the leak loss process. Contents of the letter and initial responses were discussed on March 7, 2011 in a teleconference with the tribes. We will continue to provide leak loss assessment reports to the tribes for review and will brief the tribes quarterly on leak loss assessment results.

The 241-SX-107 final draft that will become part of the tank integrity report addressing leak locations and waste leak causes was distributed..

Part 1: Tank Farm Leak Inventory Assessments

C Farm Inventory Approach
Comments on the draft approach and write-up for C Farm were discussed. The following items will be included and discussed in the assessment report.

1. Waste process timelines for each of the tanks reviewed whether classified as sound or assumed leakers.
2. Clarify statements from Welty (SD-WM-TI-356) that drywells or tank liquid levels, "remained stable during the review period."
3. Further assess overfilled tanks and address conditions that may or may not have resulted in a release to the soil.
4. Ensure inventory reassessments address ^{60}Co plumes from SGLS data and visuals.
5. Discuss uncertainties in liquid level measurements presented and give examples as appropriate.
6. Be sure to decay radionuclide results presented to a common date.

Re-assessment of Tanks C-101 and C-102
Information was presented for tanks C-101 and C-102. This information will be incorporated in the revised C farm assessment. One suspect liquid level measurement suggests a change in the rate of decrease after the liquid level decreased below the spare inlet port in tank C-101. However, if this level is incorrect, there may be no change in slope. This would indicate that all of the liquid level decrease observed in the 1960s could be attributed to evaporation. Although other sources indicate that evaporation does not account for liquid losses in C Farm, these sources assume that the tank condensate condenser equipment was operating efficiently and condensate was routed back into the tank. There is evidence that condensate may have been released from the condenser pit to the surrounding tank area.

It was suggested that cladding waste may have been released through the cascade or spare inlet lines during the time that tank C-101 cascaded to tank C-102 in 1962. The tank was overfilled from 1965 to 1967 with waste from the CR vault. Based on the volume of the ^{60}Co plume and a 5% increase in moisture content, a leak volume of 7,000 gal was estimated. Based on the low gamma activity measured by SGLS in drywells, it was determined that the waste released was likely PUREX cladding waste and not P1 supernate (PSS),

An informal assessment of tank C-101 concluded that the tank probably did not leak, and if it did leak the release point would have been high on the tank wall (see November 2, 2010 meeting summary). A formal tank integrity assessment (TFC-ENG-CHEM-D-42) is planned after reviewing results of slant hole logging and sampling near tank C-101. Preliminary sample results are currently scheduled to be completed in July 2011.

Tank C-102 was then discussed. It was noted that the historical narrative and waste process time line for tank C-102 should include the waste transfer to tank C-102 from tank C-103 in the fourth quarter of 1962; this will be added. Although photographs indicate that tank C-102 was filled above the cascade line, there was no evidence that waste was released from the cascade line or spare inlets of this tank. The ^{60}Co plumes below tank C-102 were attributed to releases from tanks C-104 and/or C-105 to be discussed in the next meeting. There is no external evidence of waste releases from tank C-102.

MEETING SUMMARY

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: March 23, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:

Mike Barnes, ECOLOGY
Joe Caggiano; ECOLOGY
Jim Field; WRPS
Les Fort, WRPS
Paul Henwood, S.M. Stoller
Beth, Rochette, ECOLOGY

PURPOSE:
The purpose of this meeting was to assess releases near tanks 241-C-103, -104 and -105

Review Previous Meeting Summaries and Actions:
Part 1 of the meeting summary for March 16, 2011 was reviewed and approved with comments. It was suggested that the revised approach to estimate releases from or near C Farm sound tanks should not only "address ^{60}Co plumes and visuals" in the farm but also beyond the farm and should discuss potential sources of the plumes and potential waste types. It was also noted that where historical waste type estimates in the HDW model are inconsistent with sample data or process information (e.g. compositions presented in HW-7133, "Process Engineering Cesium Load Out Facility at the 241-C Tank Farm"), the sample data or process information will be used to estimate inventories. This is consistent with the BBI for waste in tanks.

Discrepancies in transfer dates and volumes and waste types were noted in different sources. It is assumed that monthly, weekly and daily process results and historical documentation are more reliable than quarterly transfer summaries and are used preferentially to estimate the inventory of waste releases. For a tank assumed to have leaked, a transfer table with references to process reports is included in the assessment reports. It was also noted that for some tanks, photographs indicate liquid levels were higher than indicated by quarterly or monthly process measurements.

Tank C-103 Assessment
Information presented for tank C-103 will be incorporated in the revised C farm assessment report. Liquid level measurements indicate that tank C-103 was filled above the cascade line between 1953 and 1956 and in 1961; and waste could have leaked from the cascade line (however, drywell data do not indicate that a release occurred). The ^{137}Cs activity (less than 100 pCi/g) in drywells around this tank was attributed to surface spills, indicated by the elevation of

the measurements. The ^{60}Co activity observed from 78 to 125 ft in drywells around tank C-103 was attributed to releases from or near Tanks C-104 or C-105.

Tank C-104 Assessment

Information presented for tank C-104 will be incorporated in the revised C farm assessment report. Liquid level measurements indicate that tank C-104 was filled above the cascade line from the first quarter of 1965 to the first quarter of 1966. A sudden decrease in the liquid level was observed in 1966 after installing a new electrode that put into question the previous liquid level increase as being uncertain. However, a large ^{60}Co plume between tanks C-104 and C-105 appears to originate near the cascade line connecting these two tanks; indicating a potential cascade line leak. Based on the size of the cobalt plume and assuming a 5% moisture increase in the wetted area the volume of waste released was assumed to be 23,000 gallons or less. It is assumed the waste released was cladding waste; the waste type in the tank when it was overfilled in 1965. Also, waste received in the second quarter of 1962 was Cs depleted waste from the 801 building ion exchange process. Significantly greater ^{137}Cs activity would be expected if the waste released was PUREX High Level supernate (P1). The composition of PUREX cladding waste (HDW rev. 5) should be used to estimate inventories for other constituents in the waste. This plume estimate is attributed to releases near tank C-104 or C-105 or both.

Tank C-105 Assessment

An update of C-105 assessments was discussed. Since the initial C Farm assessment report was written, additional data was collected in support of an integrity assessment for tank C-105 (RPP-ASMT-46452, *Tank 241-C-105 Leak Assessment Report*). Based on drywell logging results, the integrity assessment panel concluded that the inlet cascade line to C-105 leaked and the tank may have leaked. The leak estimate of < 2,000 gal of PUREX Supernate appears reasonable for the activity observed in drywell 30-05-07. Other releases from the C-105 spare inlet port and transfer line leaks near C-105 were assumed to be intermingled with the plume stemming from C-104, but other explanations are possible.

MEETING SUMMARY

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: April 5, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:
- Mike Barnes, ECOLOGY
- Joe Caggiano; ECOLOGY
- Jim Field; WRPS
- Les Fort, WRPS
- Crystal Girardot; WRPS
- Paul Henwood, S.M. Stoller
- Jeremy Johnson, ORP
- Jeff Lyon, ECOLOGY
- Beth Rochette, ECOLOGY
- Dennis Washenfelder, WRPS
- Marc Wood, CHPRC

PURPOSE:
The purpose of this meeting was to assess tanks 241-C-106, C-107, and C-108.

Review Previous Meeting Summaries and Actions:
The meeting summaries for March 16 and March 23, 2011, were reviewed and approved (with comments) by the team. Ecology requested that the reassessment discussion on the C-200 series tanks be moved forward to the next meeting and that near surface releases (including unplanned releases) be reassessed and discussed during a future meeting.

Tanks C-106 and C-107 Assessments
Information presented on tanks C-106 and C-107 during the meeting will be incorporated in the revised C farm assessment report. Liquid level measurements show that both tanks were filled above the cascade line and spare inlet ports. Liquid level decreases in tank C-106 were attributed to the high heat waste content and evaporation of cooling water. Retrieval assessments (RHO-RE-EV-97) showed the need to continue adding cooling water to tank C-106, but determined that additional water was not needed for tank C-105. Water additions provide a potential driving force for contaminants if the water is released to the soil. There were no occurrence reports for liquid level decreases for tank C-107. Drywell SGLS readings around tanks C-106 and C-107 indicate less than 100 pCi/g of near surface ^{137}Cs. Drywells near tank C-106 show deep ^{60}Co activity attributed to releases from or near tank C-108. There was no

indication of leaks from cascade lines, spare inlet ports, or from the liner for these tanks; nor a basis to quantify the measured low activity attributed to surface releases.

Tank C-108 Assessment

Information presented for tank C-108 will also be incorporated in the revised C farm assessment report. Temperature data were presented from 1989 to the present. Earlier data will be included in the assessment report or a statement that earlier data were not available. Liquid level measurements indicate that tank C-108 was filled well above the cascade line (to 568 kgal) with CW-HS waste in 1965. A liquid level decrease (0.5 inches) in 1976 was attributed to a shift in the surface solids. Other liquid level decreases may have been masked during cascade overflows and transfers. At drywell 30-08-02, close to the cascade line connected to tank C-109, a narrow ^{137}Cs and ^{154}Eu spike was observed at about 20-22 ft bgs. Drywell 30-08-02 also shows ^{60}Co activity from 46 to 80 ft. Similar ^{60}Co activity was found in other nearby drywells. It was suggested that the narrow peak of ^{137}Cs and ^{154}Eu probably indicated residual waste in the cascade line. The activity may also be migration from a known surface leak near tank C-108. The apparent lateral migration indicated by pulsing readings, a vertical gap of 25-30 ft between the ^{137}Cs spike and ^{60}Co activity, and the observation that the spike is probably from pipeline residuals all indicate the ^{60}Co likely migrated from a different source than the observed ^{137}Cs/^{154}Eu spike measured in Drywell 30-08-02. Based on activity in surrounding drywells a release volume of 18,000 gallons was estimated. Given the ^{137}Cs activity in the drywells, it was postulated that hot semi works waste was released during the time that the tank was overfilled in 1965. Explanations and inventory calculations discussed will be included in the assessment report.

MEETING SUMMARY

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: April 19, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:

Mike Barnes, ECOLOGY
Joe Caggiano; ECOLOGY
Susan Eberlein, WRPS
Jim Field; WRPS
Jordan Follett, WRPS
Les Fort, WRPS
Crystal Girardot; WRPS

Don Harlow, WRPS
Michelle Hendrickson, ECOLOGY
Paul Henwood, S.M. Stoller
Jeremy Johnson, ORP
Bob Lober, ORP
Jeff Lyon, ECOLOGY
Dennis Washenfelder, WRPS
Marcus Wood, CHPRC

PURPOSE:
The purpose of this meeting was to:

1) Discuss response to Nez Perce letter regarding C-104/C-105 leak volume assessment estimates and discuss rationale for direct pushes near C-200 series tanks and recommended work plan revisions. (Part 1);
2) Discuss tank leak location and cause of liner integrity issues at tank 241-SX-112 (Part 2).

Review Previous Meeting Summaries and Actions:
The meeting summary for April 5, 2011, was reviewed and approved (with comments). Actions from the previous meeting were completed and Michelle Hendrickson noted that the TPA Change Package to modify due dates for M-045-91F milestones was completed and sent for review.

Part 1. Tank Farm Leak Inventory Assessments

Review of Nez Perce email: C-104/C-105 cascade line leak

A draft response to the email was presented and reviewed. Three key comments were:

- Due to uncertainty as to when preliminary ^{99}Tc and nitrate laboratory analyses of the tank C-101 direct push samples will be reported it was suggested that the response letter exclude a date for the next revision of the C tank farm leak assessment report. These and other new C farm direct push and SGE results obtained since completing RPP-ENV-33418 Rev. 0 will be discussed and incorporated in the revised reports.
- Further clarification was needed regarding the assessment rating value of 0.42. Need to clarify that this is not a probability, but a review team confidence indicator.
- Delete the discussion on the primary focus of the leak assessments.

As indicated in the proposed response, a C farm reassessment approach and initial results will be presented and discussed during the next WMA C PA working session (May). Prior to release, a briefing on revisions to the C farm leak assessment report (RPP-ENV-33418) will be provided to the tribal nations for review and comment.
Results from the leak assessment report will be incorporated in the WMA C RCRA Facility Investigation Report.

Rationale for direct pushes near C-200 series tanks
The August 3, 2010 meeting summary for the C-200 series tanks assessment was addressed. This assessment concluded that although three of four 200 series tanks were overfilled the liquid level remained steady in those tanks, evaporation accounted for liquid level decreases and the C-200 series tanks were probably not the source of uranium and cyanide detected in samples from well 299-E27-7.

It was recognized that some direct pushes are still needed near the C-200 tanks, but fewer than currently planned. It was recommended that the focus of pushes near the C-200 tanks should be directed toward SGE investigations, investigations into potential leaking pipelines near the C-200 tanks and the source of uranium and cyanide at 299-E27-7. The direct pushes should be planned to optimize SGE investigations. Other locations, such as near tank C-105, that may benefit from direct push logging and samples were discussed. These and other alternatives will be further discussed in future WMA C work planning meetings.

ECOLOGY (Jeff Lyon) concurred with these recommendations.

MEETING SUMMARY

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: May 3, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:

Mike Barnes, ECOLOGY
Joe Caggiano; ECOLOGY
Jim Field; WRPS
Jordan, Follett, WRPS
Crystal Girardot; WRPS

Don Harlow, WRPS
Michelle Hendrickson, ECOLOGY
Paul Henwood, S.M. Stoller
Jeremy Johnson, ORP

PURPOSE:
The purpose of this meeting was to:
1) Assess releases near tanks 241-C-109, -C-110, -C-111 and –C-112 (Part 1);
2) Discuss tank leak location and cause of liner integrity issues at tank 241-SX-113 (Part 2).

Review Previous Meeting Summaries and Actions:
The meeting summary for April 19, 2011 was reviewed and approved with comments. An action was taken to investigate if the uranium found in samples from groundwater well 299-E27-7 was depleted uranium to further assess the source. It was noted that cyanide was also detected in groundwater samples and ^{60}Co was detected in vadose zone geophysical logs.

Part 1: Tank Farm Leak Inventory Assessments

Re-assessment of Tanks 241-C-109, 110, 111 and 112
Information presented for tanks 241-C-109. 110, 111 and 112 will be incorporated in the revised C Farm assessment. There was no indication of a loss of liner integrity for any of these tanks. Drywell activity near tank C-109 was attributed to migration from C-108 cascade line releases.

There was no change in previous release estimates for tanks C-110 and C-111. Since the previous tank farm leak assessment a formal integrity assessment was performed for these tanks (RPP-ASMT-38219 and RPP-ASMT-39155). The assessment concluded that both tanks were "sound" (the integrity classification of a waste storage tank for which surveillance data indicate no loss of liquid attributed to a breach of integrity). Activity near tank C-110 in dry well 30-10-09 was likely from spare inlet overflows with an estimated release of less than 2,000 gal of evaporator bottoms – ion exchange (EB-IX) waste. Liquid level decreases in tank C-111, previously ascribed to a tank leak, can be explained by water evaporating from the waste. There was no evidence of a release near tank C-111.

Activity in drywells 30-12-01 and 30-12-13 was attributed to a transfer line release between the 252-C diversion box and tank C-112 and/or a salt-well pump pit release. The estimated size of the release was 7,000 gal based on an assumed distribution of the waste released, derived from measured increases in soil water content through direct push sampling and assessments and an assumed waste mix of cladding waste and ion exchange waste. Calculations and discussion of this leak estimate and waste composition will be included in the assessment report.

Comments received on the information presented and assessment observations will be included in the revised assessment report.

MEETING SUMMARY

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: May 31, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:

Mike Barnes, ECOLOGY
Jim Field; WRPS
Jordan, Follett, WRPS
Les Fort, WRPS
Crystal Girardot; WRPS

Don Harlow, WRPS
Michelle Hendrickson, ECOLOGY
Paul Henwood, S.M. Stoller
Jeremy Johnson, ORP
Dennis Washenfelder, WRPS

PURPOSE:
The purpose of this meeting was to:
1) Assess near surface releases and Unplanned Releases (UPRs) in C Farm (Part 1);
2) Discuss tank leak location and cause of liner integrity issues at tank 241-SX-114 (Part 2).

Review Previous Meeting Summaries and Actions:
The meeting summary for May 3 was reviewed and approved with comments.

The draft leak assessment report for B Farm was distributed for review with a disk copy provided to Ecology at the meeting. Comments were requested by June 17.

Uranium data from groundwater well 299-E27-7 was reviewed. Only total uranium groundwater analyses were performed, so it could not be determined whether uranium in the groundwater is depleted. Geophysical logs show ^{235}U and ^{238}U in the vadose zone at concentrations of about 2 and 20 pCi/g, respectively. However, at the low concentrations measured, differences are within the margin of uncertainty. Consequently, it cannot be determined from the available data whether the uranium in the vadose zone is depleted.

As discussed in the April 19 meeting, transfer lines from the C farm 200 series tanks appear to be the most likely source for uranium and cyanide in well 299-E27-7.. Other potential sources discussed were tank leaks, overflows through spare inlets, discharges to French drains, and UPRs north of the well.

Re-assessment of C Farm UPRs and Near Surface Releases

Information and conclusions from the previous C Farm leak assessment report (RPP-ENV-33418, Rev. 1) were reviewed and new data acquired since the release of the report presented. Information presented will be included in Revision 2 of the assessment report. The new data discussed included 3D SGE analyses near UPRs 200-E-81, 200-E-82 and 200-E-86 and direct push logging and samples; ^{99}Tc and NO_3 direct push sample results were discussed.

The new data support the previous assessment results and inventory estimates for UPR 81 and UPR-82. The SGE data indicate resistivity anomalies are deep near UPR-86 and direct push holes and samples may have been too shallow. The results also suggest that the 17,385 gallon release volume for UPR-86 documented in the Maxfield report (RHO-CD-673) may be high. The volume estimate is based on an evaluation of AR vault processing and transfer information, but references cited in the Maxfield report could not be located. It is possible that once measured high gamma activity was entirely covered by the shotcrete cap and the investigative direct push holes did not get close enough.

The Nez Perce suggested that based on the coordinates in the Maxfield report the shotcrete cap, direct pushes, and SGE may be in the wrong location. The location for direct push samples was carefully reviewed against tank farm drawings and drawings in the Maxfield report. The Maxfield location coordinates are listed as approximate and it was determined that the pipeline leak was near a bend in the pipe and near the location where a bypass line was installed and the old line was cut and capped. The shotcrete CAP is located at these locations. The assessment team concurred that the shotcrete cap, SGE and direct push samples were probably in the right place. It was also noted that 3D SGE surveys cover the current assumed location and Maxfield coordinates. The SGE results will be completed in July and will be discussed in the re-assessment report.

Past near surface release estimates were also reviewed. A surface radiation map for C farm will be included in the revised report. Surface radiation areas will be correlated with other sample and logging data. Near surface direct push results will also be considered to refine inventory estimates and better estimate waste types and constituents for surface releases.

MEETING SUMMARY

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: June 14, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:

Mike Barnes, ECOLOGY
Joe Caggiano, ECOLOGY
Jim Field; WRPS
Andrea Fillafer, WRPS Intern
Les Fort, WRPS
Crystal Girardot; WRPS
Don Harlow, WRPS
Andrea Hopkins, WRPS
Michelle Hendrickson, ECOLOGY Brendan Hedel, WRPS Intern
Paul Henwood, S.M. Stoller
Jeremy Johnson, ORP
Natalie Kirch, WRPS Intern
Jeff Lyon, ECOLOGY
Megan Sax, WRPS Intern

PURPOSE:
The purpose of this meeting was to revisit tank C-111 liquid level information and the need for the planned direct push at Site V and begin TX Farm tank leak inventory assessment. (Part 1);

Review Previous Meeting Summaries and Actions:
The meeting summary for May 31 was reviewed and approved with comments.

C-111 liquid level information and the need for the planned direct push at Site V
Information and conclusions from the C Farm leak assessment report (RPP-ENV-33418, Rev. 1) were reviewed. The assessment concluded that, "Evaporation calculations and plotted liquid level and evaporation rates clearly indicated that the liquid-level decrease can be attributed to evaporation and suggests that high tank waste temperature information was apparently not available for previous assessments. The assessment team believed that the data supports the potential to reclassify tank C-111 as sound and recommended that it be reassessed per TFC-ENG-CHEM-D-42.

The tank classification for C-111 was reassessed per TFC-ENG-CHEM-D-42 in 2008 and the assessment team concluded that, "The combined effects of evaporation and thermal waste contraction caused the observed 8.5 in surface level decrease in tank C-111 during the 1965 – 1969 period" and recommended that the integrity status of tank C-111 be changed from "Assumed Leaker" to "Sound" (RPP-ASMT-39155).

Given the information presented, Ecology concurred that a push near tank C-111 (Site V) is not needed to further assess whether the tank leaked or overflowed. Alternate push locations will be considered through the WMA C work planning process.

MEETING SUMMARY

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: September 27, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:

Joe Caggiano, ECOLOGY
Jim Field; WRPS
Les Fort, WRPS
Crystal Girardot, URS/WRPS
Don Harlow, SC101/WRPS

Paul Henwood, S.M. Stoller
Andrea Hopkins, WRPS
Chelsea Rosenkrance, WRPS
Dennis Washenfelder, WRPS
Marc Wood, CHPRC

PURPOSE:
The purpose of this meeting was to discuss further the reassessment of waste releases from Tanks C-101 and C-104

Review Previous Meeting Summaries and Actions:
The September 13 meeting summary was reviewed and approved by those in attendance.

Revised Inventory Estimates for tanks 241-C-101 and 241-C-104
Additional information for tanks C-101 and C-104 was presented and discussed by the assessment team. It was proposed that the new information and inventory estimates be incorporated into the reassessment report. All participants concurred with the new estimates.

Tank C-108 releases and drywell data were also discussed. It was noted that while ^{60}Co was observed near other tanks. The base of tank C-108 is one place in C Farm that ^{60}Co is still moving. Several possibilities for this movement were discussed.

MEETING SUMMARY

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: November 2, 2010
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Mike Barnes, ECOLOGY
Joe Caggiano, ECOLOGY
Jim Field, WRPS
Les Fort, WRPS
Paul Henwood, S.M. Stoller
Bob Lober, ORP
Marcus, Wood, CHPRC

PURPOSE:
Review additional data for Tank C-101 and U Farm "Sound" Tanks

Review of Previous Meeting Summaries:
The meeting summary for October 19, 2010 was reviewed and approved with minor changes. Responses were provided to Ecology comments on the BY Farm leak inventory assessment report. Ecology will review the responses and provide feedback. Ecology also provided comments on the BX Farm leak inventory assessment report. WRPS will review the comments and provide responses.

Tank 241-C-101
On October 7, 2010 a meeting was held to discuss a recommendation to sluice tank 241-C-101 (C-101). The basis for the recommendation was the observation that the liquid surface level in tank C-101 appeared to be stable at 54 inches above the bottom center of the tank. Ecology concurred with a revision to RPP-22520, "*241-C-101 and 241-C105 Tanks Waste Retrieval Work Plan",* to accommodate modified sluicing of tank C-101 contingent upon the following:

a. Two direct push hole pairs will be installed near tank C-101. These holes will be logged and sampled as specified in the WMA-C work plan (RPP-PLAN-39114). One of the direct push holes will be positioned near tank C-101 spare inlets.

Additional direct push holes will be drilled as needed for complete HRR coverage during retrieval. Gamma and neutron logging will be performed and an electrode string will be placed in these holes. The electrodes will be placed to an approximate depth of 80 ft, near the high moisture zone in this area. Additional pushes for sampling near the HRR system holes will be contingent on logging results and determined jointly by ORP and Ecology.

b. Tank C-101 liquid/waste level will be limited and maintained below ~54 inches in depth during all retrieval activities.

Pre-1975 strip chart logs for drywells near tank C-101 were reviewed and discussed. The strip charts were attached to a letter re. Rockwell International Study on Questionable Integrity Tank Analysis (TRAC-1308) released October 2010. The Questionable integrity study referring to the dry well data as being reviewed previously as part of C-101 leak evaluations, but the strip chart log data before 1975 was not available. The 1970 log data shows high total gamma activity (10^6 counts per second) starting at about 22 ft bgs in drywell 30-01-09 that decayed to 10,000 cps by 1979 and was at 1,000 pCi/g in 1987 SGLS data. This data supports earlier suppositions of a spare inlet overflow or a leak close to the elevation of the spare inlets. However, the data also shows a 1971 spike of ~50,000 cps between 30 and 45 ft, near the base of the tank at drywell 30-01-01. The spike at drywell 30-01-01 was not present in 1970 and decayed to ~100 cps by 1979. By 1979, less than 1 pCi/g ^{137}Cs and ~0.1 pCi/g Cobalt were observed.

It was concluded that the new data does not change the October 7, 2010 agreement that tank C-101 could be retrieved using modified sluicing contingent on the results of the additional direct push logging and maintaining a liquid level below 54 inches in the tank. However, the 1971 activity spike at drywell 30-01-01 raises additional questions and increases the importance of complete coverage during leak detection monitoring and of additional logging on the North/Northwest side of this tank. The group will re-evaluate tank C-101 and inventory the waste that has been released after the new data is obtained. This action will also support the final Tank Waste Retrieval Work Plan and recommendations for future integrity evaluations for tank C-101 per TFC-ENG-CHEM-D-42. The C Farm leak assessment report will be revised as necessary to incorporate new data and additional leak inventory evaluations.

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APPENDIX B

241-C TANK FARM INFORMATION SUMMARIES: TANKS ASSUMED TO HAVE LEAKED

TABLE OF CONTENTS

B1.0 TANK 241-C-101

This section provides information on the historical waste loss event associated with tank 241-C-101 (C-101). Waste operations for tank C-101 are summarized in Figure B1-1.

B1.1 TANK 241-C-101 WASTE HISTORY

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

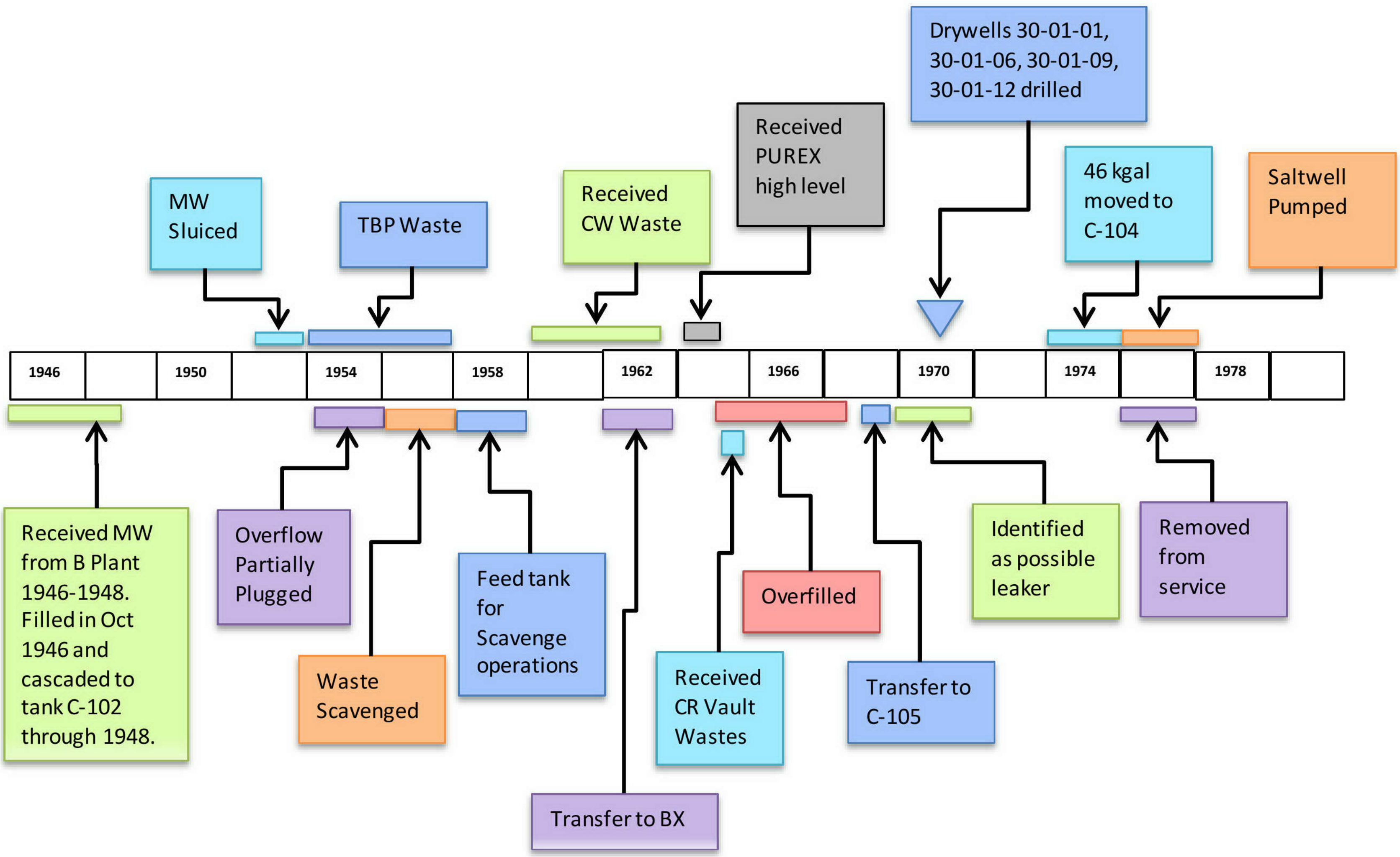
Tank C-101 began receiving metal waste (MW) from the 221-B Plant bismuth phosphate process in March 1946. In May 1946, the tank was declared full and began cascading waste to tank C-102. Tank C-102 was filled with MW in August 1946 and MW supernate cascaded to tank C-103. The cascade of tanks C-101,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

The MW sat undisturbed in tank 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 supernate and sludge were removed from tank C-101 from the fourth quarter 1952 through May 14, 1953. Metal waste removal from tanks C-102 and C-103 was also conducted during this period. These tanks were inspected and deemed fit for re-use to store additional waste.

Tank C-101 received Tri-Butyl Phosphate (TBP) Plant waste intermittently from 221-U Plant[2] beginning on May 15, 1953 (HW-28377, *Separations Section Waste – Status Summary May 31, 1953*, p. 4). During August 1953, tank C-101 was filled with TBP Plant waste and supernate was cascaded to tank C-102. Tri-Butyl Phosphate Plant supernatant waste was pumped from tank C-101 to tank C-103 in September 1953. The reason why waste was not cascaded from tank C-101 to C-102 and then to C-103 is not provided in the monthly tank farm reports. The cascade overflow line from tank C-101 to tank C-102 may have been plugged. The cascade overflow line to tank C-102 is first noted in the tank farm monthly reports as being partially plugged in June 1954 (HW-32389, *Separations Section Waste – Status Summary, Planning and Scheduling Separations – Operations, June 30, 1954*, page 4). All three tanks were noted as being filled with TBP Plant waste in October 1953.

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

Figure B1-1. Tank 241-C-101 Waste Operations Summary



CW = cladding waste, aluminum clad fuel   CWP = Plutonium Uranium Extraction CW   MW = metal waste   TBP = Tri-Butyl Phosphate (plant)

In December 1955, TBP Plant supernatant waste was transferred from tank C-101 to the 244-CR Vault for precipitation of cesium and strontium using ferrocyanide (so-called In Farm scavenging)[3]. The TBP Plant waste along with the ferrocyanide (FeCN) precipitate was discharged to tank 241-C-109 (C-109) for settling of the precipitate, with the supernate then transferred to 216-BC-4 crib (HW-44784, page 20). Tank C-101 was then refilled (total waste volume 485,000 gal) with TBP Plant supernate from tank 241-C-104 (C-104) in January 1956.

In September and October 1956, 354,000 gal of TBP Plant supernate were transferred from tank C-101 to 244-CR Vault (see Table B1-1) for In Farm scavenging, leaving ~131,000 gal of waste in tank C-101. The TBP Plant waste along with the FeCN precipitate was discharged to tank 241-C-112 (C-112) for settling of the precipitate, with the supernate then transferred to 216-BC-10 crib (HW-48518, *Radioactive Contamination in Liquid Wastes Discharged to Ground at Separations Facilities Through December 1956*, p. 19). The volume of waste in tank C-101 was later revised to 98,000 gal in February 1957 as a result of a new waste surface electrode measurement.

Tank 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 C-101 received TBP Plant supernate and 242-B Evaporator bottoms wastes from the tanks listed in Table B1-1. The scavenged waste was transferred to tanks 241-C-108 (C-108), C-109, 241-C-111 (C-111) and C-112 for settling of the FeCN precipitate before discharge to the 216-BC trenches.

Table B1-1. Tri-Butyl Phosphate Plant Supernate and 242-B Evaporator Bottoms Transferred to Tank 241-C-101

Tank	Volume, gal	Date	Reference
241-BY-101	455,000	June 1957	HW-51348, *Chemical Processing Department Waste Status Summary June 1, 1957 – June 30, 1957 Planning and Scheduling – Production Operation*, p . 5
241-BY-102	717,000	June 1957	
241-BY-101	227,000	July 1957	HW-83906 C RD, *Chemical Processing Department 200 West Area Tank Farm Inventory and Waste Reports January 1957 Through December 1958*, p . 64
241-BY-103	551,000	July 1957	
241-BY-103	162,000	August 1957	HW-83906 C RD, p. 72
241-B-101	228,000	August 1957	HW-83906 C RD, p. 72
241-B-102	424,000	August 1957	HW-83906 C RD, p. 72
241-B-103	297,000	August 1957	HW-83906 C RD, p. 72
241-B-107	265,000	September 1957	HW-83906 C RD, p. 80
241-B-108	399,000	September 1957	HW-83906 C RD, p. 80
241-B-109	403,000	September 1957	HW-83906 C RD, p. 80

[3] 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.

Table B1-1. Tri-Butyl Phosphate Plant Supernate and 242-B Evaporator Bottoms Transferred to Tank 241-C-101

Tank	Volume, gal	Date	Reference
241-B-106	379,000	October 1957	HW-83906 C RD, p. 88
241-B-112	495,000	October 1957	HW-83906 C RD, p. 88
241-BX-110	88,000	October 1957	HW-83906 C RD, p. 88
241-BX-110	113,000	November 1957	HW-83906 C RD, p. 97
241-BX-111	511,000	November 1957	HW-83906 C RD, p. 97
241-BX-108	484,000	November 1957	HW-83906 C RD, p. 97
241-BX-109	243,000	December 1957	HW-83906 C RD, p. 104

Tank C-101 contained ~98,000 gal of sludge and ~27,000 gal of supernate 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, *Chemical Processing Department Waste Status Summary, December 1, 1960 – December 31, 1960*, p. 4) and intermittently until 1962, tank C-101 received plutonium-uranium extraction (PUREX) process cladding removal waste (CW) from the PUREX Plant. During 1962, tank C-101 was filled and further additions of PUREX CW led to the cascade of supernate to tanks C-102 and C-103. The PUREX CW was subsequently transferred from tanks C-102 and C-103 to tanks 241-BX-101 and 241-BX-102. Tank C-101 stopped receiving PUREX CW in June 1962 (HW-74647, *Chemical Processing Department Waste Status Summary January 1, 1962 Through June 30, 1962*). The PUREX coating removal waste was transferred to tank 241-B-107 in the fourth quarter of 1963, leaving ~94,000 gal of sludge in tank C-101.

In the fourth quarter of 1963, tank C-101 received 276,000 gal of PUREX high-level waste supernate (PSN) from tank 241-A-102 (A-102) in order to prepare tank A-102 for use in sluicing sludge from tank 241-A-103 (A-103) (HW-80379, *Chemical Processing Department Waste Status Summary, July 1, 1963 through December 31, 1963*, p. 4). Tank C-101 also received 172,000 gal of PSN from tank A-103 in the first quarter of 1964 (HW-83308, *Chemical Processing Department Waste Status Summary January 1, 1964 Through June 30, 1964*, p. 4), bringing the total waste volume to 546,000 gal, which is above the cascade overflow level. In the second quarter of 1965, tank C-101 is reported to have received 28,000 gal of waste from 244-CR Vault and the tank liquid level was reported as 574,000 gal (RL-SEP-659, *Chemical Processing Department Waste Status Summary January 1, 1965 through June 30, 1965*, p. 4), which exceeds the nominal operating capacity of 530,000 gal and the cascade overflow level. However, there is no record that waste cascaded from tank C-101 into tank C-102 during this timeframe.

No additional transfers of waste into or waste removals from tank C-101 are reported until the fourth quarter of 1969. Table B1-2 summarizes the waste level in tank C-101 for 1963 through 1970. During the period between January 1965 and September 1969, the liquid level decreased in tank C-101 from 574,000 to 538,000 gal, a decrease of 36,000 gal. No records could be located indicating the basis for the decrease in tank C-101 liquid level. In the fourth quarter of

1969, the supernate in tank C-101 was transferred to tank 241-C-105 (C-105) and then to B Plant for processing through the cesium ion exchange system. The pumpable liquid was removed from tank C-101 in 1969, leaving ~47,000 gal of supernate (~17 in.) covering 87,000 gal (~40.7 in.) of sludge. The liquid level continued to decrease from 1970 through 1974.

Table B1-2. Tank 241-C-101 Waste Inventory 1963 to 1970

Period	Tank 241-C-101 Waste Volume (Kgal)	Comments	Document Number (full titles in Section B7.0 REFERENCES
01/01/63 – 6/30/63	524	Tank contains a mixture of PUREX coating removal waste and TBP Plant waste. Tank contains 109,000 gal of sludge.	HW-78279, p. 4
07/1/63 – 12/31/63	370	Transferred 430,000 gal of supernate out of tank 241-C-101 to 241-B-107. Tank 241-C-101 received 276,000 gal of PUREX HLW from tank 241-A-102. Tank contains 109,000 gal of sludge.	HW-80379, p. 4
01/01/64 – 06/30/64	542	Tank 241-C-101 received 172,000 gal of PUREX HLW from tank 241-A-103.	HW-83308, p. 4
07/01/64 – 12/31/65	546	New electrode (reading confirmed)	RL-SEP-260, p. 4
01/01/65 – 06/30/65	574	Received 28,000 gal of waste from 244-CR Vault	RL-SEP-659, p. 4
07/01/65 – 09/30/65	568		RL-SEP-821, p. 4
10/01/65 – 12/31/65	565		RL-SEP-923, p. 4
01/01/66 – 03/31/66	563		ISO-226, p. 4
04/01/66 – 06/30/66	571	New electrode reading	ISO-404, p. 4
07/01/66 – 09/30/66	565		ISO-538, p. 4
10/01/66 – 12/31/66	563		ISO-674, p. 4
01/01/67 – 03/31/67	557		ISO-806, p. 4
04/01/67 – 06/30/67	555		ISO-967, p. 4
07/01/67 – 09/30/67	555		ARH-95, p. 5
10/01/67 – 12/31/67	549		ARH-326, p. 5
01/01/68 – 03/31/68	545		ARH-534, p. 5
04/01/68 – 06/30/68	545		ARH-721, p. 5
07/01/68 – 09/30/68	545		ARH-871, p. 5
10/01/68 – 12/31/68	541		ARH-1061, p. 5
01/01/69 – 03/31/69	541		ARH-1200 A, p. 5
04/01/69 – 06/30/69	538		ARH-1200 B, p. 5
07/01/69 – 09/30/69	538		ARH-1200 C, p. 5

Table B1-2. Tank 241-C-101 Waste Inventory 1963 to 1970

Period	Tank 241-C-101 Waste Volume (Kgal)	Comments	Document Number (full titles in Section B7.0 REFERENCES
10/01/69 – 12/31/69	132	7,000 gal liquid; transferred 404,000 gal to B Plant via tank C-105	ARH-1200 D, p. 5
01/01/70 – 03/31/70	134	47,000 gal liquid	ARH-1666 A, p. 5

HLW = high-level waste PUREX = plutonium-uranium extraction TBP = Tri-Butyl Phosphate (plant)

B1.2 INTEGRITY OF TANK 241-C-101

Tank C-101 is currently designated as an "assumed leaker," with a leak volume estimate of 20,000 gal. The tank was removed from service in the first quarter of 1976 and was categorized as a "confirmed leaker" in 1980. Intrusion prevention was completed in December 1982 (HNF-EP-0182, *Waste Tank Summary Report for Month Ending August 31, 2010*). Table B1-2 summarizes the waste history for tank C-101.

Prior to 1980, no estimate of the potential waste loss from tank 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, *Review of Classification of the Nine Hanford Single-Shell "Questionable Integrity" Tanks*). The 1980 review team membership included the following tank farm organizations:

- Surveillance
- Process Control
- Effluent Control
- Chief Scientist.

RHO-CD-896 indicates tank 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, p. 48). Also, radioactivity was detected in the three of the five drywells around this tank (RHO-CD-896, p. 46):

- 30-00-06
  - Available data from 1968 to 1979 show only background
- 30-01-01
  - No radioactivity when initially monitored
  - 450 counts per second (c/s) at 33 ft 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 ft when first monitored (1970)
  - Activity slowly receded to 70 c/s at 73 ft (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-ft levels
  - Activity (15,000 c/s) at 26 ft is stable with very little decay
  - Activity at 36 ft (~6,400 c/s) has decreased to ~200 c/s (1979)
- 30-01-12
  - Very low level activity (~12 c/s) in top 20 ft when first monitored and activity is presently stable at background levels

Tank liquid level data presented in Table B1-2 indicates the liquid level in tank C-101 may have begun 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 B1-4 (RHO-CD-896, pp. 52-54). The review team concluded 17,000 to 24,000 gal of waste had leaked from tank C-101 during January 1968 through December 1969 (RHO-CD-896, p. 4).

Table B1-4. 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

B1.3 INTERIM STABLIZATION

Tank C-101 was interim stabilized in November, 1983. Interior photos of the tank (Figure B1-2) show a sludge surface with shallow pools of liquid (HNF-SD-RE-TI-178, *Single-Shell Tank Interim Stabilization Record*). As of September 2009, tank C-101 contains 88,000 gal consisting of 55,000 gal PUREX CW (1956-1960) (CWP1) sludge and 33,000 gal TBP sludge (RPP-RPT-43028, *2009 Auto-TCR for Tank 241-C-101*).

B1.4 TANK 241-C-101 TEMPERATURE HISTORY

Interior tank temperature data for tank C-101 were recorded by 11 thermocouples attached to a single thermocouple tree (WHC-SD-WM-ER-349, *Historical Tank Content Estimate for the Northeast Quadrant of the Hanford 200 East Area*). Figure B1-3 shows temperatures for thermocouples at 40 in., 112 in. and 184 in. above the bottom of the tank in risers 11 and 13 between 1992 and 2011.

B1.5 DATA REVIEW & OBSERVATIONS

The following sections contain surface level and drywell logging data and assessment discussions of data reviewed (additional discussion is included in meeting summaries (Appendix A).

B1.5.1 Tank Surface Level Measurements

Tank liquid level measurements before 1973 were not available, other than from the transfer data in waste process reports (Table B1-1). Figure B1-4 details liquid level monitoring results between 1980 and 2011. Table B1-3 shows liquid level measurements in the tank between 1973 and 1986.

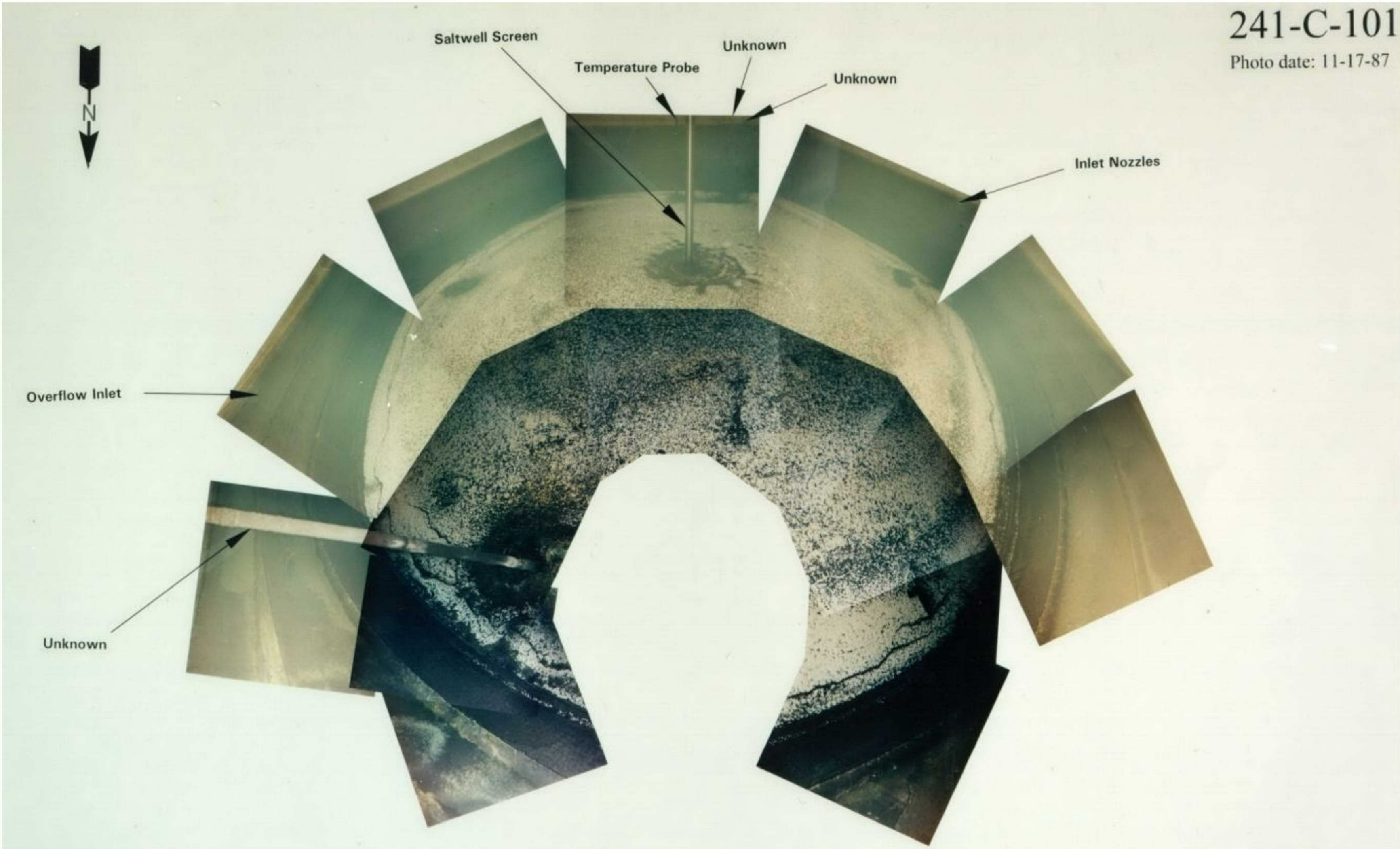
Tank C-101 was overfilled (Figure B1-5) from 1965 through 1967 with a high volume of ~656,000 gal reported at the second quarter of 1966 (WHC-MR-0132, *A History of the 200 Area Tank Farms*); this was subsequently assumed to be in error when compared to quarterly reports. Tank C-101 received unknown type of waste during this period of time.

Table B1-3. Tank 241-C-101 Liquid Level Measurements and Changes (1973 to 1987)

Liquid Level.

Date	Liquid level (in.)	Baseline ref.	Change from previous reading (in.)	Cumulative change (in.)	Comments
06/15/73	39.50				
07/14/73	39.00		-0.50	-0.50	Slow decrease
10/15/73	39.00			-0.50	Readings fluctuate ±0.25 in.
10/16/73	43.00			-0.50	New tape
02/07/74	43.00			-0.50	Stable
02/08/74	42.50			-0.50	New tape
05/23/74	42.00		-0.50	-1.00	Slow decrease
08/14/74	42.00			-1.00	Stable
08/17/74	31.00			-1.00	Transfer
08/24/74	30.50		-0.50	-1.50	Unexplained
09/18/74	30.00			-1.50	Transfer
10/15/74	29.50		-0.50	-2.00	Slow decrease
11/18/74	29.25		-0.25	-2.25	Slow decrease
12/09/74	29.00		-0.25	-2.50	Slow decrease
05/31/75	28.75		-0.25	-2.75	Slow decrease
09/30/75	28.50		-0.25	-3.00	Slow decrease
04/01/76	28.50			-3.00	Stable
04/07/76	22.50			-3.00	Salt-well transfers and new tape
02/21/77	22.50			-3.00	Stable, but salt-well pumping
02/22/77	22.00			-3.00	New numbers put on zip cord
07/23/77	22.25			-3.00	Stable ±0.25 in.
07/27/77	28.75			-3.00	New tape installed
10/07/77		28.25	-0.50	-3.50	Unexplained
04/05/78	28.50		+0.25	-3.25	Erratic increase
04/05/79	28.50			-3.25	Stable
03/31/80	28.25		-0.25	-3.50	Stable
04/13/81	28.25			-3.50	Stable
04/19/82	28.25			-3.50	Stable
04/12/83	27.50		-0.75	-4.25	Slow decrease
04/09/84	27.75		+0.25	-4.00	Stable
04/01/85	28.25		+0.50	-3.50	Stable
04/01/86	27.00		-1.25	-4.75	Erratic decrease
07/07/86	26.50		-0.50	-5.25	New tape installed
01/06/87	25.00		-1.50	-6.75	Steady decrease
04/10/87	26.00		+1.00	-5.75	New tape installed

Figure B1-2. Tank 241-C-101 Waste Surface Photo Mosaic



Reference: WHC-SD-WM-ER-349, *Historical Tank Content Estimate for the Northeast Quadrant of the Hanford 200 West Area.*

Figure B1-3. Tank 241-C-101 Waste Temperature Measurements

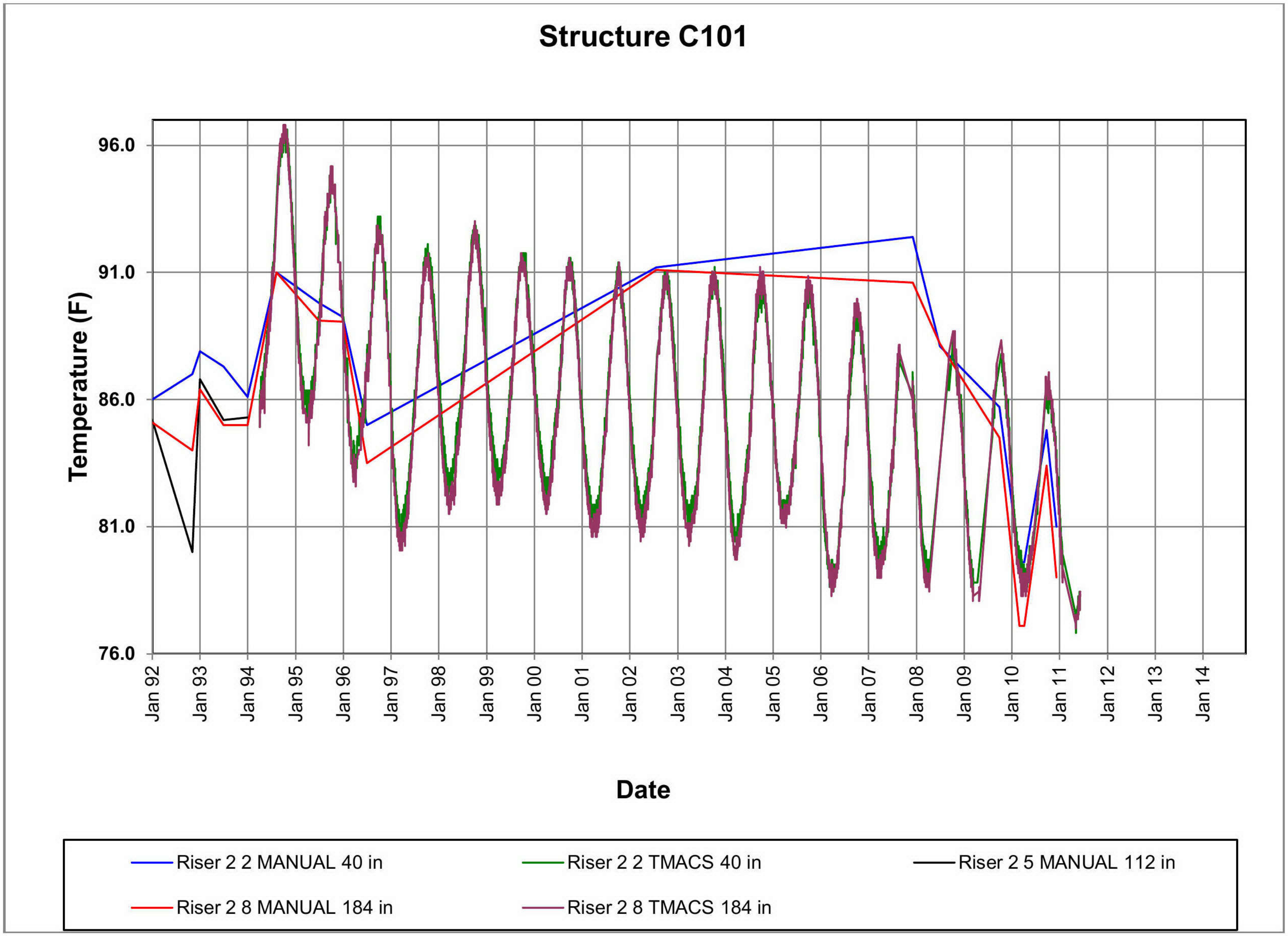


Figure B1-4. Tank 241-C-101 Waste Surface Level Measurements

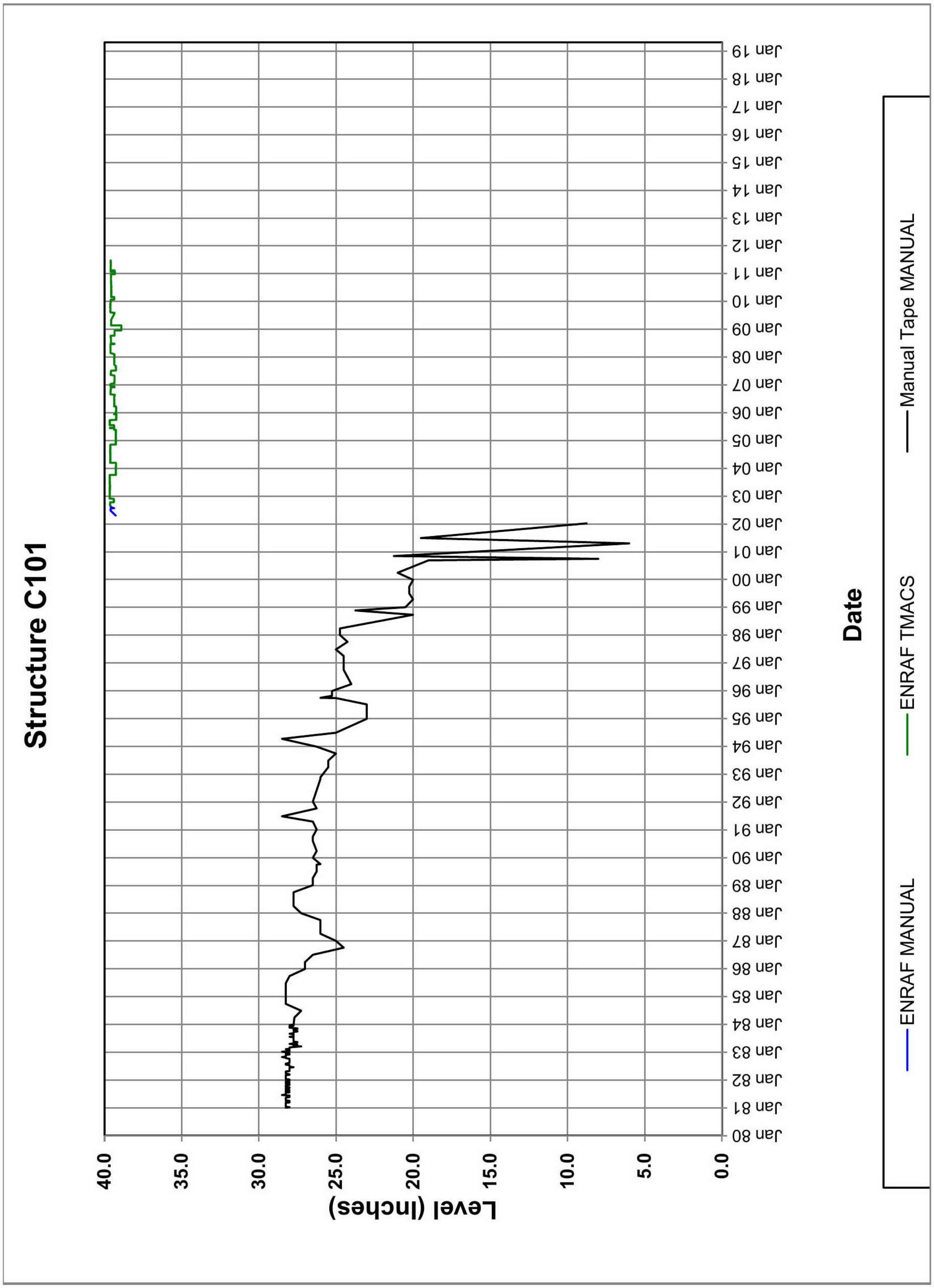
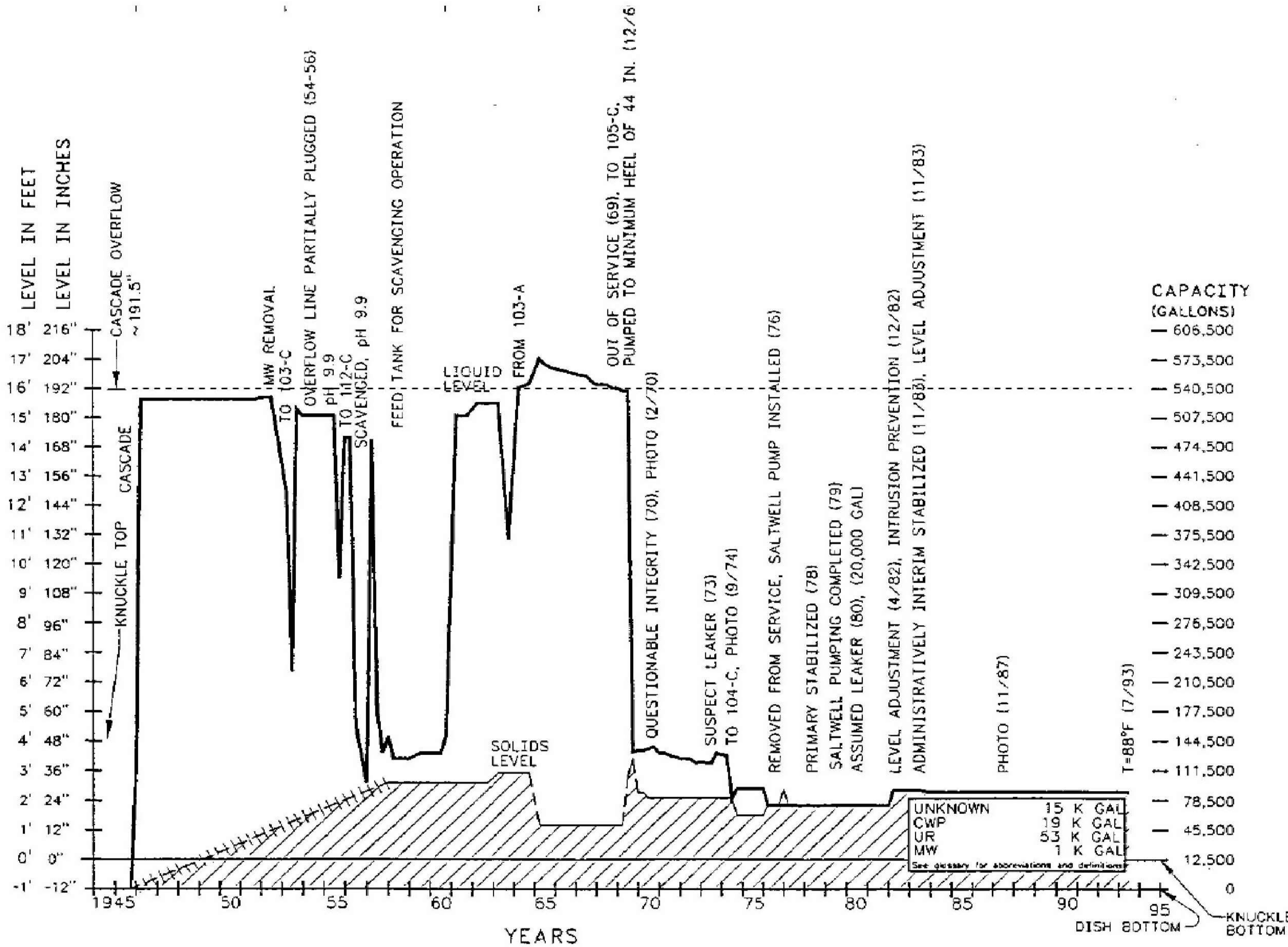


Figure B1-5. Tank 241-C-101 Quarterly Waste Fill History



B1.5.2 Drywell Logging Data

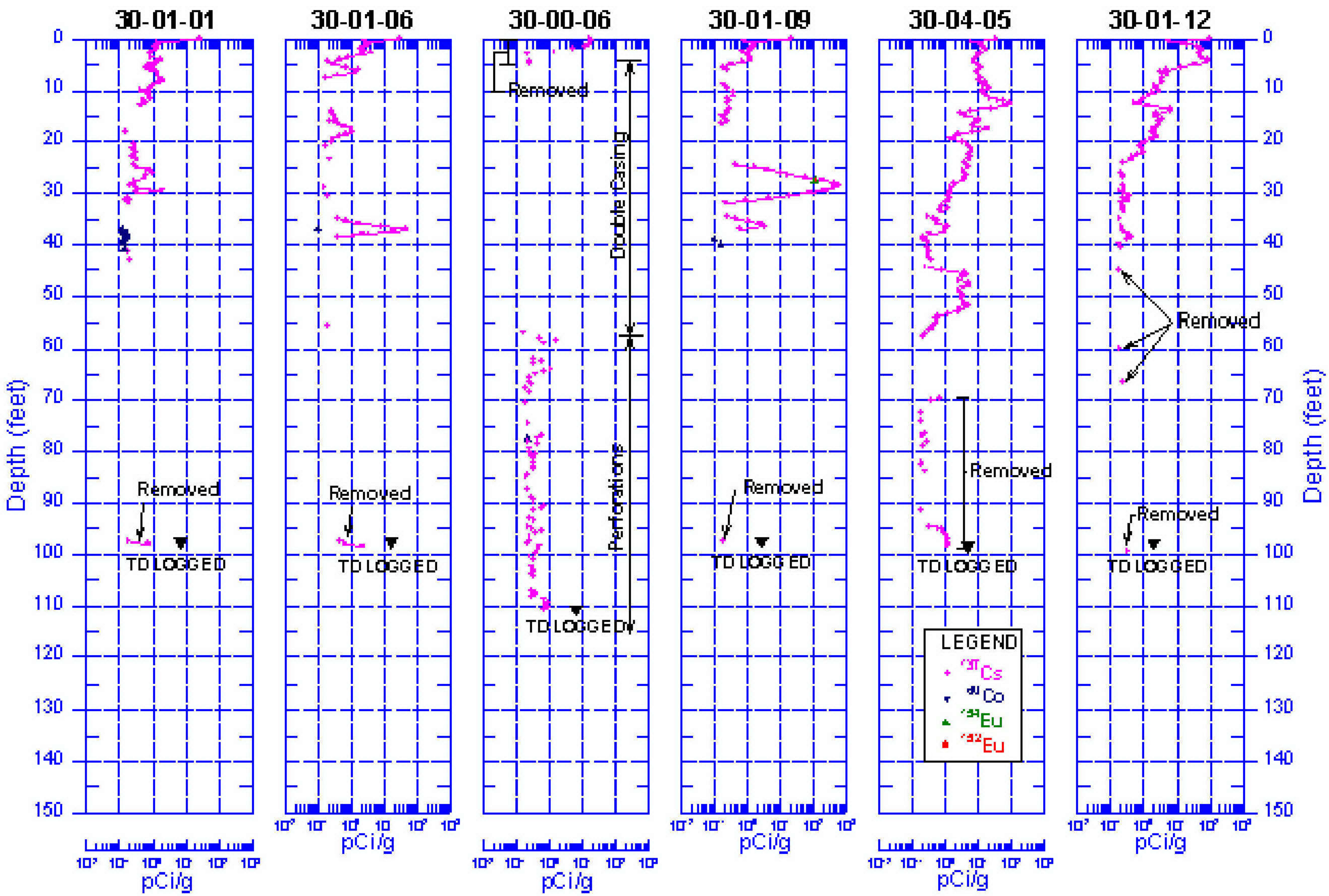
Six vadose zone monitoring drywells surround tank C-101. These drywells are 30-01-01, 30-01-06, 30-00-06, 30-01-09, 30-04-05, and 30-01-12. Figure B1-6 shows SGLS results from 1996 logging activities for these drywells.

<u>Drywell Information</u>: In 1970, several new drywells (30-01-01, 30-01-06, 30-01-09 and 30-01-12) were installed around tank 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 to 10,000 counts per minute (c/m) activity was encountered at the 38-ft level and drilling was terminated (ARH-1526 1, *Chemical Processing Division Daily Production Reports January, 1970 through March, 1970*, p. 130). Drilling of the fourth drywell was resumed on March 18, 1970 and 5,000 to 10,000 c/m activity was encountered between the 42- and 48-ft level, but after 48 ft, no gamma activity was seen (ARH-1526 1, p. 132). Drilling of the fourth drywell around tank C-101 was reported as being completed on March 24, 1970 (ARH-1526 1, p. 138). Gamma activity was not reported as being encountered during the drilling of other wells around tank 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 C-101 in 1970, it is thought that the "fourth" drywell is in reference to drywell 30-01-09. According to RHO-CD-896, p. 46, drywell number 30-01-09 was found to have gamma activity between the 29- and 36-ft 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 B1-6. 1997 Spectral Gamma Logging Results for Drywells near Tank 241-C-101 (GJ-HAN-18)



B1.5.3 Discussion of Data Reviewed

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 activity 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[4] assuming no heat losses to the tank structure or surrounding soil.

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[4] 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 B1-7 (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 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 B1-4.

Table B1-4. Analyses of 241-A Tank Farm Condensate

Constituent	1959 Analyses[5]	1961 Analyses[6]
	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

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

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

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 B1-7. Atmospheric Condenser for Single-Shell Tanks

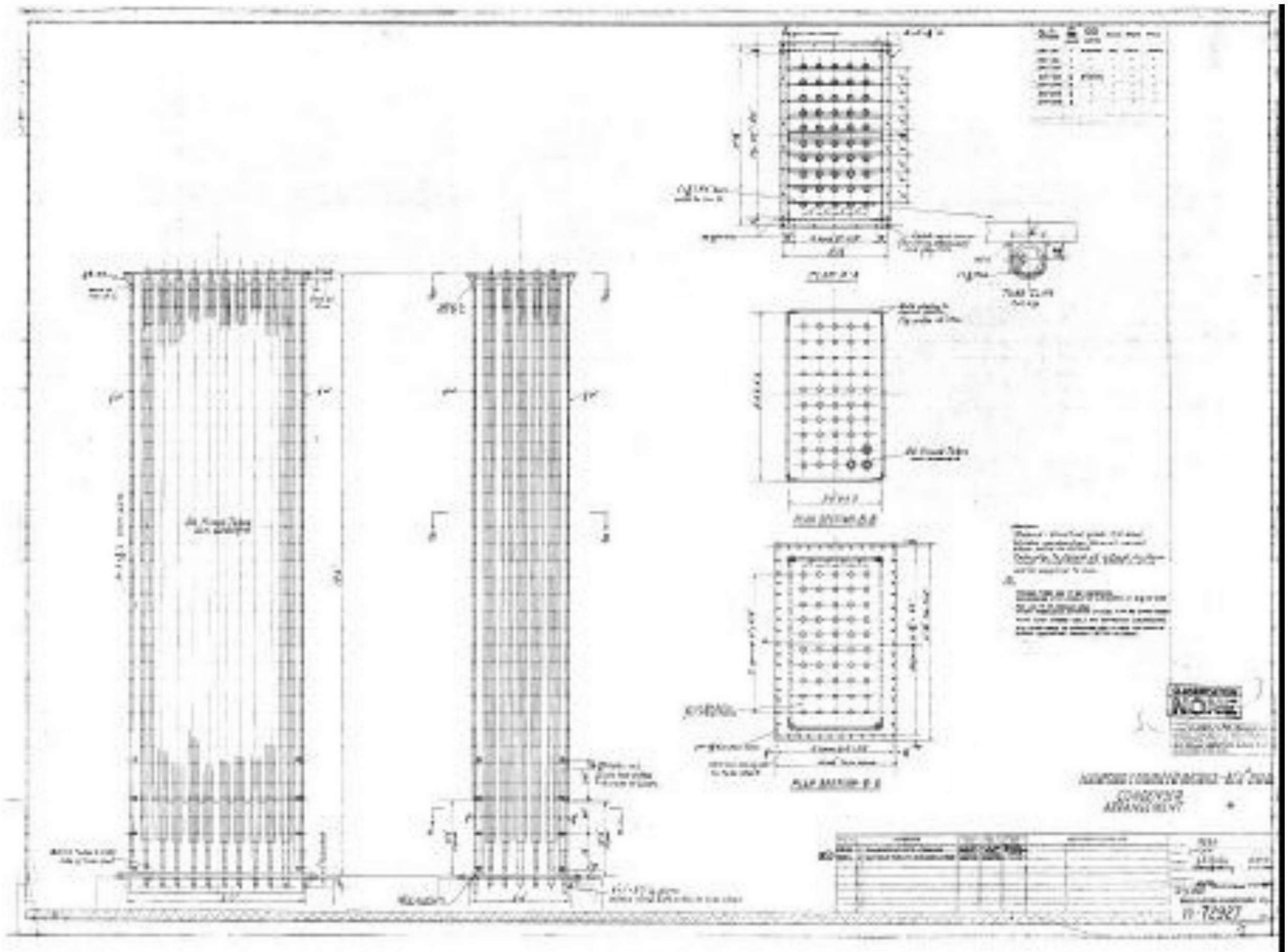


Table B1-5 shows summary information for tank C-101.

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 37,000 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 gamma activity 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 37,000 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, 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.

Table B1-5. Summary 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		

B2.0 TANK 241-C-110

This section provides information on the historical waste loss event associated with tank 241-C-110 (C-110). Waste operations for tank C-110 are summarized in Figure B2-1.

B2.1 TANK 241-C-110 WASTE HISTORY

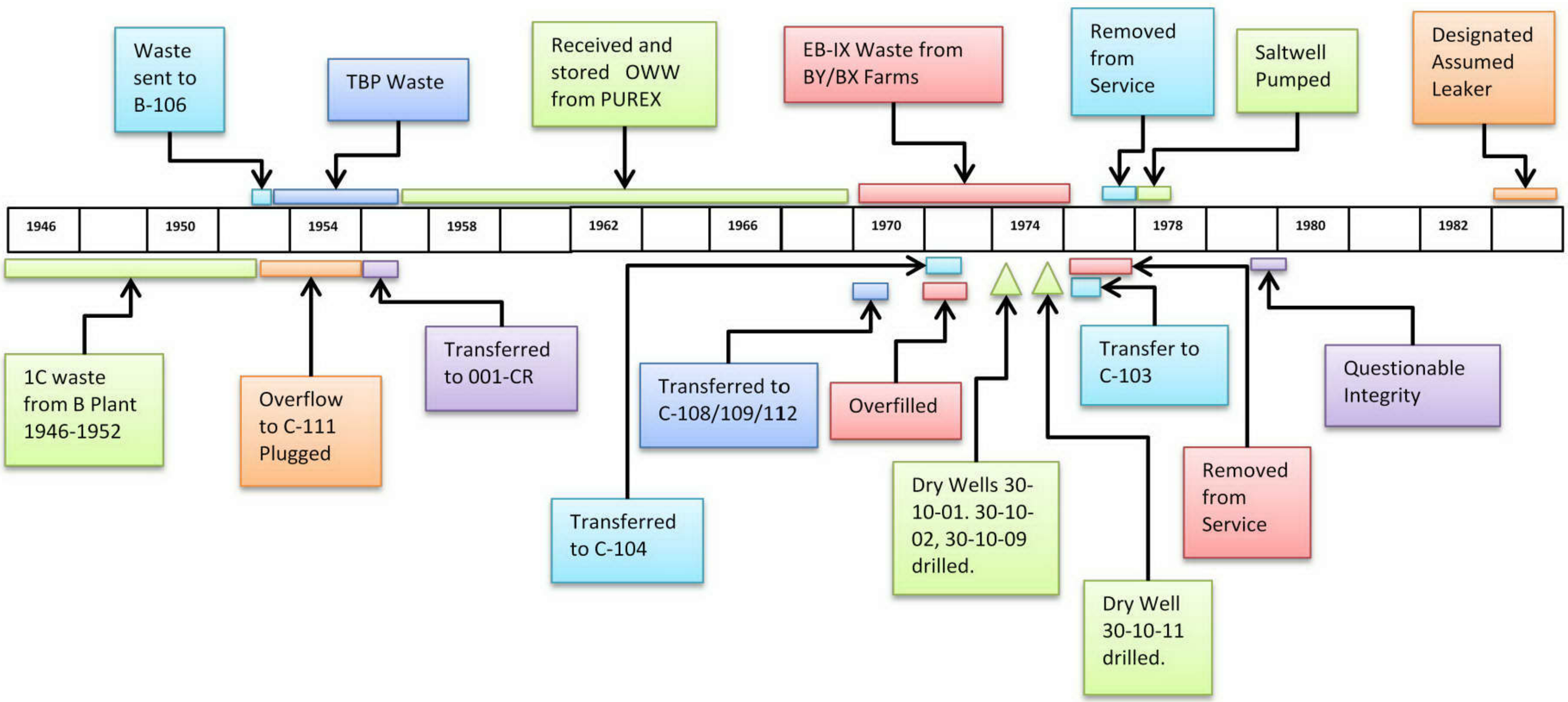
SST C-110 has a nominal capacity of 2,006,000 liters (530,000 gallons), a diameter of 23 m (75 ft) (HNF-EP-0182), and is passively ventilated. The tank is equipped with four inlet nozzles and a cascade overflow line connection to SST C-111. The centerline of the inlet nozzles on the tank side wall are 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[7] 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.

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

Figure B2-1. Tank 241-C-110 Waste Operations Summary



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 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. 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. 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 saltwell 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).

B2.2 INTEGRITY OF TANK 241-C-110

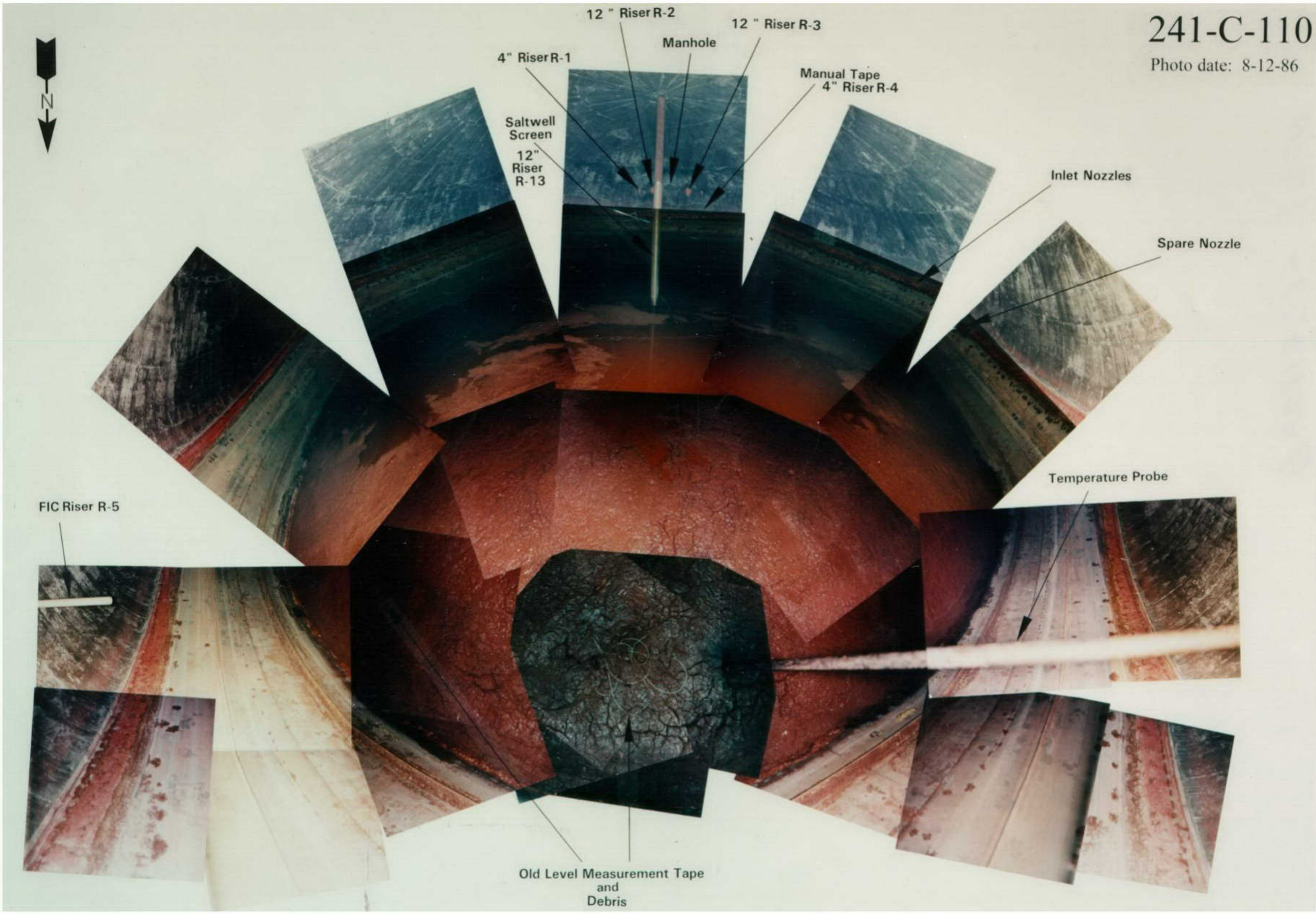
SST C-110 was declared as "questionable integrity" in 1977 and an "assumed leaker" in 1984 following the discovery of unexplained activity in drywell 30-10-09. The gross gamma peak readings above background were detected in drywell 30-10-09 from October 1974 through February 1976 at approximately 53 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).*

B2.3 B2.3 INTERIM STABLIZATION

Tank C-110 was interim stabilized in June, 1995 after repeated saltwell pumping. Interior photos of the tank (Figure B2-2) shows a largely dry and cracked waste surface (HNF-SD-RE-TI-178). As of September, 2009 tank C-110 contains 17 kgal consisting of 1C liquid and solid sludge (RPP-RPT-43037, Rev.0).

Figure B2-2. Tank 241-C-110 Waste Surface Photo Mosaic



Reference: WHC-SD-WM-ER-349, *Historical Tank Content Estimate for the Northeast Quadrant of the Hanford 200 West Area.*

B2.4 TANK 241-C-110 TEMPERATURE HISTORY

Interior tank temperature data for tank C-110 were recorded by 12 thermocouples attached to a single thermocouple tree (WCH-SD-WM-ER-349). Figure B2-3 shows temperatures for thermocouples at 40 inches, 112, inches and 184 inches for riser 8 between 1992 and 2011.

B2.5 DATA REVIEW & OBSERVATIONS

The following sections contain surface level and drywell logging data and assessment discussions of data reviewed (additional discussion is included in meeting summaries (Appendix A).

B2.5.1 TANK SURFACE LEVEL MEASUREMENTS

Tank liquid level measurements before 1973 were not available, other than from the transfer data in waste process reports. Figure B2-3 details liquid level monitoring results between 1980 and 2011. Table B2-4 shows liquid level measurements in the tank between 1973 and 1986. Tank C-110 appears to have been filled above the cascade overflow level between 1954 and 1956 (Figure B2-3).

Figure B2-3. Tank 241-C-110- Waste Temperature Measurements

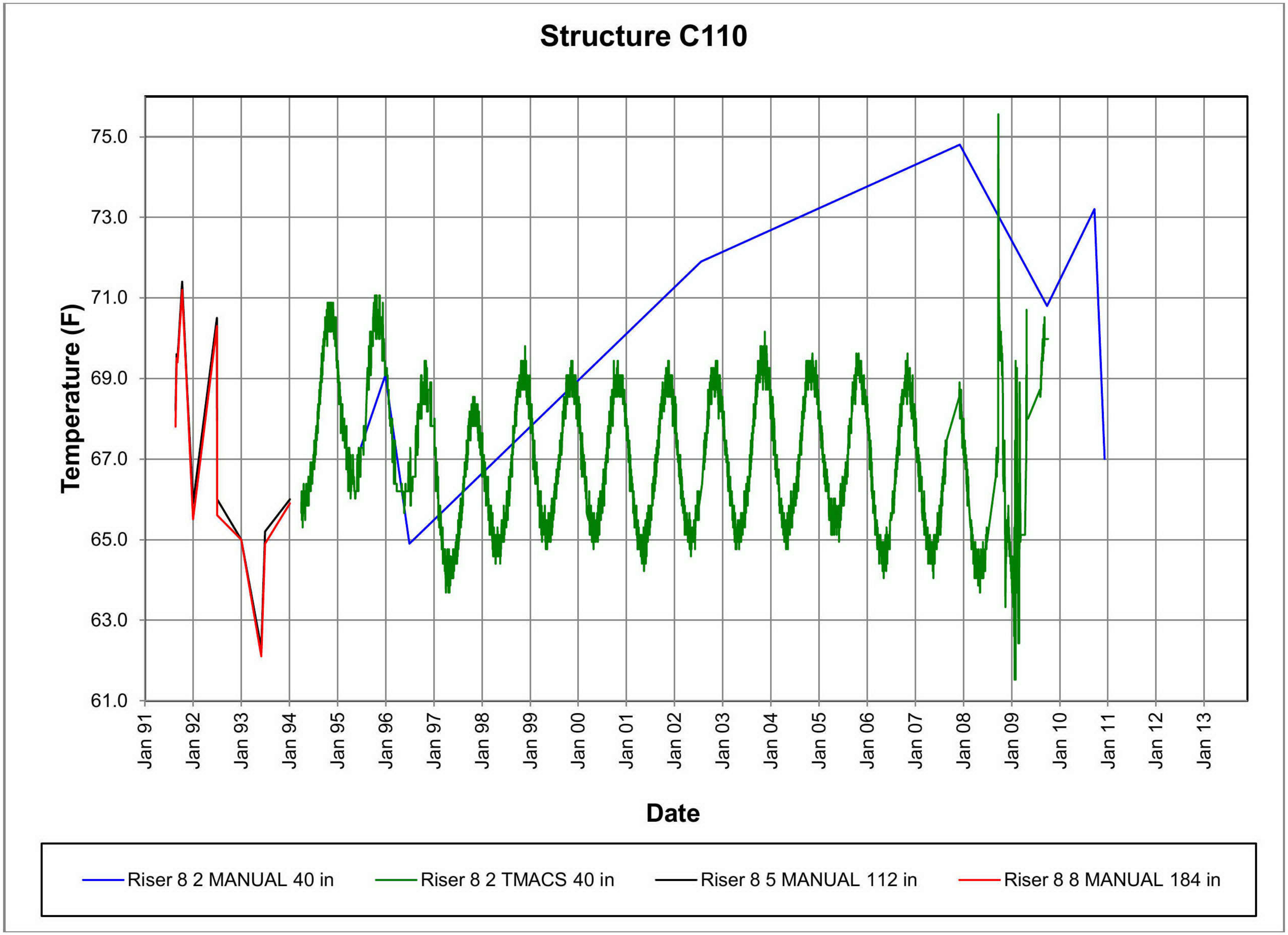


Table B2-1. Tank 241-C-110 Liquid Level Measurement and Changes (1973 to 1978)

TANK 110-C

Liquid Level.

Date	Liquid level (in.)	Baseline ref.	Change from previous reading (in.)	Cumulative change (in.)	Comments
06/15/73	132.20		-	-	
07/10/73	132.10		-0.10	-0.10	Stable
12/26/73	132.10		-	-0.10	Calibration
01/29/74	132.10		-	-0.10	Stable
02/22/74	132.00		-0.10	-0.20	Stable
03/29/74	132.10		+0.10	-0.10	Stable
01/27/75	132.00		-0.10	-0.00	Stable
04/17/75	132.00		-	-0.00	Calibration
07/07/75	132.15		+0.15	+0.15	Stable
07/31/75	132.05		-0.10	+0.05	Stable
08/29/75	92.70		-	+0.05	Transfer
03/03/76	92.80		+0.10	+0.15	Stable
03/17/76	81.60		-	+0.15	Transfers
06/06/76	78.50		-	+0.15	Steady decrease following salt well transfers
06/07/76	68.75		-	+0.15	Now using manual tape
03/17/77	67.00		-	+0.15	Slow decrease following salt well transfers
10/04/77	67.50		+0.50	+0.65	Slow increase
02/28/78	67.50		-	+0.65	Stable
09/28/78		66.25	-	+0.65	Salt well pumping ±0.25 in.
04/10/79	66.50		+0.25	+0.90	Slow erratic increase ±0.25 in.
03/27/80	67.00		+0.50	+1.40	Slow erratic increase ±0.25 in.
04/16/81	67.25		+0.25	+1.65	Slow erratic increase ±0.25 in.
04/26/82	67.50		+0.25	+1.90	Slow increase
04/12/83	67.75		+0.25	+2.15	Slow increase
04/09/84	68.00		+0.25	+2.40	Slow increase
04/08/85	68.00		-	+2.40	Stable fluctuates ±0.25 in.
04/07/86	68.25		+0.25	+2.65	Slow increase
06/09/86	68.25			+2.65	Stable
06/16/86	68.50		+0.25	+2.90	Increase
07/31/86		68.50		+2.90	EPDR 86-03 intrusions
04/20/87	68.25		-0.25	+2.65	

Figure B2-3. Tank C-110 Waste Surface Level History

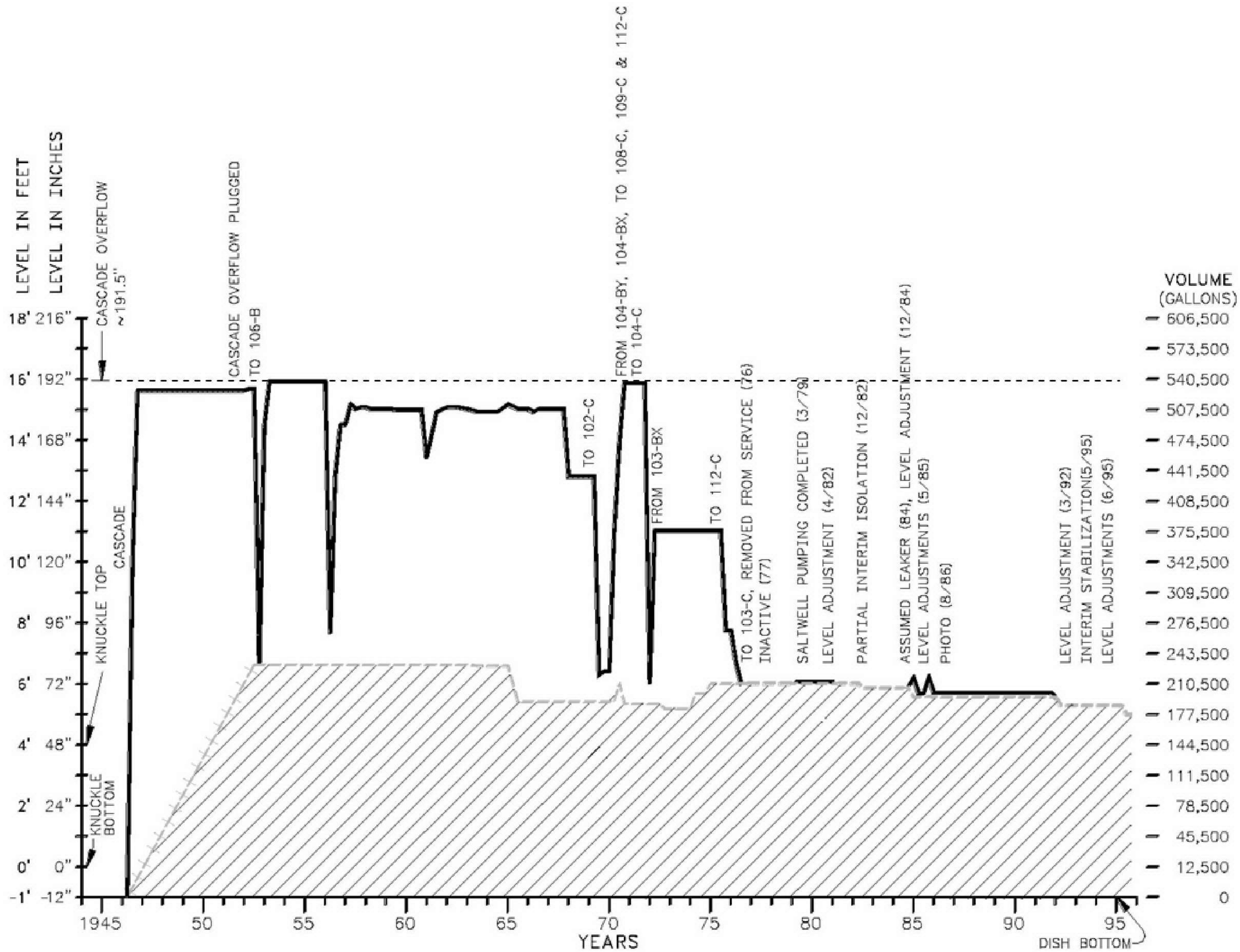
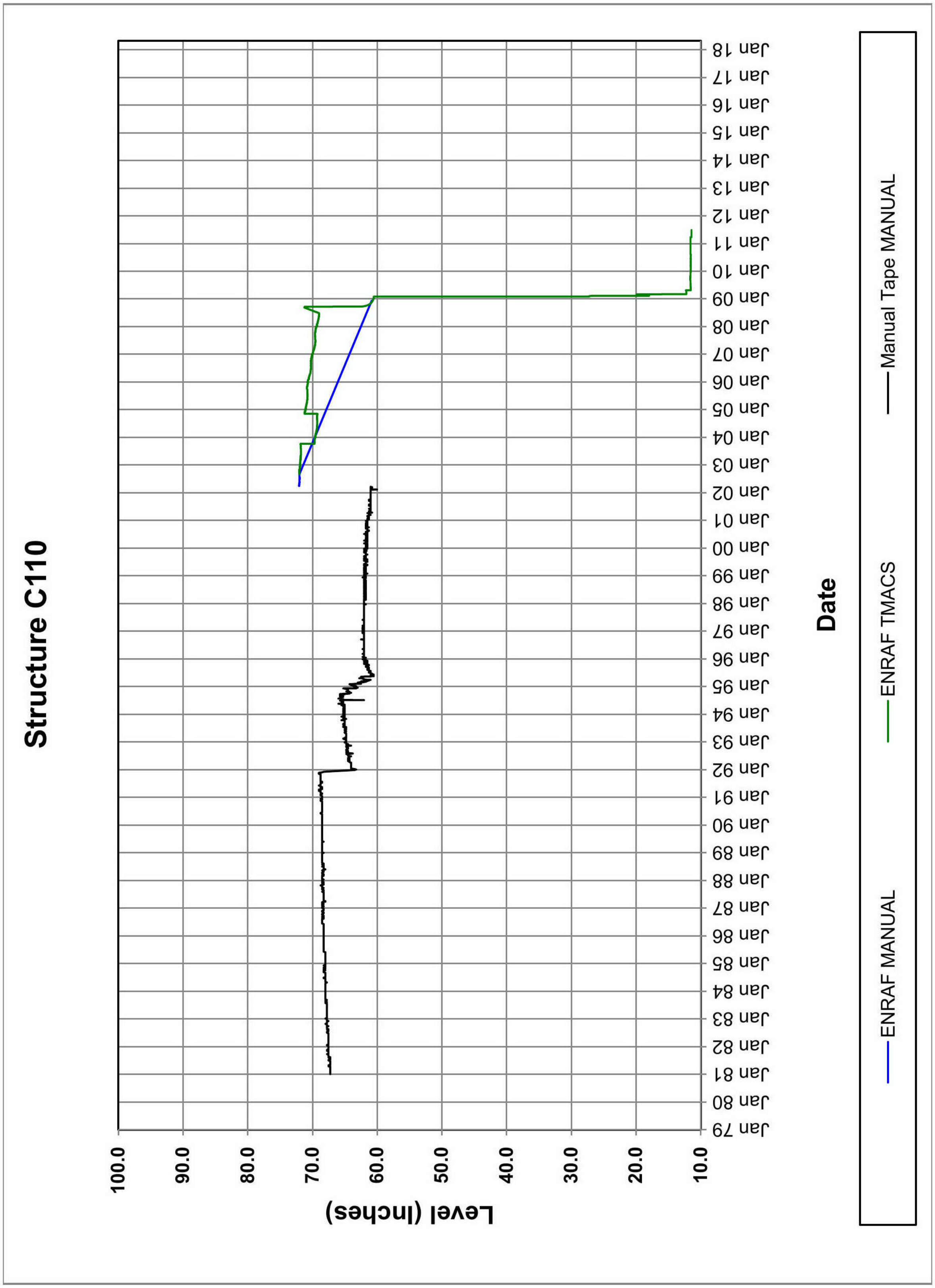


Figure B2-4. Tank 241-C-110 Waste Surface Level Measurements

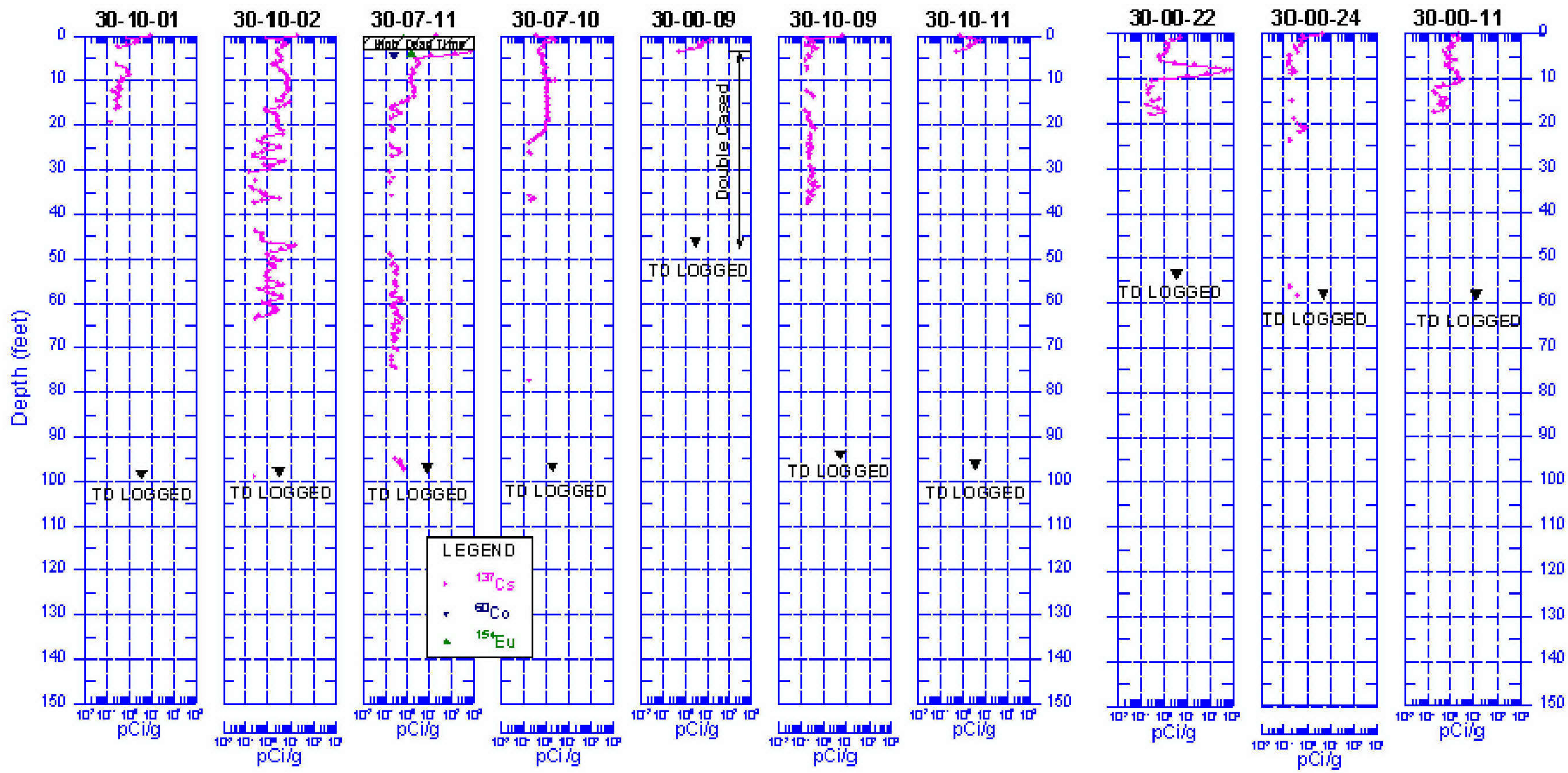


A manual tape with an electrode was used for many of the liquid level measurements reported in the 1950's through the 1970's. The statistical accuracy of the manual tape and electrode measurement technique was 0.75 in. (~2,060 gallons), as determined in July 1955 (HW-51026, 1957, page 4, *Leak Detection – 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.

B2.5.2 DRYWELL LOGGING DATA

Ten vadose zone monitoring drywells surround tank C-110. These drywells are 30-10-01, 30-10-02, 30-07-11, 30-07-10, 30-00-22, 30-00-24, 30-00-11, 30-00-09, 30-10-09, and 30-10-11. Figure B2-5 shows SGLS results from 1997 logging activities near these drywells.

Figure B2-5. 1997 Spectral Gamma Logging Results for Drywells near Tank 241-C-110 (GJ-HAN-92)



B2.5.3 Discussion of Data Reviewed

The tank was classified as "questionable integrity" because the source of gamma activity 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 gamma activity exists directly beneath SST C-110. The only activity 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 (see 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. 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 activituy detected in drywell 30-10-09.

Gamma activity was observed when drywell 30-10-09 was installed and first monitored in October 1974. Activity 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).

There are very low concentrations (less than 10-pCi/gm) of ^{137}Cs detected in the soil surrounding SST C-110 (Figure B2-4). If a tank waste leak had occurred, higher concentrations of ^{137}Cs would be expected in the soil surrounding SST C-110.

No gamma activity 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 RPP-8321, page 286. Near-surface (0 to 10 ft bgs) ^{137}Cs activity 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). Activity 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 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 activity was observed in these drywells.

In June 1975, the supernate in SST C-110 was sampled and analyzed. 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.

Summary information for tank C-110 is shown in Table B2-2.
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 gamma activity 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.

Table B2-2. 2007 Assessment 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			

B3.0 TANK 241-C-11□

This section provides information on the historical waste loss event associated with tank 241-C-111. Waste operations for tank C-111 are summarized in Figure B3-1.

B3.1 TANK 241-C-111 WASTE HISTORY

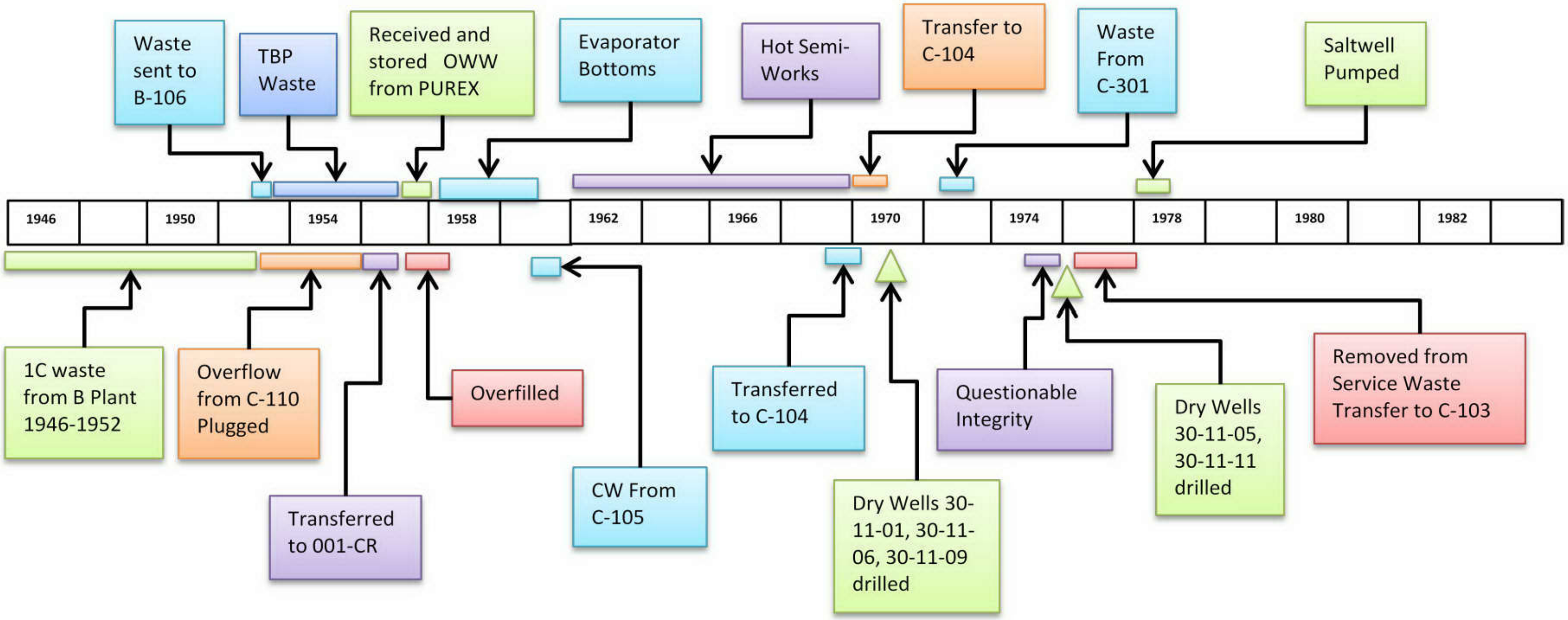
Historical waste operations for tank 241-C-111 are summarized in Table B3-1. SST C-111 has a capacity of 2,006,000 liters (530,000 gallons) and a diameter of 22.9 m (75 ft) (HNF-EP-0182). SST C-111 is passively ventilated and is the second tank in a three-tank cascade that includes SSTs C-110 C-112. 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[8] 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 (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.

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

Figure B3-1. Tank 241-C-111 Waste Operations Summary



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. The waste level in SST C-111 began to decrease, as noted in Table B3-1. 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.

Table B3-1. 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.

B3.2 INTEGRITY OF TANK 241-C-111

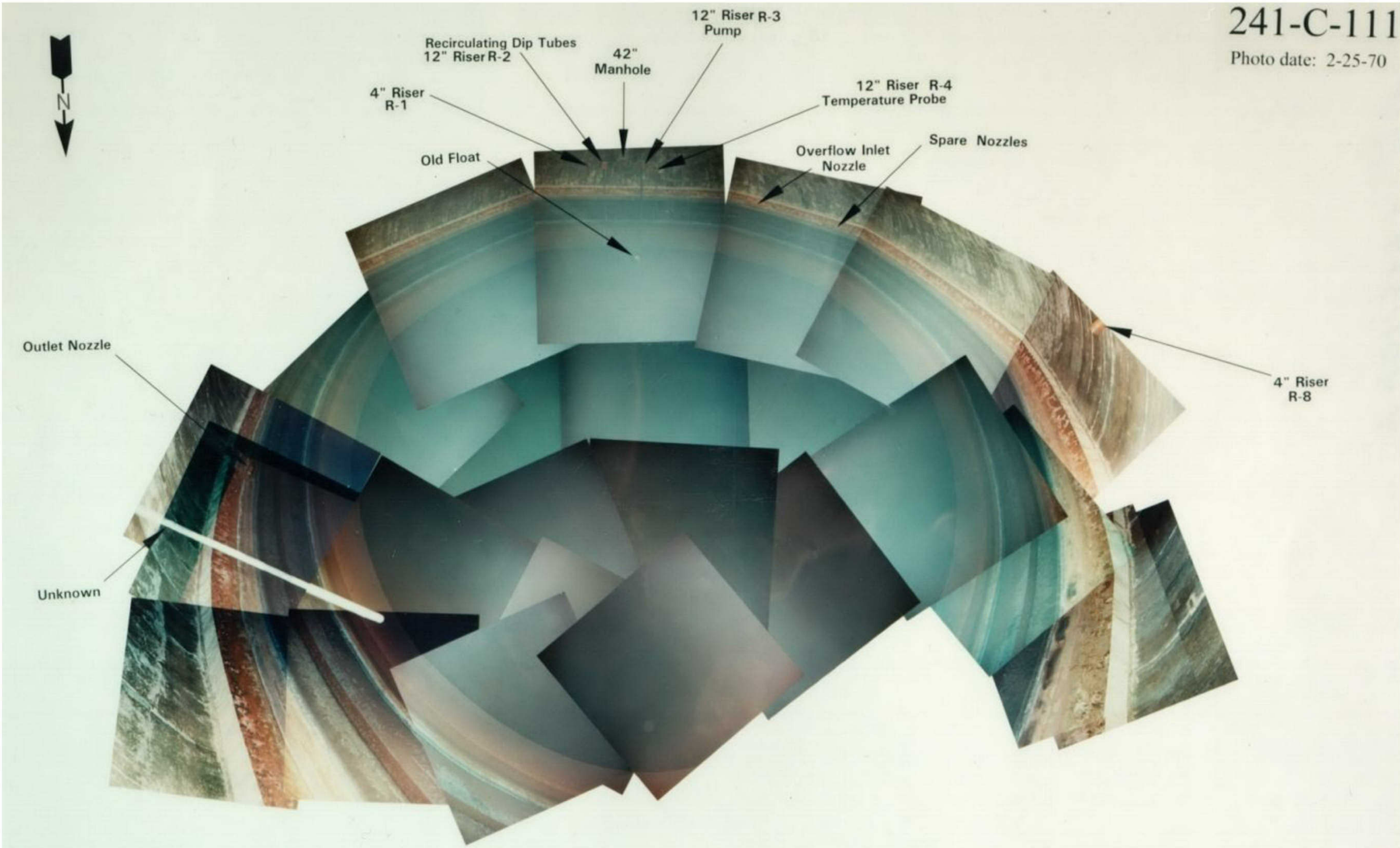
SST C-111 was classified as questionable integrity in 1968 (Baumhardt 1989). SST C-111 was declared a suspected leaker in late 1973 (ARH-2794-D, 1974, *Manufacturing and Waste Management Division Waste Status Summary October 1, 1973 Through December 31, 1973*). As a result, supernatant was transferred 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 reclassified 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).

B3.3 INTERIM STABLIZATION

Tank C-111 was interim stabilized in March, 1984. Interior photos of the tank (Figure B3-2) show a solid surface (HNF-SD-RE-TI-178). As of October 2009, tank C-111 contains 57 kgal consisting of 16 kgal CWP1 sludge, 4 kgal HS sludge, 24 kgal TFeCn sludge and 13 kgal 1C sludge (RPP-RPT-43038, Rev.0)

Figure B3-2. Tank 241-C-111 Waste Surface Photo Mosaic



Reference: WHC-SD-WM-ER-349, *Historical Tank Content Estimate for the Northeast Quadrant of the Hanford 200 West Area*.

B3.4 TANK 241-C-111 TEMPERATURE HISTORY

Interior tank temperature data for Tank C-111 were recorded by 12 thermocouples connected to a single thermocouple tree (WCH-SD-WM-ER-349). Figure B3-3 show tank temperatures for thermocouples at 19 inches, 27 inches, and 367 inches between 1989 and 2010.

B3.5 DATA REVIEW & OBSERVATIONS

The following sections contain surface level and drywell logging data and assessment discussions of data reviewed (additional discussion is included in meeting summaries (Appendix A).

B3.5.1 TANK SURFACE LEVEL MEASUREMENTS

Tank surface level measurements before 1971 were not available, except from transfer data in historical waste process reports (Table B3-1). Figure B3-4 details liquid level monitoring results between 1981 and 2011. Table B3-2 shows liquid level measurements in the tank between 1973 and 1987. C-111 was filled to or above the cascade overflow level in 1956 and 1964 (Figure B3-5).

Occurrence Reports relating to C-111 liquid levels include the following:

OR-76-42: Liquid Level Increase

On March 23, 1976, a liquid level increase exceeded the 0.5 inch action criterion. The tank was subsequently salt-well pumped. Attempts to view the waste surface were unsuccessful due to fog inside the tank, and liquid level readings were erratic due to problems contacting the waste surface, though readings appeared to stabilized thereafter.

Figure B3-3. Tank 241-C-111 Waste Temperature Measurements

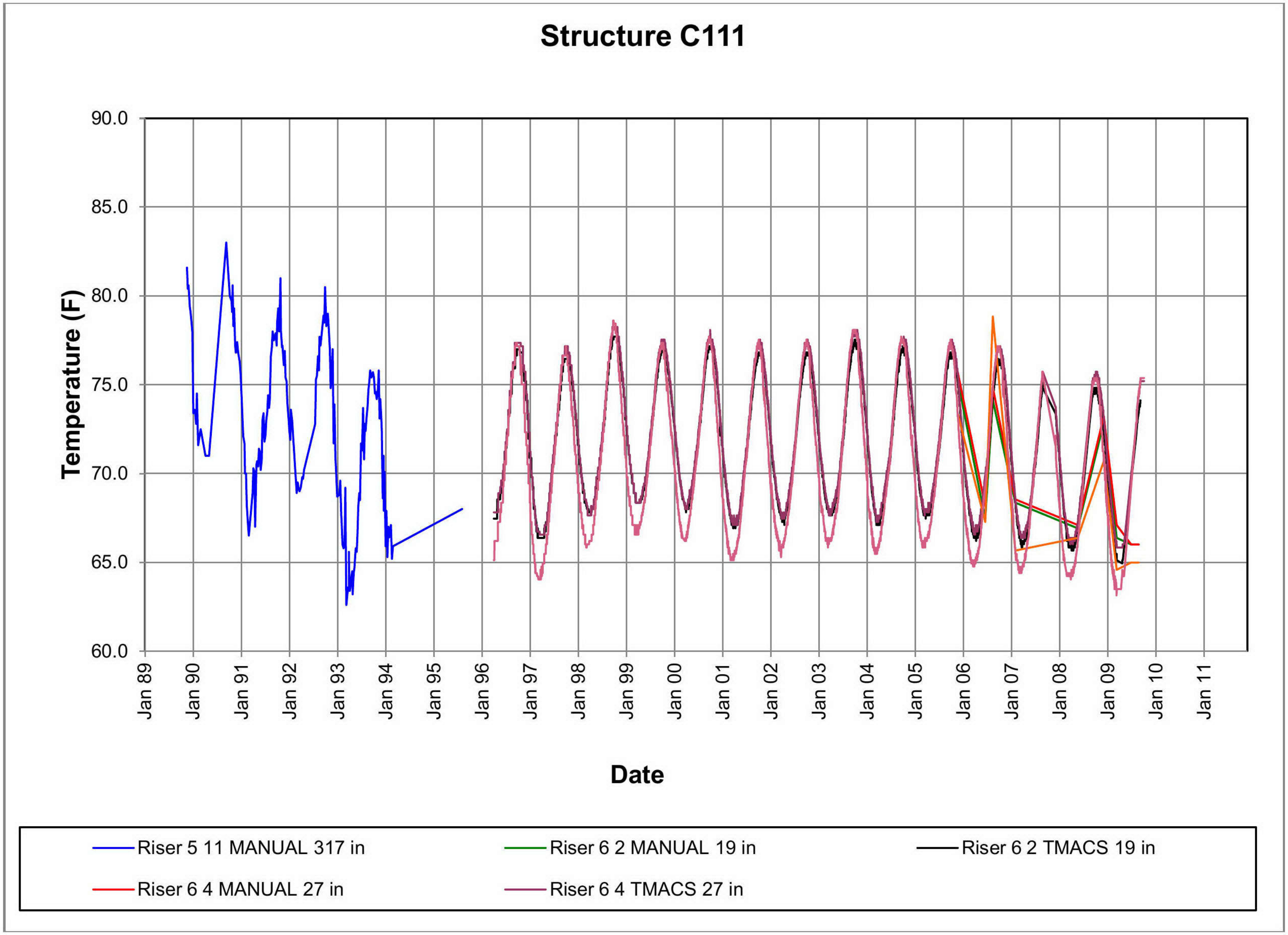


Table B3-2. Tank 241-C-111 Liquid Level Measurements and Changes (1973-1987)

TANK 111-C

Liquid Level.

Date	Liquid level (in.)	Baseline ref.	Change from previous reading (in.)	Cumulative change (in.)	Comments
06/15/73	58.00		-	-	
12/22/73	58.00		-	-	Stable
03/26/74	57.50		-0.50	-0.50	
04/05/74	57.75		+0.25	-0.25	
04/08/74	35.00		-	-0.25	Transfer
04/10/74	34.00		-	-0.25	Transfer
06/24/74	37.00		-	-0.25	New type
03/31/75	36.75		-0.25	-0.50	Slow decrease
04/16/75	36.50		-0.25	-0.75	
02/25/76	35.00		-	-0.75	Transfer
03/03/76	28.00		-	-0.75	Transfer
03/06/76	21.00		-	+0.75	Salt-well transfers
03/22/76	20.75		-0.25	-1.00	Stable
03/23/76	22.00		+1.25	+0.25	Unexplained increase
03/30/76	22.00		-	+0.25	Readings fluctuate from 19.25 to 22.00 in.
08/01/76	21.00		-	+0.25	Slow decrease following salt-well pumpings
08/19/76	21.00		-	+0.25	Readings erratic
02/13/77	20.50		-	+0.25	Slow decrease following salt-well pumpings
02/28/77	20.50		-	+0.25	Stable
03/01/78	14.00		-	+1.25	Tape lost, zip cord installed
03/07/78	14.00		-	+0.25	Stable
03/08/78		16.50	-	+1.25	New tape installed
04/07/78	16.50		-	+0.25	Stable
04/10/79	16.50		-	+0.25	Stable
03/31/80	16.25		-0.25	0.00	Readings fluctuate from 16.50 to 16.00 in.
04/16/81	16.25		-	0.00	Stable
12/08/81	16.00		-	-0.25	Readings fluctuate from 16.25 to 16.00 in.
04/26/82	16.00		-	-0.25	Stable
04/12/83	16.00		-	-0.25	Stable
04/09/84	14.75		-1.25	-1.50	Readings fluctuate from 14.50 to 16.00 in.
04/01/85	14.75		-	-1.50	Stable
04/01/86	14.50		-0.25	-1.75	Fluctuate
04/06/87	14.50			-1.75	Stable

Figure B3-4. Tank 241-C-111 Waste Surface Level Measurements

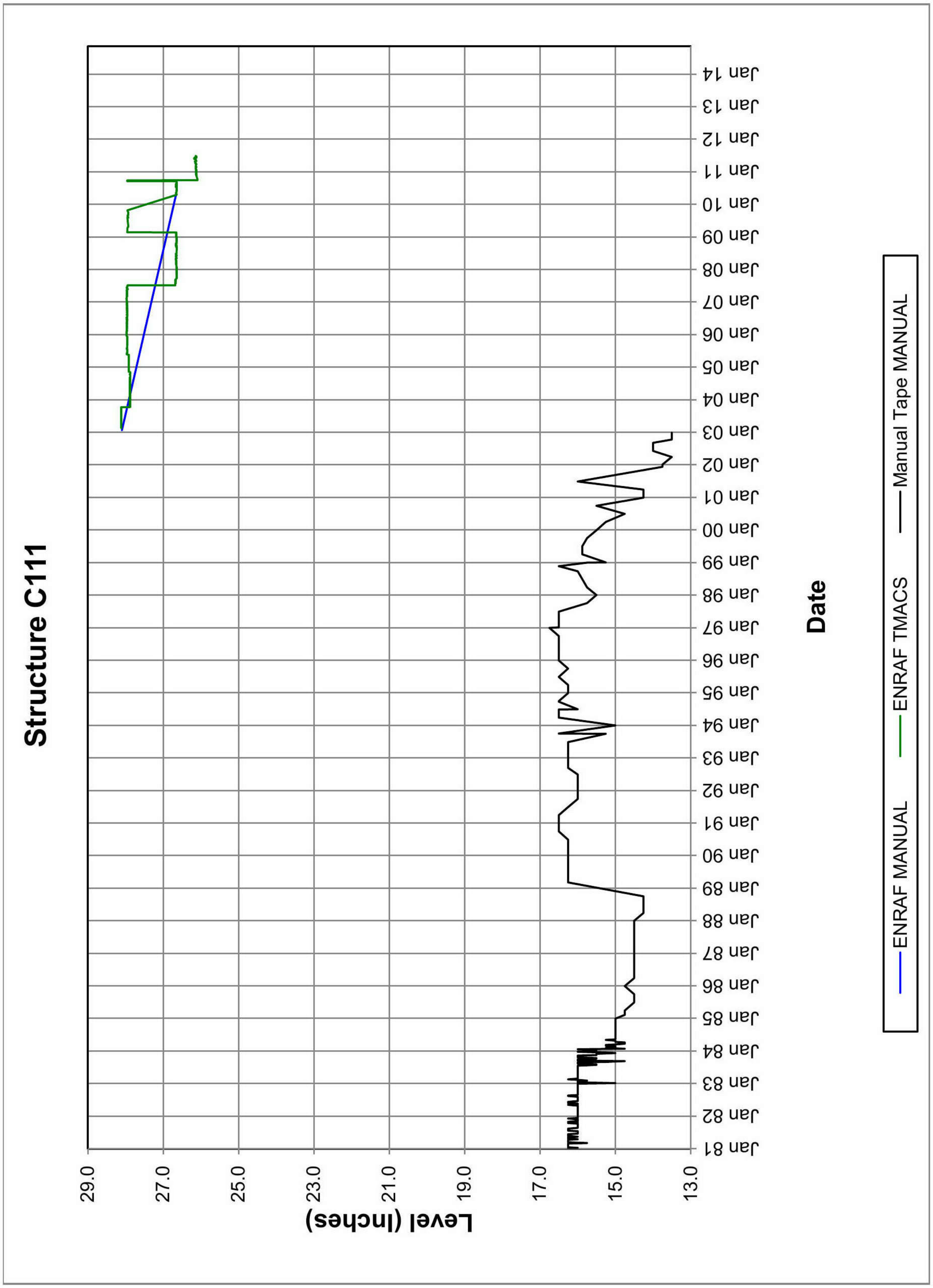
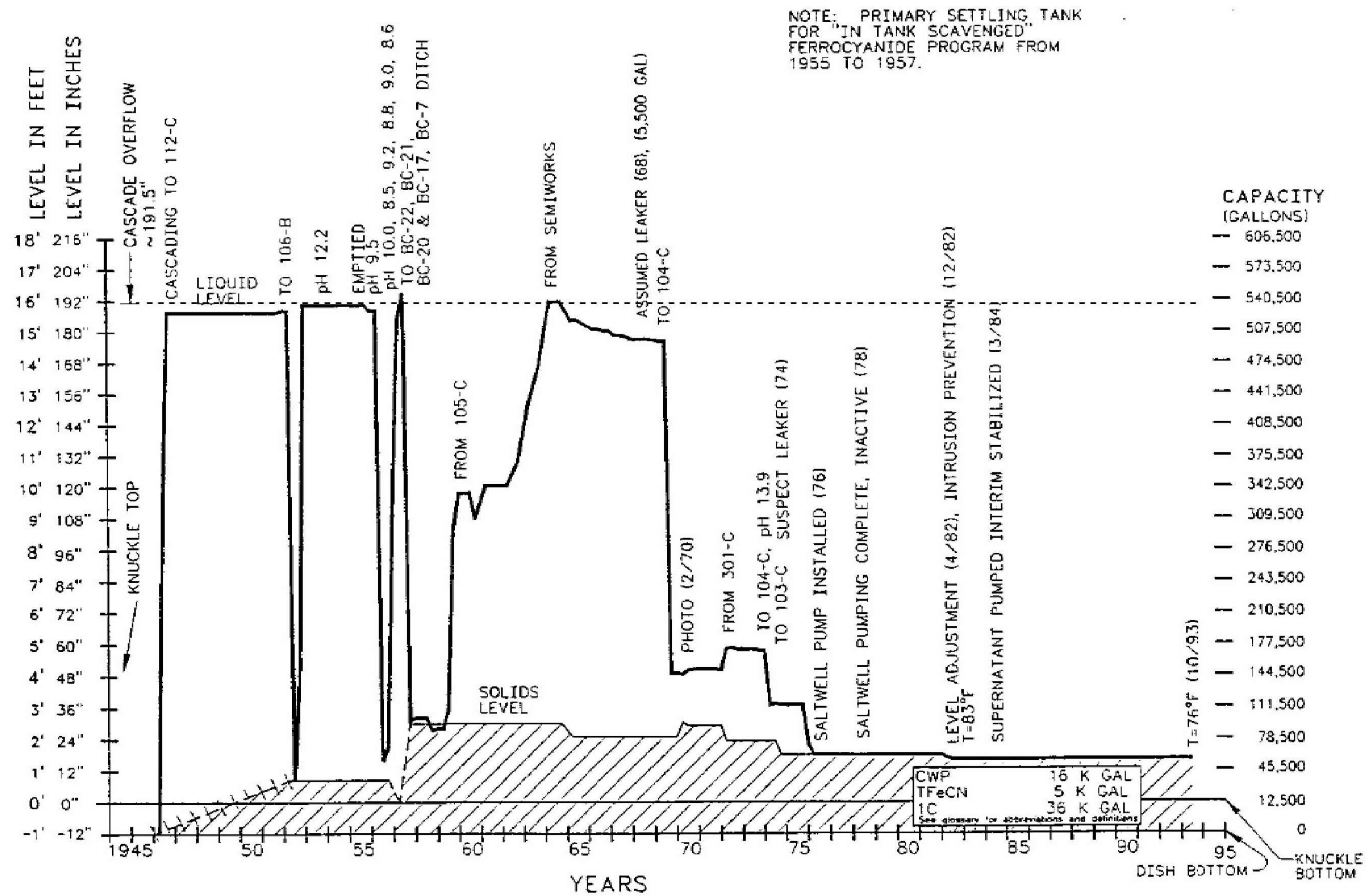


Figure B3-5. Tank C-111 Quarterly Waste History (WCH-SD-WM-ER-349)



B3.5.2 DRYWELL LOGGING DATA

Nine vadose zone monitoring drywells surround tank C-111.These are 30-11-01, 30-08-12, 30-11-05, 30-11-06, 30-10-02, 30-10-01, 30-11-09, 30-00-10, and 30-11-11. Figure B3-5 presents SGLS results from 1997 logging activities. The SGLS detected a peak Cs-137 concentration of 10 pCi/g from 0 to 25 ft bgs in all the drywells and from 50 to 70 ft bgs in drywells 30-08-12 and 30-10-02.

B3.5.3 Discussion of Data Reviewed

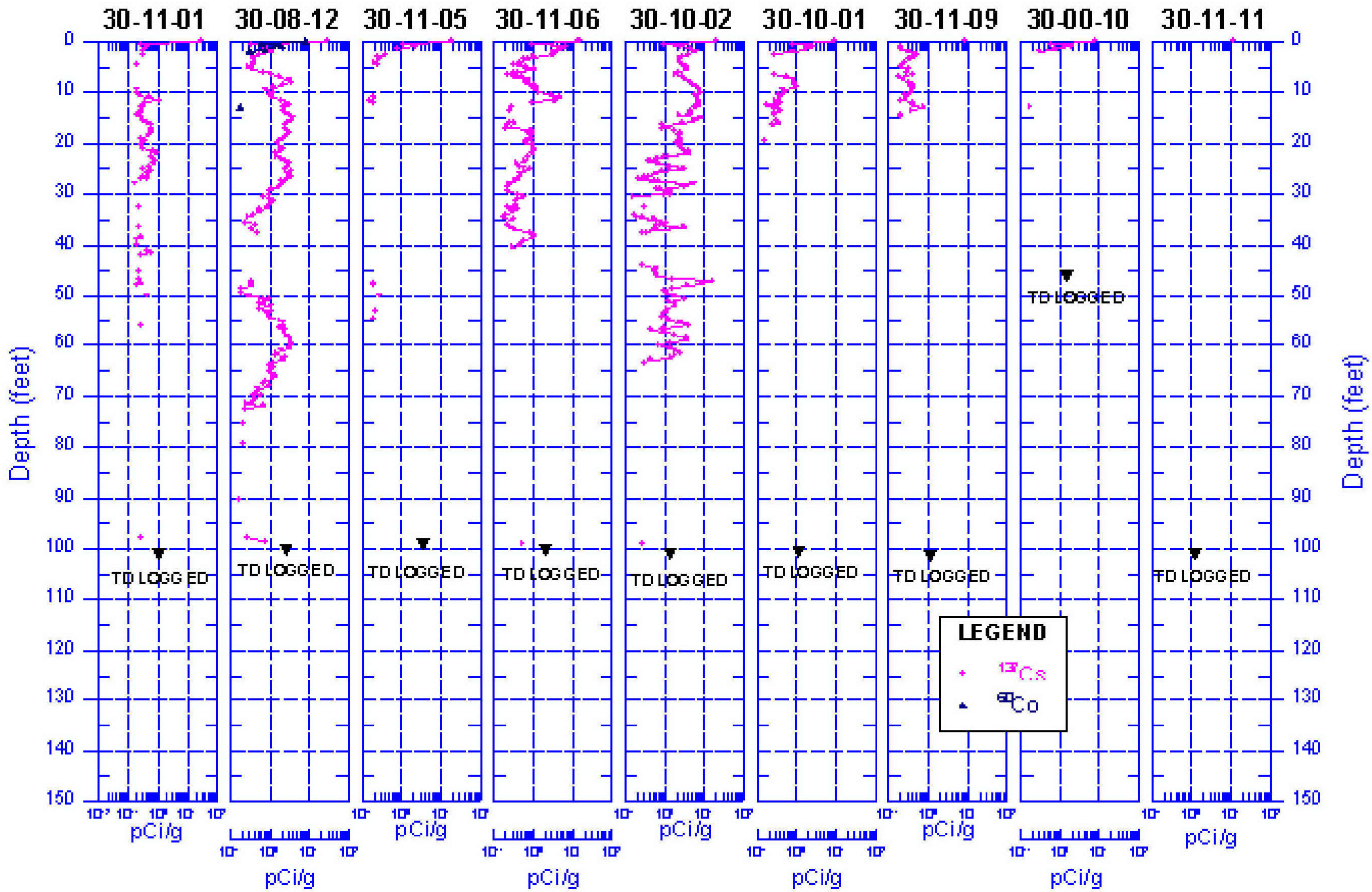
The summary information shown in Table **B3-3** for tank C-111 was discussed.

Minor surface level activity and less than 10 pCi/g of ^{137}Cs was detected in drywells surrounding tank C-111 when gamma spectral logging was conducted between 1997 and 2000 (GJPO-HAN-18, 1998 and GJO-98-39-TARA, 2000).

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.

Figure B3-5. 1997 Spectral Gamma Logging Results for Drywells near Tank 241-C-111 (GJ-HAN-93).



A key difference in current evaporation calculations and previous estimates (RHO-CD-1193) is that previous report estimated evaporation for a 100°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°F or higher.

Between October 1, 1965 and December 26, 1969 there was an unexplained 8.5 in surface level decrease in the tank, equivalent to a 23,400 gallon loss. In 1968 the tank was declared to be a "Questionable Integrity" tank. During the fourth quarter of 1969, 350,000 gallons of supernatant were removed from the tank. No further liquid level decreases were reported once the transfer was made, and the liquid level appears to have remained stable until tank C-111 received catch tank waste in the second quarter of CY 1972 (RPP-ASMT-39155).

Four independent teams from June, 1980 – April, 1981 reviewed the 1965 – 1969 data as part of a coordinated review of six single-shell tanks classified as "Questionable Integrity" tanks. Three of the four teams recommended that the tank C-111 leak integrity status be changed from "Questionable Integrity" to "Confirmed Leaker"; the fourth team recommended that the existing Questionable Integrity classification be retained. According to the ground rules in effect, the teams' recommendations had to be unanimous to change the Questionable Integrity classification to "Confirmed Leaker". In 1984 the "Questionable Integrity" and "Confirmed Leaker" tank classifications were combined and changed to "Assumed Leaker". A leak volume estimate was not made until 1989, when a 5,500 gallon volume was assigned.

The leak assessment report RPP-ASMT-39155, *Tank 241-C-111 Leak Assessment Report*, documented the recommendation that the tank C-111 leak integrity status be revised from "Assumed Leaker" to "Sound". It was concluded in the assessment report that the most probable explanation for the 1965 – 1969 surface level decrease in tank C-111 was evaporation of the thermally hot waste. Calculations showed that a passive breathing rate of about 2.3 cubic feet per minute of 190 °F saturated air would account for the loss, when combined with the thermal contraction as the waste began to cool during the latter part of the 1965 through 1969 period. The 2.3 cubic feet per minute passive breathing rate is small compared to single-shell tank passive breathing rates measured during the 1990's.

Table B3-3. 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. 280 (July 2011) 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).**
1974 Leak	1968	22,000	None	7,000 Ci Cs-	Accession # D196207372, LET-013074, "Radionuclide

Table B3-3. Tank C-111 Leak Information Summary

Item	When	Estimated Leak Volume (gallons)	Range of Leak Volume (gallons)	Possible Sources	Comments
Estimate				137 (1968)	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			

B4.0 TANK 241-C-105

Figure B4-1 details waste transfer operations for tank C-105.

B4.1 TANK 241-C-105 WASTE HISTORY

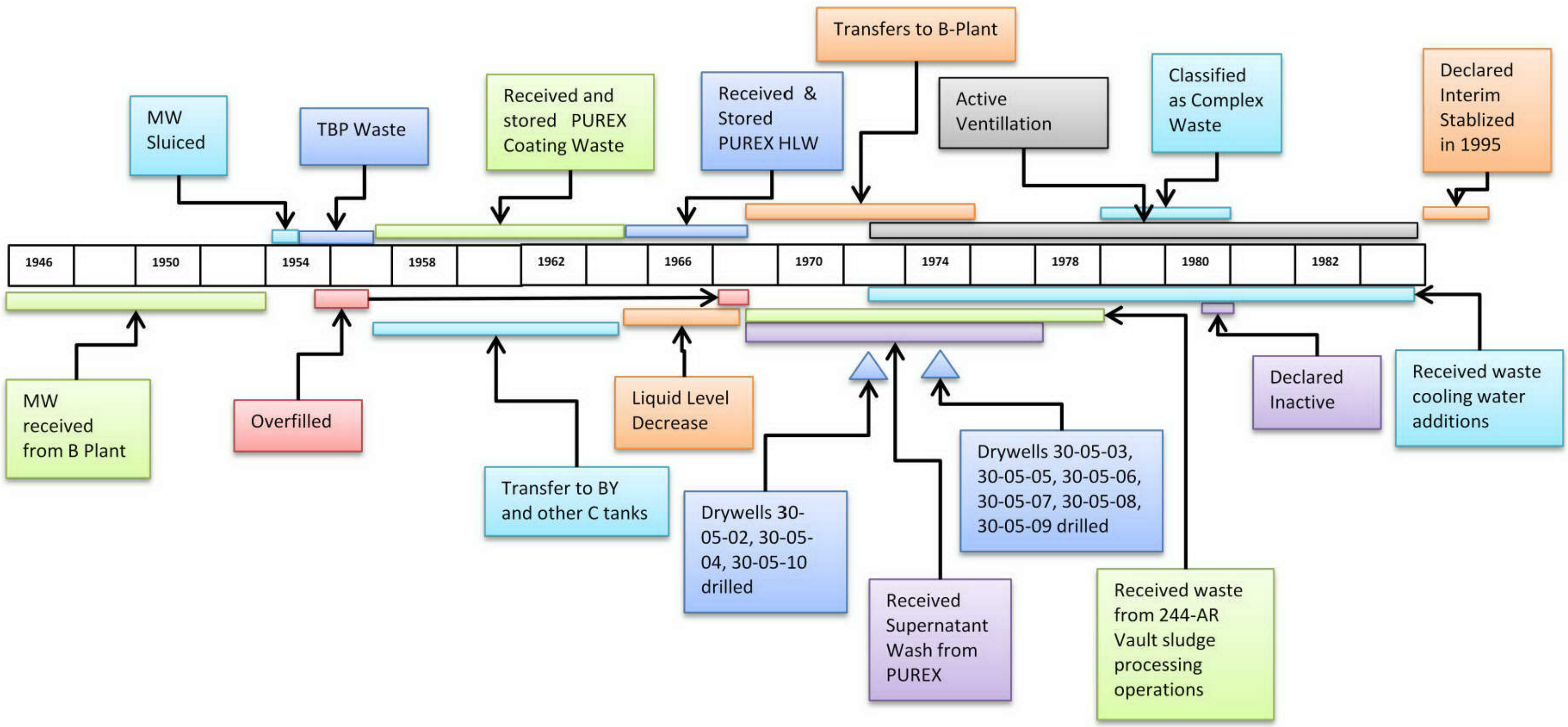
Tank C-105 is a single-shell tank (SST), which was constructed in 1944 through early 1945. SST C-105 has a capacity of 530,000 gallons and a diameter of 75-ft (W-72743). A cascade overflow line connects SST C-105 as second in a cascade series of three tanks continuing through SSTs C-104 and C-106. The cascade overflow line 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. 280). The operational history for SST C-105 for 1947 through 1980 is presented in WHC-MR-0132 and summarized in the following discussion.

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.

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.

Figure B4-1. Tank 241-C-105 Waste Operations Summary



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).

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.

B4.2 INTEGRITY & INTERIM STABLIZATION OF TANK 241-C-105

Tank C-105 is designated as a "sound" tank (HNF-EP-0182). However, since the initial C-Farm assessment report was written, additional data was collected in support of an integrity assessment for tank C-105 (RPP-ASMT-46452). Based on direct push logging results obtained for the assessment, the integrity assessment panel concluded that the inlet cascade line to C-105 leaked and the tank may have leaked, and the panel recommended that the tank classification be changed to "assumed leaker." C-105 was interim stabilized in October, 1995. Figure B4-2 shows an interior photo mosaic of C-105's waste surface. Stabilization records note that a net volume of 12,000 gallons of liquid was evaporated from C-105 between May, 1993, and October, 1995 (HNF-SD-RE-TI-178). As of October, 2009, tank C-105 contains 132 kgal consisting of 119 kgal CWP1 solids and 113 kgal TBP solids (RPP-RPT-43032, Rev.0).

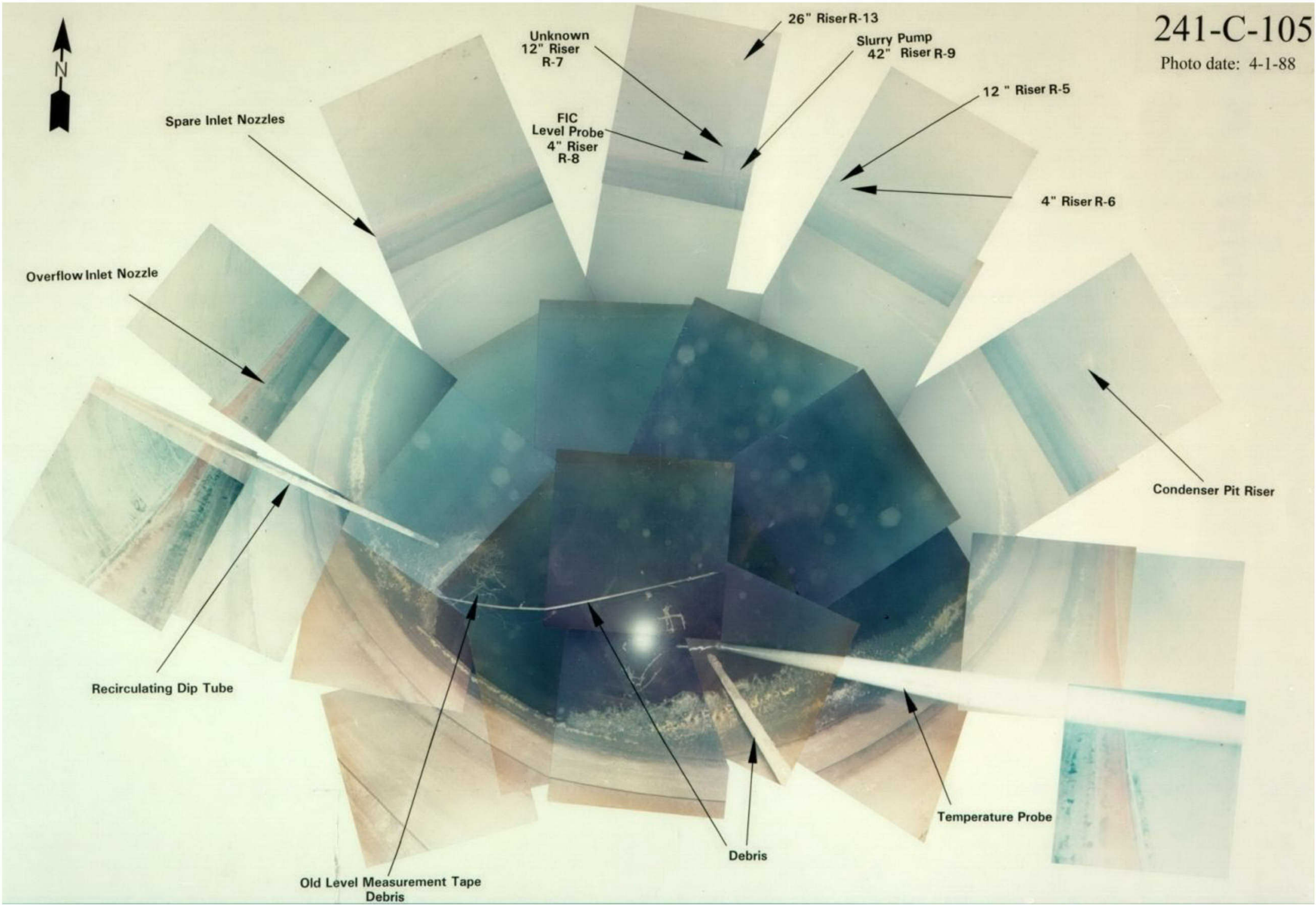
B4.3 TANK 241-C-105 TEMPERATURE HISTORY

Interior tank temperature data for tank C-105 was recorded by 7 thermocouples connected to a single thermocouple tree (WCH-SD-WM-ER-349). Figure B4-3 shows temperatures for thermocouples at 38 inches, 86 inches, and 192 inches in risers 12, 14 and 16 between 1986 and 2011.

B4.4 DATA REVIEW & OBSERVATIONS

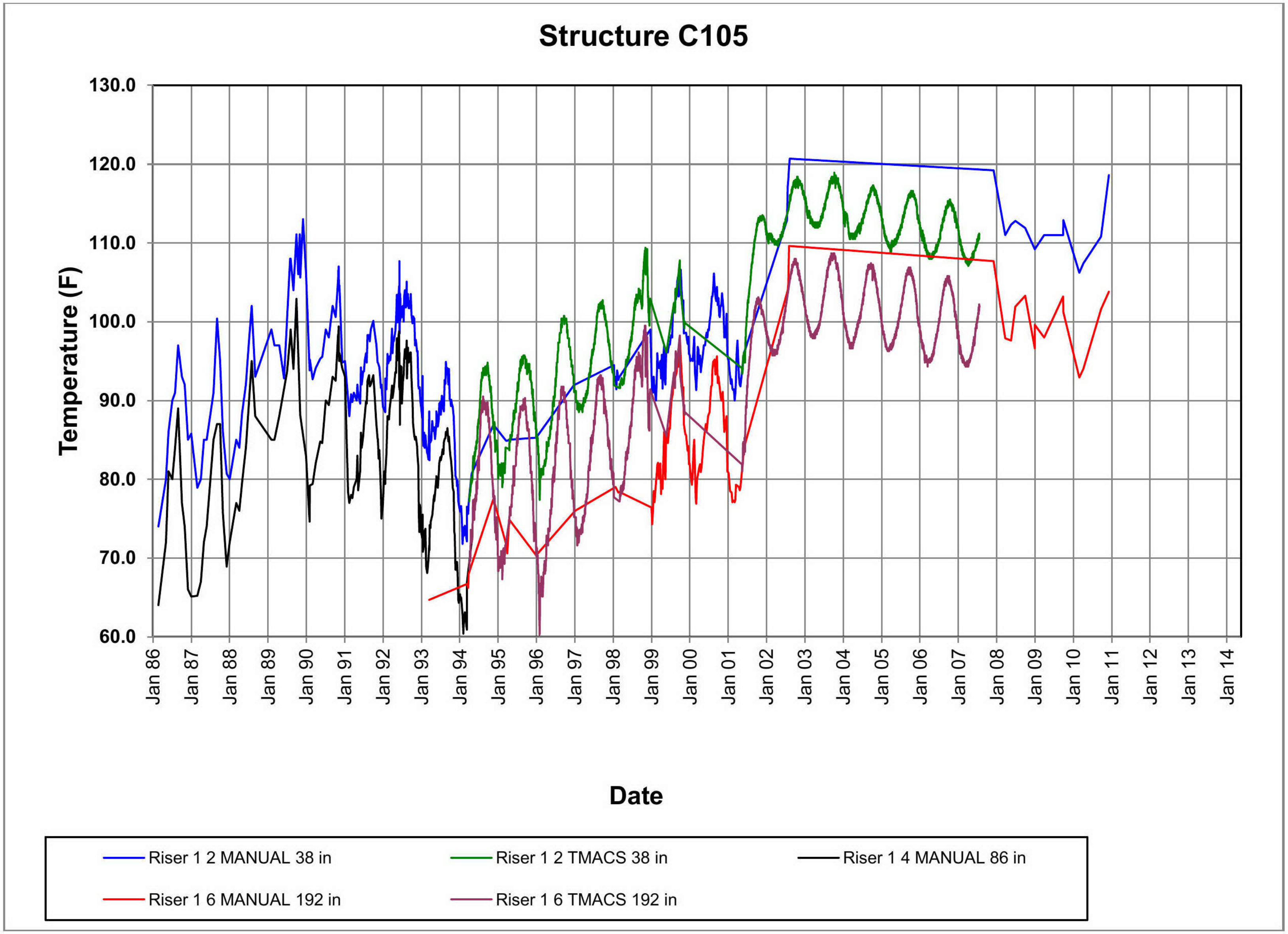
The following sections contain surface level and drywell logging data and assessment discussions of data reviewed additional discussion is included in meeting summaries (Appendix A).

Figure B4-2. Tank 241-C-105 Waste Surface Photo Mosaic



Reference: WHC-SD-WM-ER-349, *Historical Tank Content Estimate for the Northeast Quadrant of the Hanford 200 West Area*.

Figure B4-3. Tank 241-C-105 Waste Temperature Measurements



B4.4.1 TANK SURFACE LEVEL MEASUREMENTS

Tank C-105 was filled to 546 kgal in the third quarter of 1954 and remained that full until the end of 1955. C-105 was again filled to 538 kgal in 1957 and 543 kgal in 1958 (Figure B4-5). A 36 inch (~100,000 gal) liquid level decrease was observed between 1963 and 1967. This decrease was attributed to evaporation. The actual tank temperature from 1963 to 1967 is unknown. The temperature of supernatant received from tank A-102 was 220°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°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°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°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 liquid level measurements between 1973 and 1987 are detailed in Table B4-1, while liquid level measurements for different measurement devices between 1981 and 2011 are shown in Figure B4-4.

Occurrence reports relating to liquid level changes in tank C-105 include the following:

On November 4, 1976, a gradual liquid level decrease exceeded the 0.5 inch action criteria. The decrease was attributed to evaporation (OR-76-173).

Table B4-1. Tank 241-C-105 Liquid Level Measurements and Changes (1973-1987)

TANK 105-C

Liquid Level.

Date	Liquid level (in.)	Baseline ref.	Change from previous reading (in.)	Cumulative change (in.)	Comments
06/15/73	79.00		-	-	
07/11/73	78.50		-0.50	-0.50	Slow decrease
07/13/73	85.50		-	-0.50	Calibration
07/23/73	85.10		-0.40	-0.90	Slow decrease
08/30/73	83.80		-1.30	-2.20	Slow decrease
10/03/73	82.00		-1.80	-4.00	Slow decrease
11/10/73	80.80		-1.20	-5.20	Slow decrease
02/08/74	79.00		-1.80	-7.00	Slow decrease
03/02/74	78.50		-0.50	-7.50	Slow decrease
03/13/74	78.95		-	-7.50	Transfer
03/21/74	121.20		-	-7.50	Transfer
03/30/74	158.10		-	-7.50	Transfer
05/15/74	157.20		-0.90	-8.40	Slow decrease
06/16/74	156.60		-0.60	-9.00	Slow decrease
07/14/74	155.40		-1.20	-10.20	Slow decrease
08/02/74	154.75		-0.65	-10.85	Slow decrease
08/09/74	155.80		-	-10.85	Water flushes
09/06/74	153.50		-2.30	-11.15	Slow decrease
09/23/74	85.40		-	-11.15	Transfer
09/27/74	79.20		-	-11.15	Transfer
09/28/74	79.60		+0.40	-10.75	Drain back
10/27/74	78.00		-1.60	-12.35	Slow decrease
11/27/74	76.55		-1.45	-13.80	Slow decrease
12/02/74	76.30		-0.25	-14.05	Slow decrease
12/07/74	98.85		-	-14.05	Transfer
01/07/75	97.00		-1.85	-15.90	Slow decrease
02/21/75	95.50		-1.50	-17.40*	Slow decrease
04/16/76	76.30		-	-17.40	Transfers
05/24/76	75.95		-0.35	-17.75	Below minimum slow decrease
05/25/76	76.10		-	-17.75	Water added
06/05/76	76.65		-	-17.75	Water added
07/21/76	76.10		-0.55	-18.30	Slow decrease
07/22/76	76.70		-	-18.30	Water added
09/08/76	76.60		-0.10	-18.40	Stable
10/15/76	116.20		-	-18.40	Transfers
12/13/76	114.20		-2.00	-20.40	Slow decrease
02/05/77	77.00		-	-20.40	Transfers

*The liquid-level decrease as reflected in the cumulative change is consistent with the measured amount of water vapor in the exhaust system (3.5-0.57 in./wk).

Figure B4-4. Tank 241-C-105 Waste Surface Level Measurements

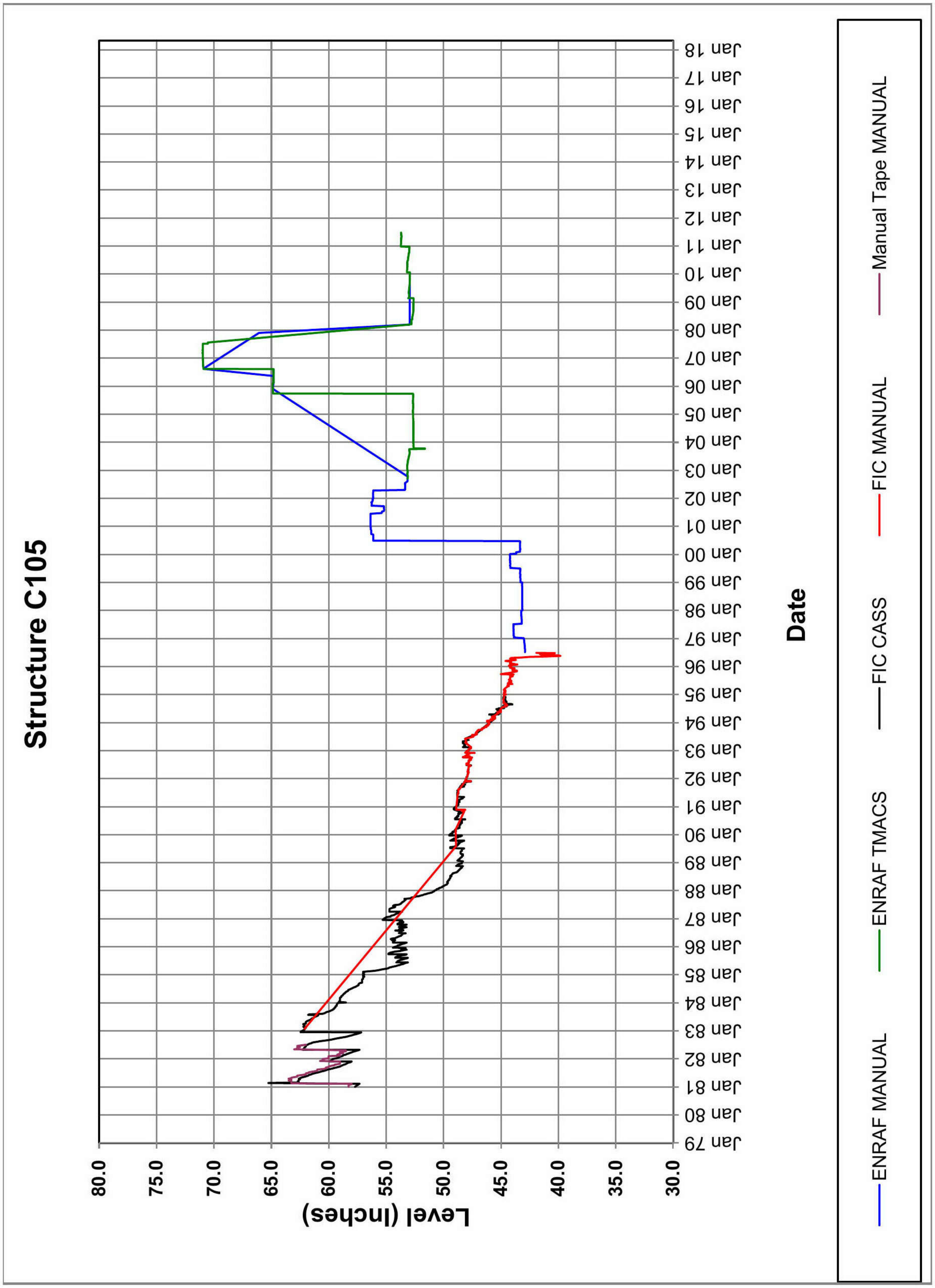
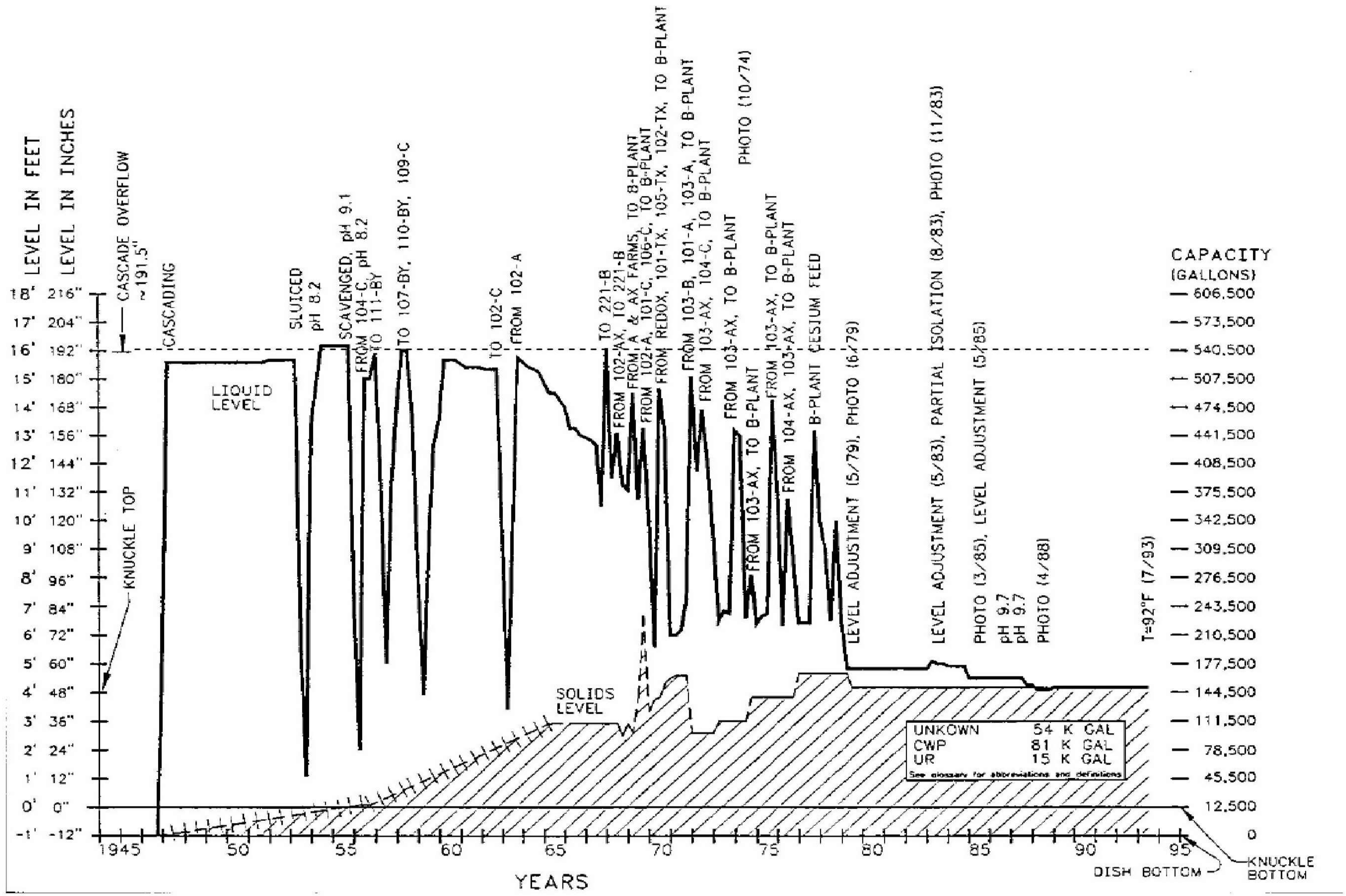


Figure B4-5. Tank C-105 Quarterly Waste Fill History

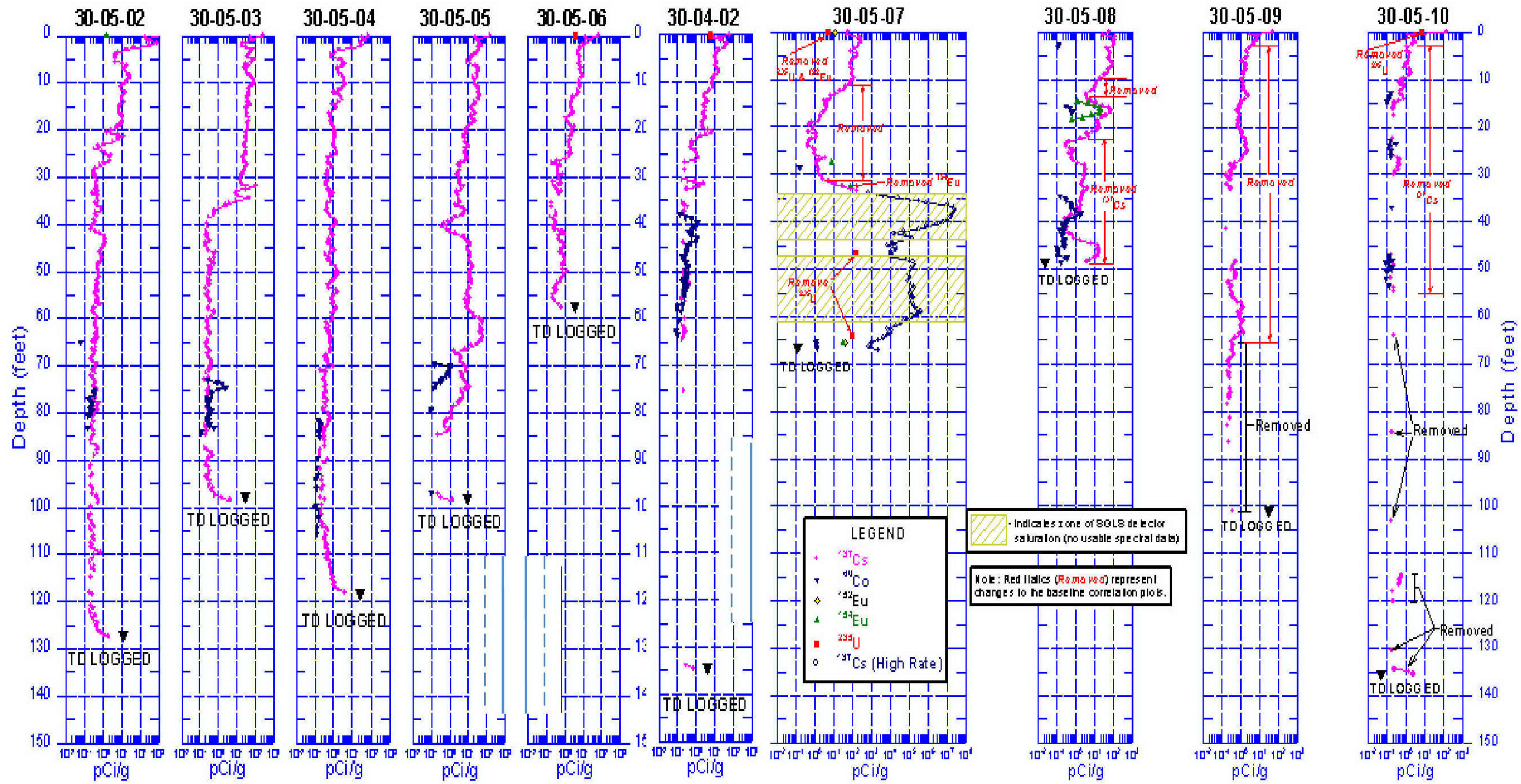


B4.4.2 DRYWELL LOGGING DATA

Ten vadose zone monitoring drywells surround tank C-105. These drywells are 30-05-02, 30-05-03, 30-05-04, 30-05-05, 30-05-06, 30-05-07, 30-04-02, 30-05-08, 30-05-09, and 30-05-10. The SGLS detected a significant amount of near-surface and shallow subsurface Cs-137 activity amd moderate to high Cs-137 activity at the ground surface in all the drywells (Figure B4-6). In addition, a zone of elevated Cs-137 activity was detected below 41 ft in drywell 30-05-02. This activity zone occurs approximately 3 ft below the base of the tank.

On August 13, 1974, drywell 30-04-02, located halfway between C-104 and C-105, showed an increase in radiation at the 40 foot depth .There were no abnormal liquid level measurements in C-105 that might coincide with the increased radiation readings (OR-74-120, *Increasing Drywell Radiation between Tanks C-104 & C-105*).

Figure B4-6. 1997 Spectral Gamma Logging Results for Drywells near Tank 241-C-105 (GJ-HAN-83).



B4.4.3 Discussion of Data Reviewed

The radioactivity detected in drywells around SST C-105 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, indicating a potential leak in the tank liner near the bottom of SST C-105.

Several pipeline, spare inlet nozzle, and cascade line waste loss events occurred in the vicinity of SSTs C-104 and C-105, which are summarized in Table B4-2. 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, significant radionuclide activity was detected in drywell 30-05-07, located near SST C-105. These events are discussed further below.

a) Waste Loss from SST C-105 Spare Inlet Nozzles: 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 activity 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, 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. ^{137}Cs is detected from the ground surface to the bottom of the drywell. ^{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 drywell 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 activity 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 gamma activity between 14-ft and18-ft is likely associated with pipeline V103. This activity may reside inside the pipeline, since the gamma logging of the drywell does not differentiate between gamma activity in the soil and buried objects.

Table B4-2. Potentially New Unplanned Releases of Waste in Vicinity of Tanks C-104, C-105 and C-106 (3 sheets)

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 B4-2. Potentially New Unplanned Releases of Waste in Vicinity of Tanks C-104, C-105 and C-106 (3 sheets)

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 B4-2. Potentially New Unplanned Releases of Waste in Vicinity of Tanks C-104, C-105 and C-106 (3 sheets)

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°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 is located between SSTs C-104 and C-105, near the cascade line and transfer pipeline V103. The activity 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 drywells were drilled to better define the source of activity. 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-105 and a few feet from pipeline V103. Sediments were obtained during installation of drywell C4297 and water extracted for analyses (RPP-23752). Spectral gamma analysis of drywell C4297 was conducted in 2004 (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 activity 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 activity (>10^7pCi/g) have been found in drywell 30-05-07 between 36 and 40 feet bgs, (Figure B4-X). 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 steadily decreased after first being detected (RPP-8321, pg. 211).

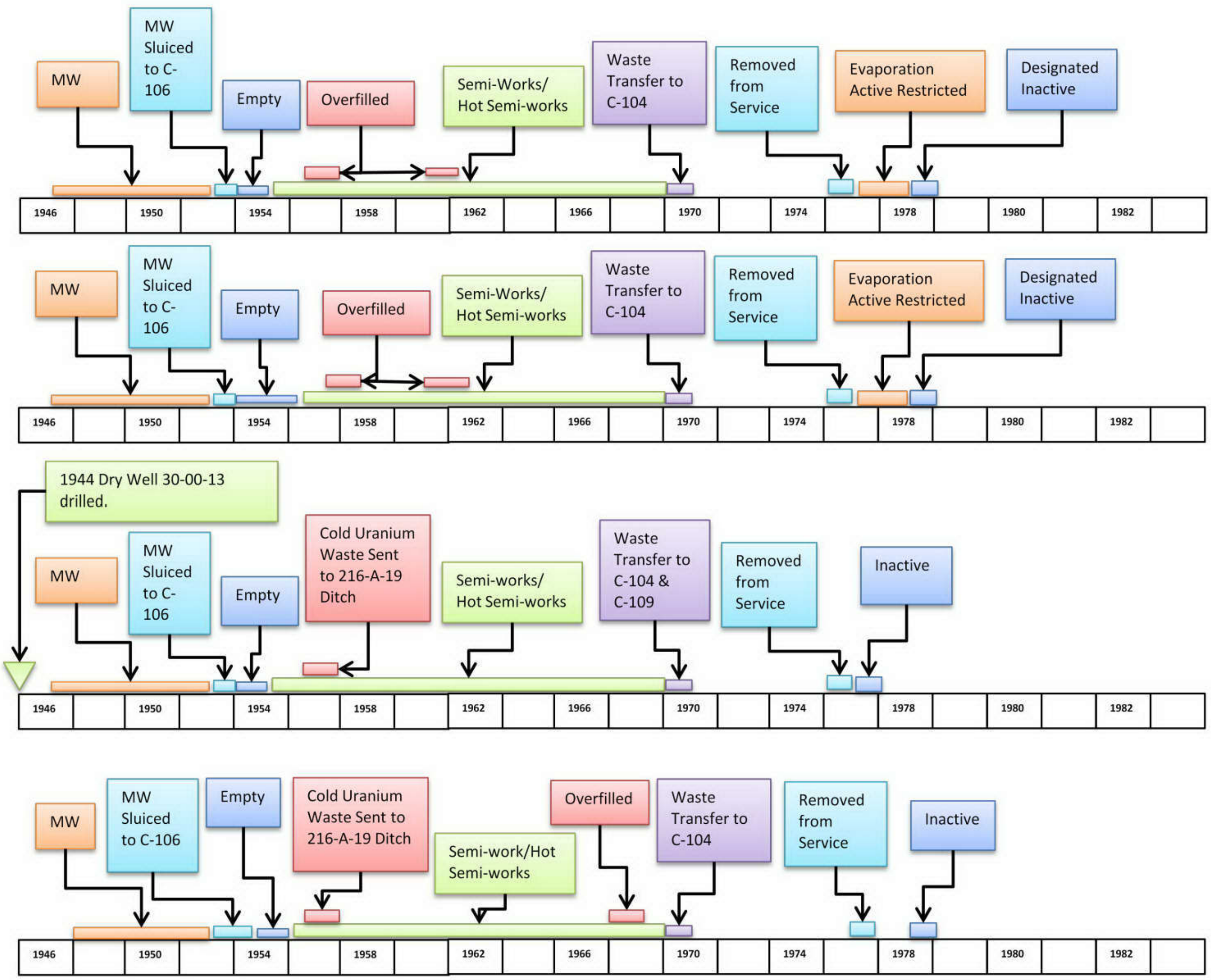
e) Waste loss from C-104 Atmospheric Condenser: The single-shell tanks that contained high heat generating wastes were equipped with an atmospheric condenser. The atmospheric condenser sat on a concrete pit atop the tank. A gasket sealed the atmospheric condenser to the concrete pit. Tank vapors were 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. 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.

B5.0 241-C-200 TANKS

Figure B5-1 details waste transfer operations for the C-200 series tanks. For additional detail on C-200 tank waste history and leak evaluations see the August 3, 2010, Meeting Summary and Attachment in Appendix A.

Figure B5-1. Tank 241-C-200 Series Tanks Waste Operations Summaries



B6.0 241-C 100 SERIES TANK WASTE VOLUMES

Table B6-1 shows percent-filled and volume data for the C-100 series single shell tank cascades between January, 1945 and July 1951 and for individual tanks between April 1952 and December, 1980. No data was available between August 1951 and May 1952. .

Table B6-1. 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
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
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
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						
April 1952 through December 1980 (Kgal)[1]							
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
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
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
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
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
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				
April 1952 through December 1980 (Kgal)[1]											
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
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
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
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

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
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
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

[1]Waste levels greater than 349 kgal for 100 series tanks or 56 kgal for 200 series tanks (above the spare inlet nozzle level) are hi-lighted.

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APPENDIX C

241-C TANK FARM INFORMATION SUMMARIES: TANKS CLASSIFIED AS SOUND

C1.0 TANK 241-C-102

The BBI assessment for tank 241-C-102 (C-102) is the same as that presented in HNF-SD-RE-TI-178, estimating the tank volume at 1,196 kL (316 kgal). Based on its process history (LA-UR-96-3860), the waste is expected to be a mixture of Plutonium-Uranium Extraction (PUREX) aluminum cladding waste from 1956-1960 (CWP1), and 1961-1972 (CWP2), PUREX decladding waste (CWZr1), tri-butyl phosphate waste from the uranium recovery process (TBP), high level thorium waste (TH1), and residual metal waste from 1944-1949 (MW1). The waste is assumed layered in the tank in the order the waste was received. Intrusion prevention has been completed.

Figure C1-1 details waste transfers for tank C-102.

C1.1 HISTORY

Tank C-102 was put into service in October 1946. Initially tank C-102 received metal waste from the cascade overflow of tank C-101 beginning in May 1946. Tank C-102 contained metal waste from the second quarter of 1946 until the second quarter of 1953. In 1953, the tank was sluiced to a sludge heel to recover uranium from the metal waste. From the third quarter of 1953 until the first quarter of 1954, tank C-102 received uranium recovery waste. From the third quarter of 1954 until the fourth quarter of 1961, tank C-102 contained U Plant waste. During the second quarter of 1957, the waste in tank C-102 was scavenged and pumped out of the tank. From the third quarter of 1960 until the fourth quarter of 1969, C-102 received PUREX cladding waste. Also during the third quarter of 1960, the tank received wastewater. Tank C-102 received Thorium high level waste during the second quarter of 1966. From the second quarter of 1968 until the first quarter of 1969, C-102 received PUREX organic wash waste. Presently, the tank waste is classified as dilute complexed waste.

C1.2 SURFACE LEVEL DATA

As shown in Figure C1-2, tank C-102 was filled to above the inlet/spare inlet ports (note the residual waste solids on the top of the inlet pipe). Figure C1-3 shows historical quarterly waste levels for tank C-102 from 1946 to 1996, while Figure C1-4 shows surface level data from 1980 to present.

Occurrence reports relating to C-102 liquid levels include the following:

OR-74-141: Liquid Level Decrease
On December 2, 1975, a liquid level decrease in excess of 0.5 inches occurred. The decrease was attributed to measurement errors resulting from the character of the waste surface in Tank C-102.

Figure C1-1. Tank 241-C-102 Waste Operations Summary

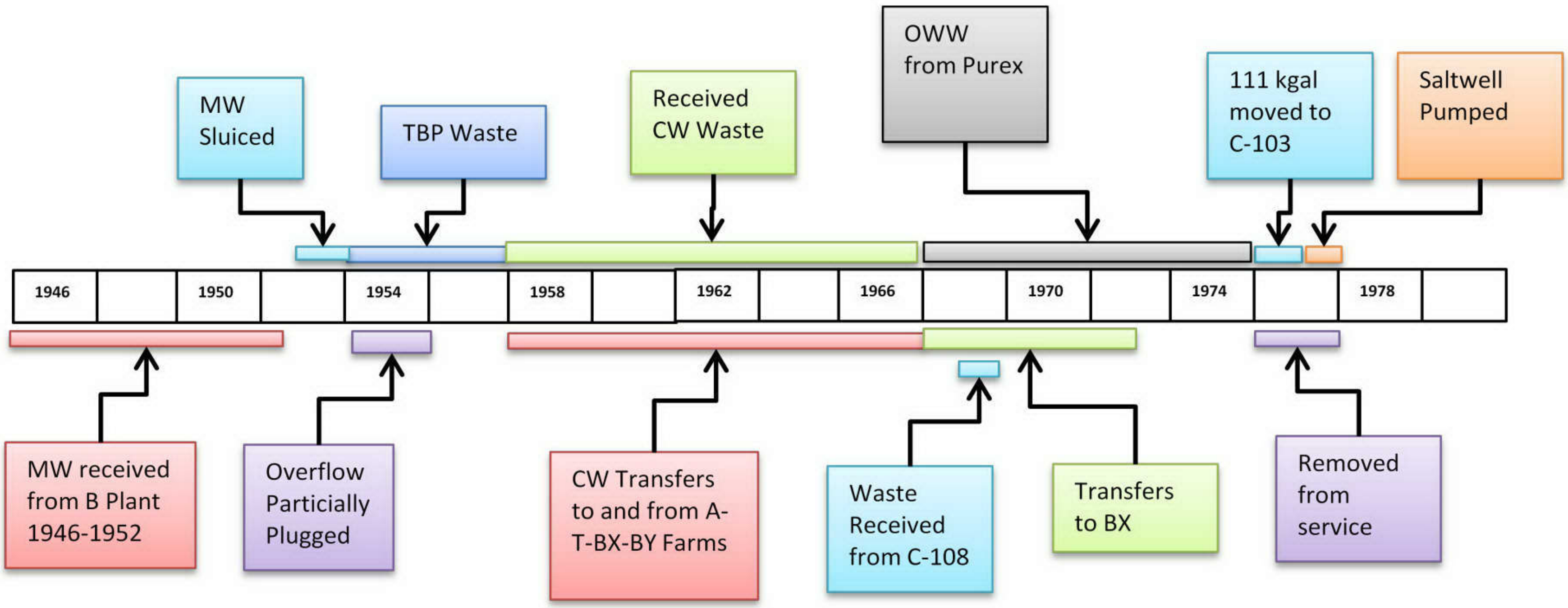


Figure C1-2. Tank C-102 Interior Photograph

C1.3 DRYWELL DATA

Five vadose zone monitoring drywells (30-03-07, 30-00-03, 30-01-01, 30-05-05, and 30-05-04) are located near tank C-102. Figure C1-5 details spectral gamma-ray logging results for these drywells. GJ-HAN-86 notes that the vadose zone in the immediate vicinity of tank C-102 could not be characterized because of a lack of adequately placed monitoring drywells. Data obtained with the SGLS from drywells associated with nearby tanks and geologic and historical information indicate that the source of the ^{137}Cs activity detected around this tank may be from a combination of surface spills and pipeline and tank leaks. Any of the tanks near tank C-102 or their associated piping could be the source of this activity. The ^{60}Co activity appears to have originated from a tank other than tank C-102.

Figure C1-3. Tank 241-C-102 Quarterly Surface Levels

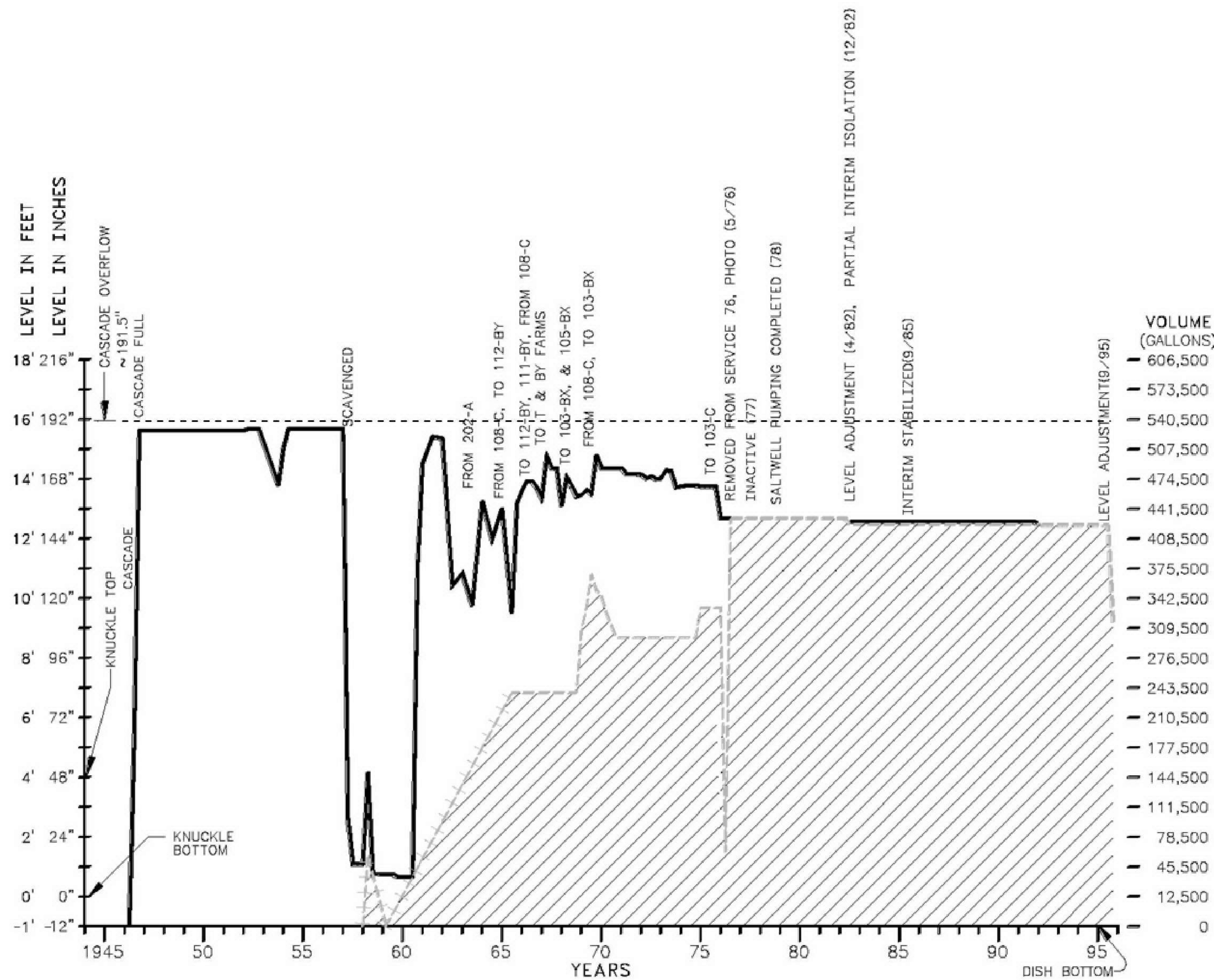


Figure C1-4. Tank 241-C-102 Surface Level Data

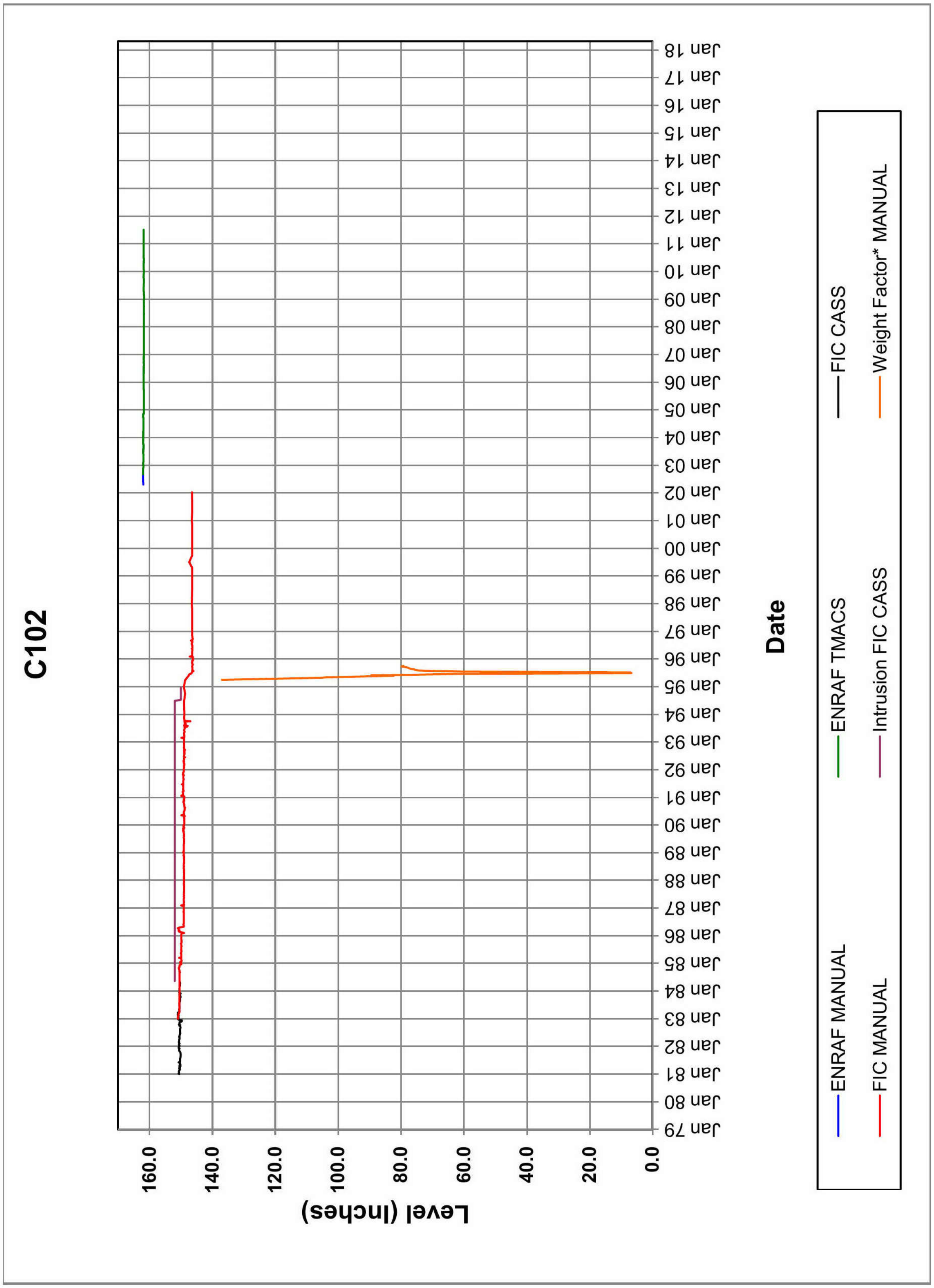
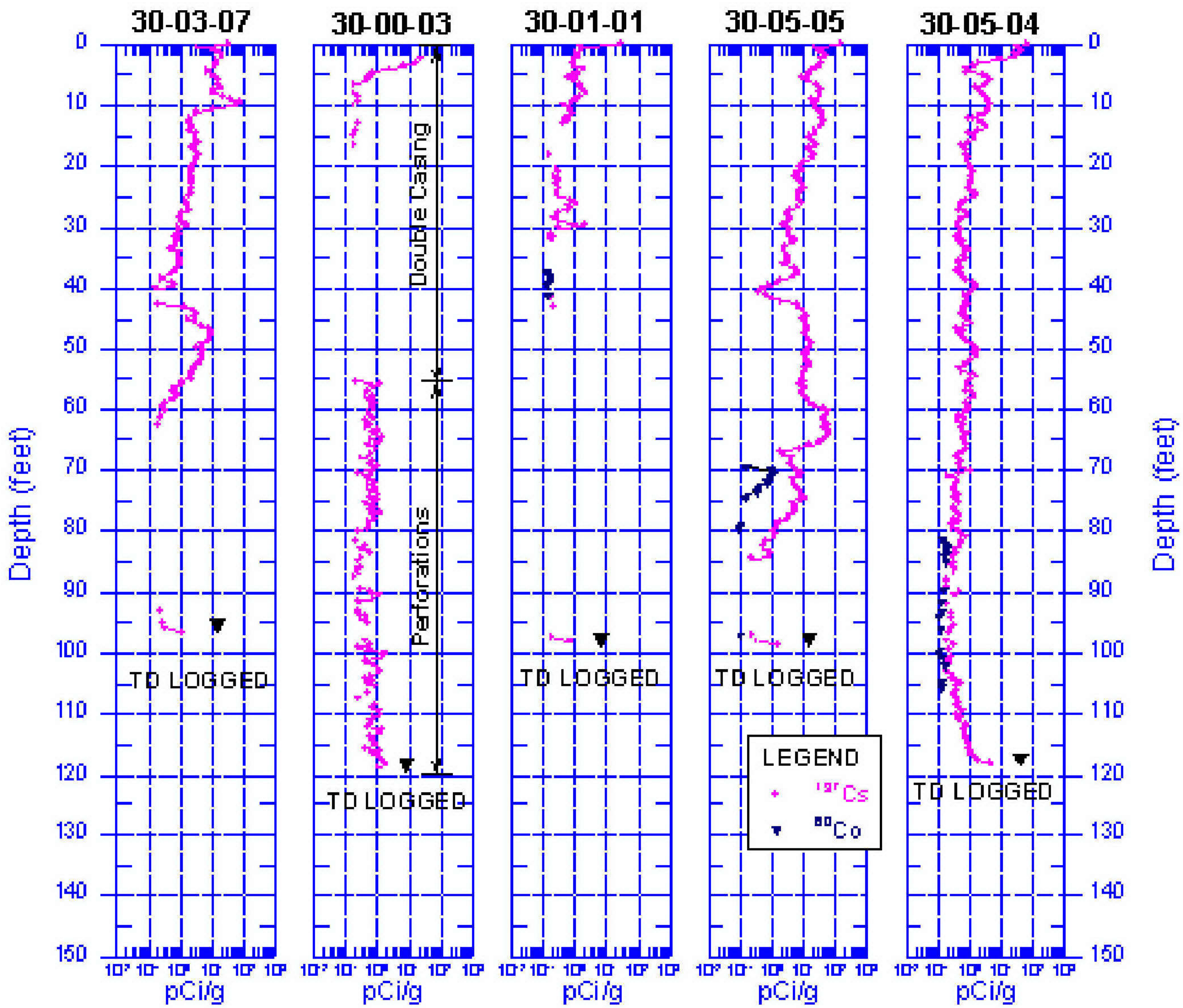


Figure C1-5. 1997 SGLS Logging Near Tank C-102 (GJ-HAN-86)



C2.0 TANK 241-C-103

Tank 241-C-103 (C-103) underwent waste retrieval operations from November 2005 and completed on June 30, 2006. Final water rinses of the residual waste were done on August 23, 2006. RPP-31159, *Post-Retrieval Waste Volume for Single-Shell Tank 241-C-103*, estimates that only 8.64 kL (2.28 kgal) of solids and 0.930 kL (0.246 kgal) of supernatant remained in the tank. Residual liquid and solids in tank C-103 were sampled after completion of waste retrieval in September 2006.

Figure C2-1 details waste transfers for Tank C-103.

C2.1 HISTORY

Tank C-103 went into service during the third quarter of 1946 when it began receiving metal waste (MW) generated from the bismuth phosphate process (Agnew 1993). In the fourth quarter of 1952, the supernatant was transferred to tank 241-C-109 and the MW was sluiced so uranium could be extracted at the U-Plant. In the third quarter of 1953, tank C-103 began receiving tri-butyl phosphate (TBP) waste from tank 241-C-101, which was stored until the second quarter of 1957 when the TBP waste was transferred to tanks 241-C-111 and 241-C-112, leaving tank C-103 nearly empty. Neutralized Plutonium-Uranium Extraction (PUREX) Plant high-level waste (PUREX high-level waste) was received from tank 241-A-102 during the third and fourth quarters of 1957; however, shortly afterwards, nearly all of this waste was transferred to tank 241-BY-103 during the first quarter of 1958. These transfers most likely consisted of supernatant transfers that contained few solids. Tank 241-C-103 then remained static until the second quarter of 1960 when transfers of aluminum cladding waste (CWP) from PUREX were received and held until 1962 when most of the tank contents were transferred to various tanks within the BX Tank Farm.

Beginning the second quarter of 1963 and extending though 1968, numerous receipts and transfers of PUREX high-level waste supernatant occurred for cesium recovery resulting in a gradual inventory reduction. During the third quarter of 1969, the majority of the supernatant waste was transferred to tank 241-C-105, which allowed for the receipt of B-Plant low-level waste (BL) from tank 241-BX-101 and evaporator bottoms liquid decanted from tank 241-B-102. Most of the waste accumulated in tank C-103 was then staged to tank 241-C-105 as feed for the B-Plant cesium recovery process. During 1970 and 1971, tank C-103 received BL waste and PUREX sludge supernatant (Agnew et al. 1997b). From 1973 to 1978, tank 241-C-103 received waste transfers from other tanks in the C Tank Farm (Agnew et al. 1997b). Finally, in 1979, supernatant was transferred to tank 241-C-104, resulting in a waste volume of 757 kL, at which point tank C-103 was declared inactive. The organic layer that once floated on the aqueous layer was believed to have been received during a transfer from tank 241-C-102 in the fourth quarter of 1975 (Agnew 1993).

Figure C2-1. Tank 241-C-103 Waste Operations Summary

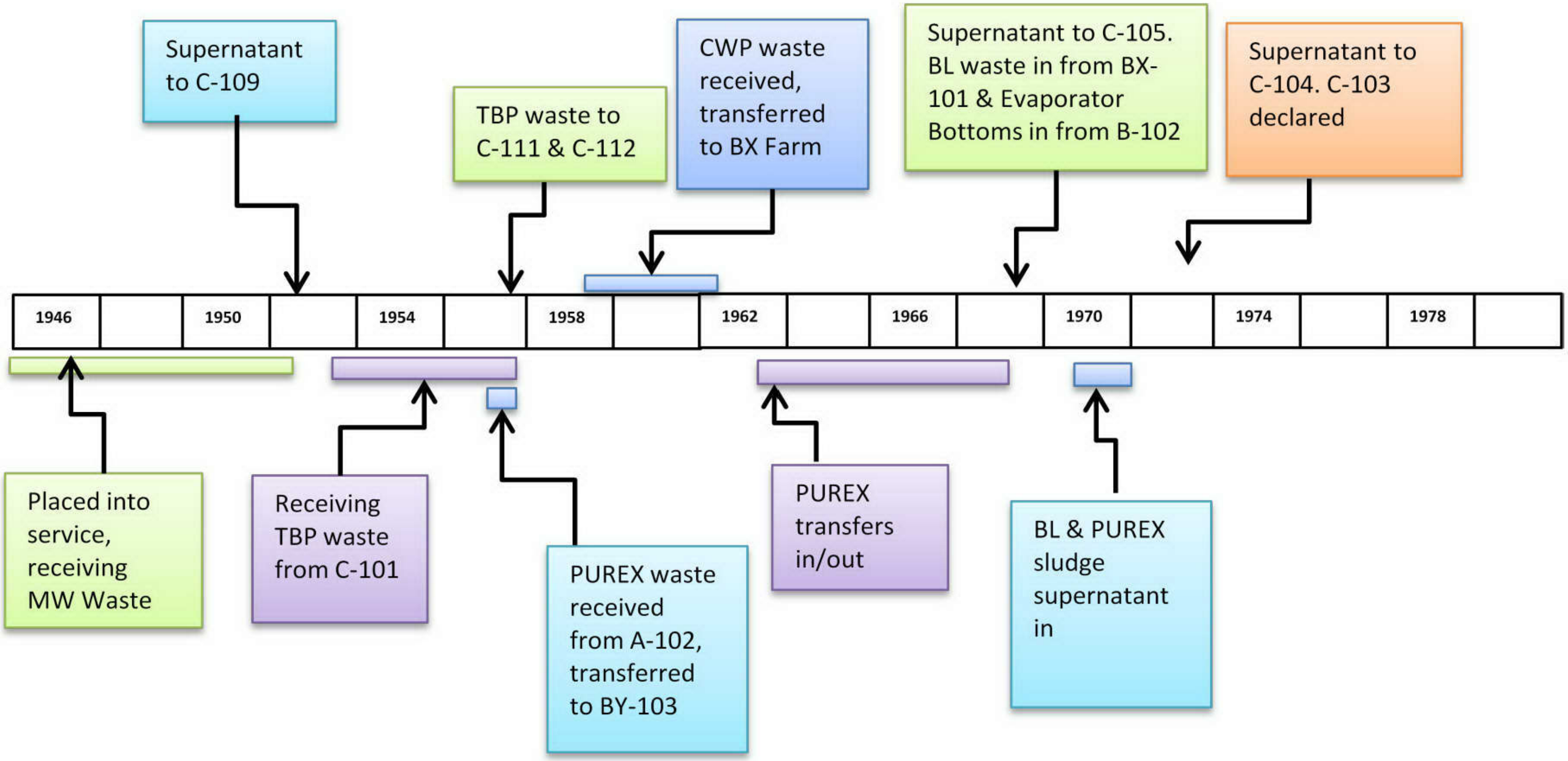


Figure C2-2. Tank C-103 Interior Photograph

C2.2 SURFACE LEVEL DATA

Tank C-103 was filled to 560 kgal from the end of 1953 through 1956 and again overfilled to as high as 563 kgal in 1961 (Anderson 1990). Figure C2-2 shows an interior view near the top of tank C-103. Figure C2-3 shows historical quarterly waste levels for tank C-103 from 1946 to 1996, while Figure C2-4 shows surface level data from 1980 to present. Although slow erratic liquid-level increases were observed in 1979 and 1980, the liquid level appeared to stabilize by 1985 (WHC-SD-WM-TI-356).

Occurrence reports relating to C-103 liquid levels include the following:

WHC-UOR-90-030-TF-07: Potential Flammable Gas Concentration in Waste Storage Tank
Sampling results of tank vapors collected from the C-103 tank in 1990 indicate that concentrations have reached 74 percent of the lower flammability limit. This is the minimum concentration of vapors in air which, if associated with an ignition source, could become flammable.

WHC-UO-88-034-TF-05: Surface Level Measurement Indicated a Decreasing Trend in the Liquid Level in Tank
On October 3, 1988, FIC measurement equipment detected a slow decrease in excess of the 0.50 inch action criteria. The decrease was attributed to evaporation.

Figure C2-3. Tank 241-C-103 Quarterly Surface Levels

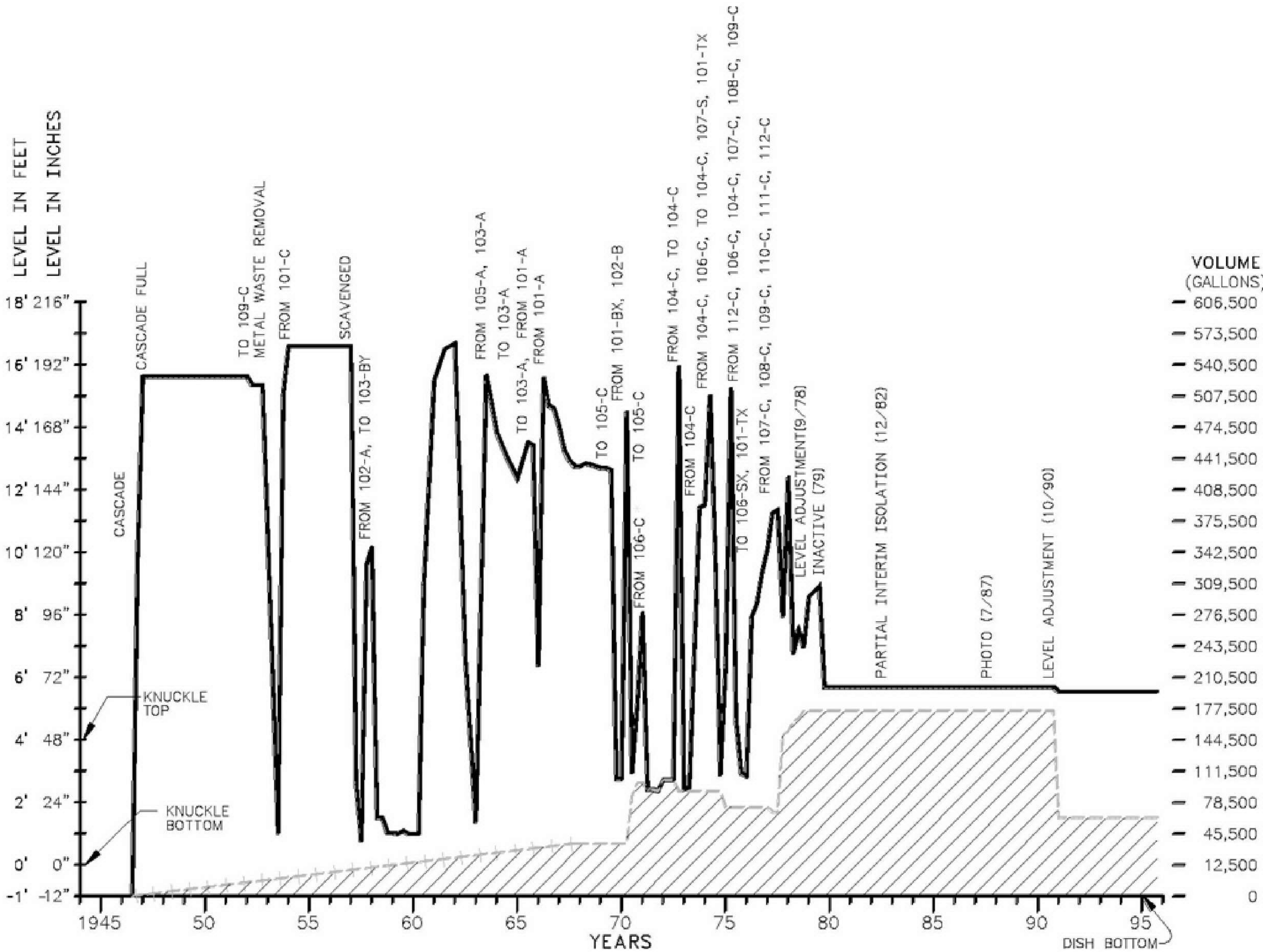
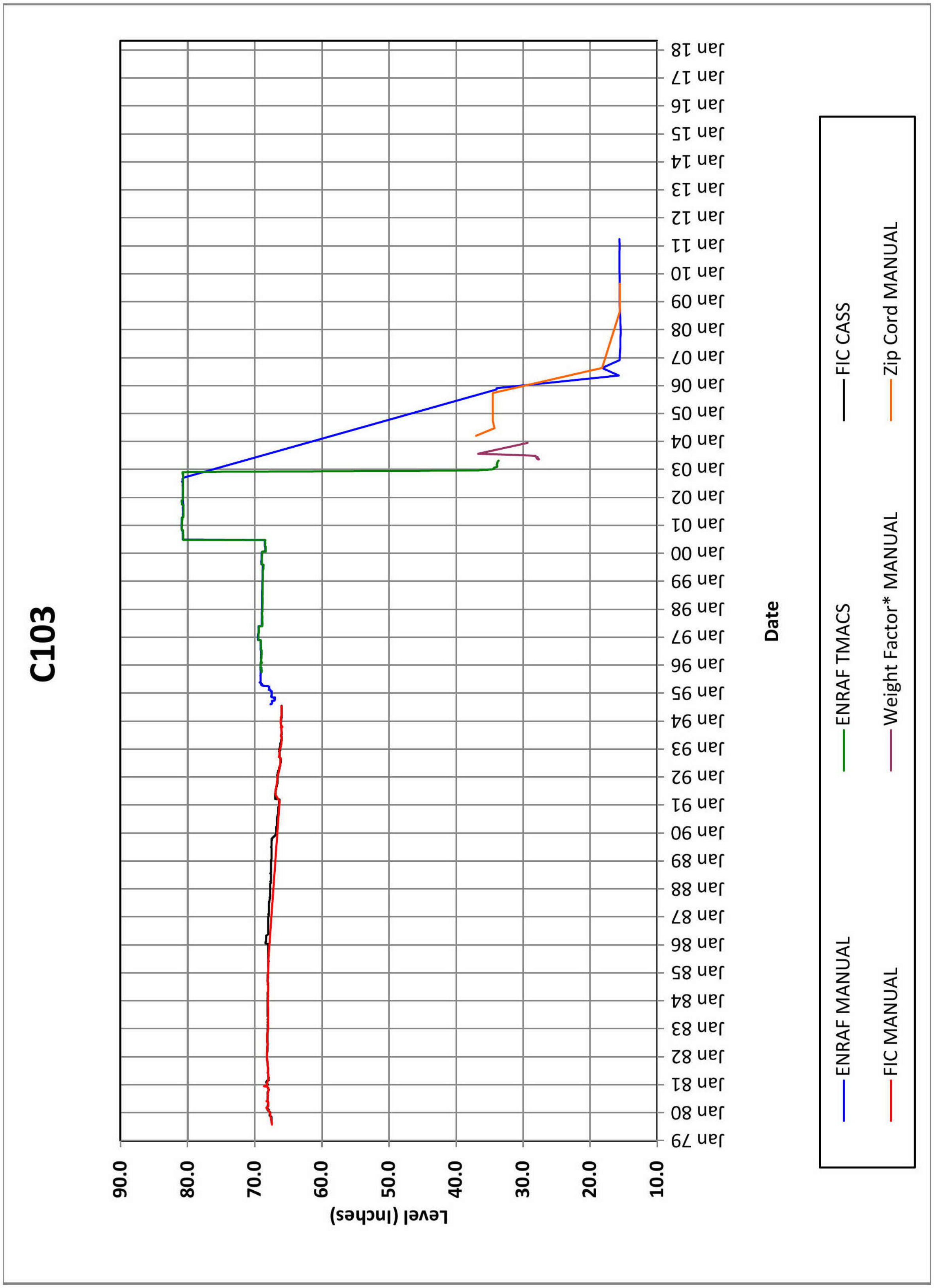


Figure C2-4. Tank 241-C-103 Surface Level Data



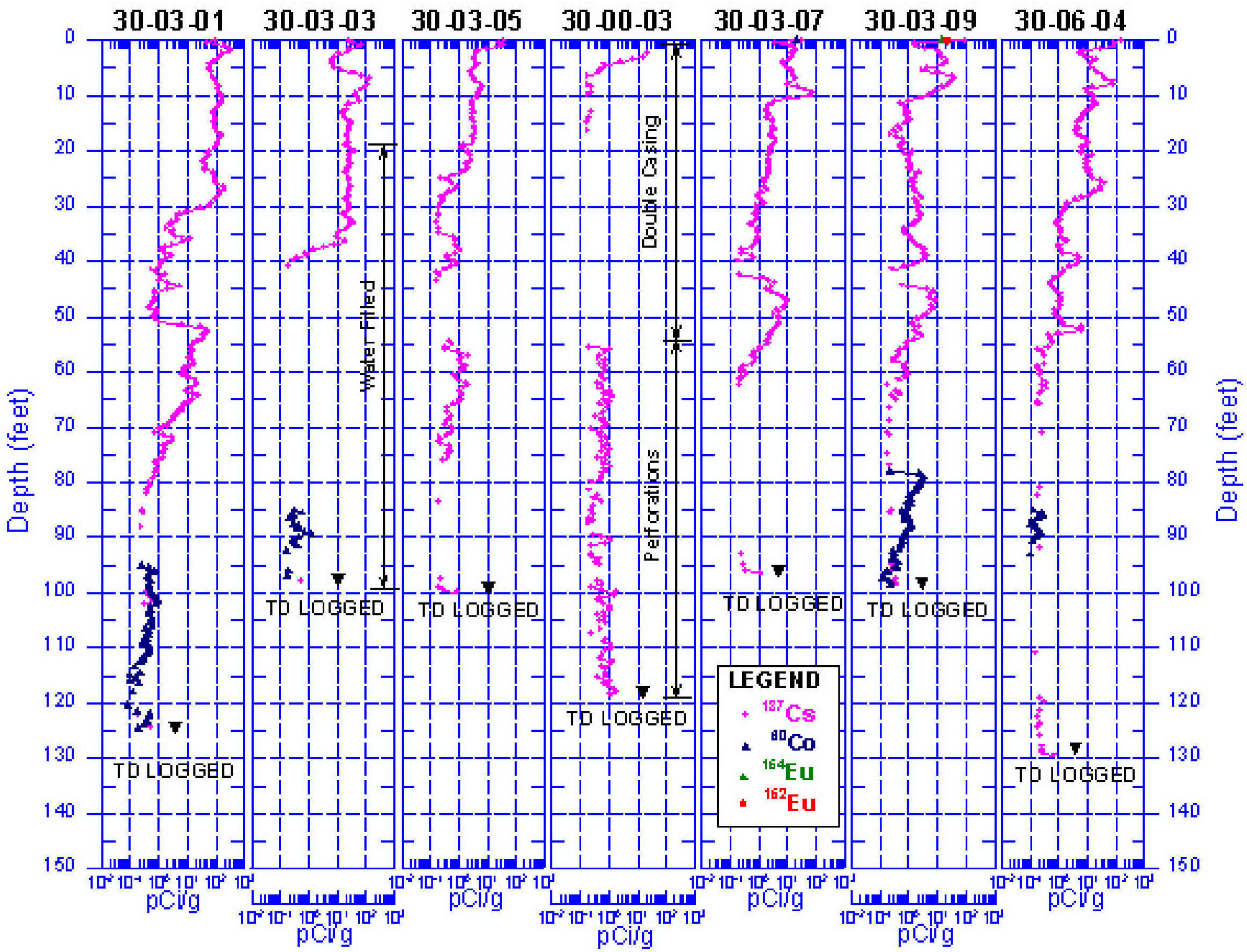
C2.3 DRYWELL DATA

Seven vadose zone monitoring drywells surround tank C-103. These are 30-03-01, 30-03-03, 30-03-05, 30-00-03, 30-03-07, 30-03-09, and 30-06-04. Figure C2-5 details spectral gamma-ray logging results for these drywells.

Occurrence reports relating to C-103 drywell readings include the following:

EPDR 87-10: Dry Well Radiation Peak Increase in Drywell 30-03-09
On May 18, 1987, a radiation increase was measured in drywell 30-03-09. Though statistically significant, the increase was below the 200 cps action criteria.

Figure C2-5. 1997 SGLS Logging Near Tank C-102 (GJ-HAN-82)



C3.0 TANK 241-C-104

The total waste volume in tank 241-C-104 (C-104) at the start of waste retrieval operations in 2009 was a volume of 980 kL (259 kgal) and was based on the January 1, 2001 ENRAF reading. The reading was adjusted to account for a 5-inch deep, dish-shaped depression under the ENRAF riser, giving a revised waste height of 101.58 inches. A waste level decrease had been observed since 1980 and was attributed to settling and evaporation. Waste retrieval operations were started on January 8, 2010. The waste retrieval operations were suspended because of an obstruction beneath the central transfer pump. Waste retrieval operations were restarted in January 2011. At the restart of waste retrieval operations, the current estimated waste volume in tank C-104 is 64 kgal.

Figure C3-1 details waste transfers for Tank C-104.

C3.1 HISTORY

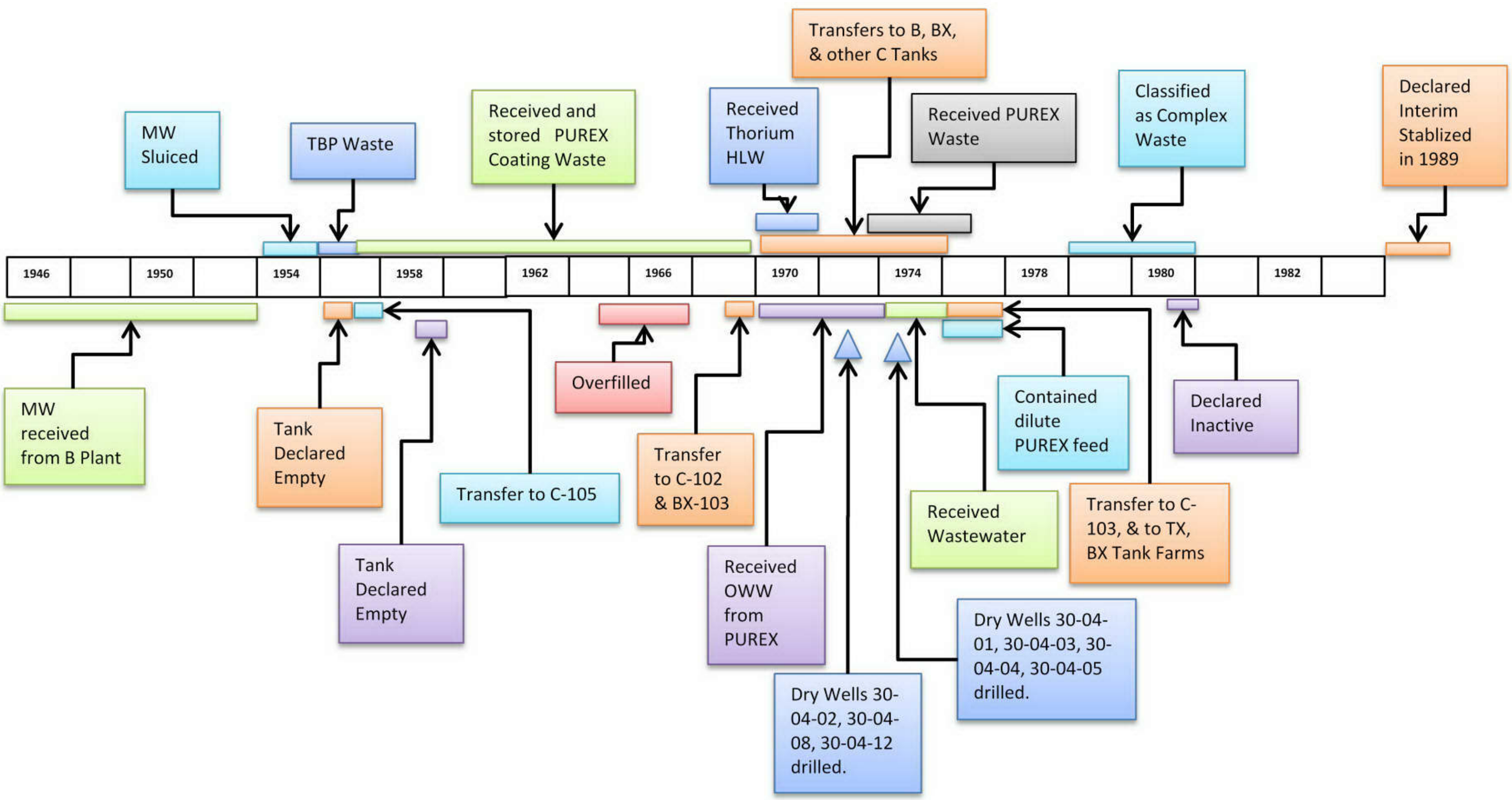
Tank C-104 was put into service in October 1946. Initially tank C-104 received metal waste from the fourth quarter of 1946 until the fourth quarter of 1954. Tank C-104 is the first tank in a three tank cascade which also includes 241-C-105 and 241-C-106. By February 1947 the cascade was full. The tank cascaded between 1946 and 1953. The metal waste was sluiced in the fourth quarter 1953 to recover uranium.

The supernatant was sent to the 244-CR process vault in 1954 and the tank was declared empty in the first quarter of 1955. U plant waste was added to the tank in the fourth quarter of 1955. The tank was emptied again and received or contained coating waste from the first quarter of 1956 until the third quarter of 1969.

The tank received supernatant from tank 241-C-105 in the first quarter of 1960. It received waste from the 244-CR Vault in the second quarter of 1965. Waste was sent to tank 241-C-102 during the second quarter of 1969. The tank received cladding waste and organic wash waste from PIJREX from the fourth quarter of 1969 to the third quarter of 1972. During this time waste was sent to and received from various other tanks.

From the first quarter of 1956 until the third quarter of 1972, the tank received Plutonium Uranium Extraction (PUREX) cladding waste. From the first quarter of 1969 until the third quarter of 1976, the tank received various wastes. The tank received decontamination waste from the second quarter of 1965 until the first quarter of 1974. From the fourth quarter of 1969 until the fourth quarter of 1972, the tank received PUREX organic wash waste. During the third and fourth quarters of 1970, the tank received thorium high-level waste. From the fourth quarter of 1970 until the second quarter of 1976, the tank received PUREX low-level waste. The tank received PUREX high-level waste from the fourth quarter of 1973 until the second quarter of 1975.

Figure C3-1. Tank 241-C-104 Waste Operations Summary



From the first quarter of 1974 until the fourth quarter of 1975, the tank received wastewater. From the second quarter of 1976 until the fourth quarter of 1977, the tank contained dilute PUREX feed. From the first quarter of 1979 until the fourth quarter of 1980, the waste was classified as complex waste. The tank is sound and was declared inactive in March 1980. Tank C-104 was partially isolated in December 1982 and declared interim stabilized in September 1989 with intrusion prevention completed in February 1991 (Brevick 1994).

C3.2 SURFACE LEVEL DATA

Tank C-104 was filled to 560 kgal in the first quarter 1965 and remained at that level until the first quarter 1966. A comment in WHC-MR-0132 notes that tank C-104 received 15 kgal of CR vault waste in the first quarter of 1965, increasing the quantity of stored waste to 560 kgal. As indicated in Figure C3-2, tank C-104 was filled above the cascade level between 1965 and 1967. Figure C3-3 shows surface level data from 1980 to present.

Occurrence reports relating to C-104 liquid levels include the following:

OLDR 82-07: Liquid Level Decrease
On May 13, 1982, a liquid level decrease occurred that exceeded the 0.5 inch action criteria. The Tank Farm & Evaporator Process Control Group determined that there was sufficient exhaustive activity in tank C-104 to account for the observed decrease.

EPDR 83-04: Liquid Level Decrease
On August 24, 1983, a liquid level decrease occurred that exceeded the 1.0 inch action criteria. The decrease was attributed to evaporation, reduced liquid area, and the FIC plummet contacting soft sludge.

OR-76-153: Liquid Level Decrease
As of November 4, 1976, a gradual liquid level decrease had exceeded the 0.5 inch action criteria. The decrease was attributed to evaporation and effects of tank air exhausting through the cascade line to C-106.

C3.3 DRYWELL DATA

Ten vadose zone monitoring drywells surround tank C-104. These are 30-04-01, 30-04-02, 30-04-03, 30-05-06, 30-04-04, 30-01-12, 30-04-05, 30-04-08, 30-07-05, and 30-04-12. The SGLS detected (Figure C3-4) moderate to high Cs-137 concentrations at the ground surface in all the drywells. Isolated occurrences of U-235 were detected at the ground surface in drywells 30-04-02, 30-04-03, and 30-05-06. A near-surface zone of very high Cs-137 activity was detected around drywell 30-04-04. This activity probably resulted from a shallow transfer-line leak because it occurs within proximity of a transfer-line valve pit. Overall logging results indicate that surface spills and subsurface leaks may have previously occurred in the vicinity of this tank and may be related to activities associated with tank C-104 or other nearby tanks.

Figure C3-2. Tank 241-C-104 Quarterly Surface Levels

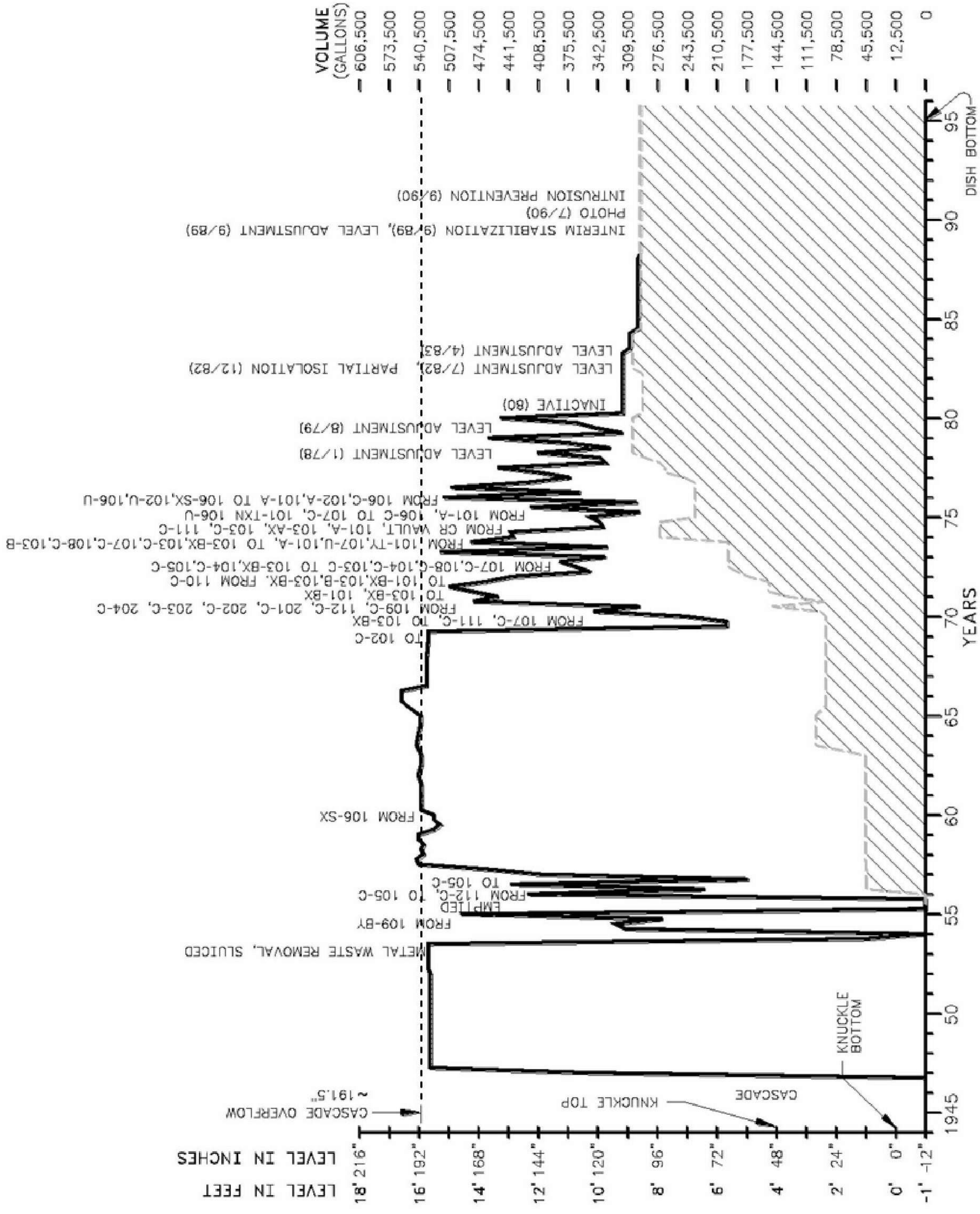


Figure C3-3. Tank 241-C-104 Surface Level Data

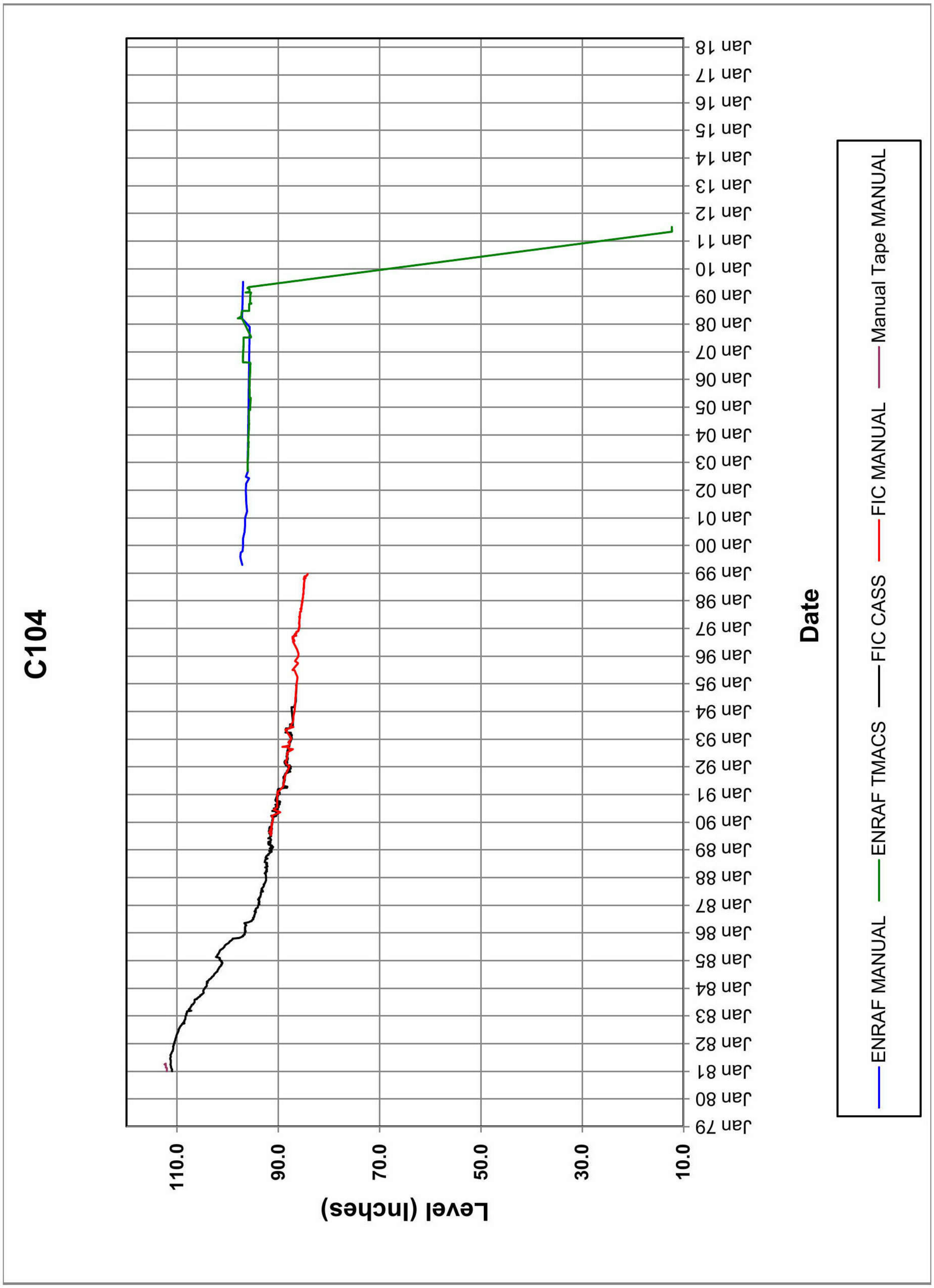
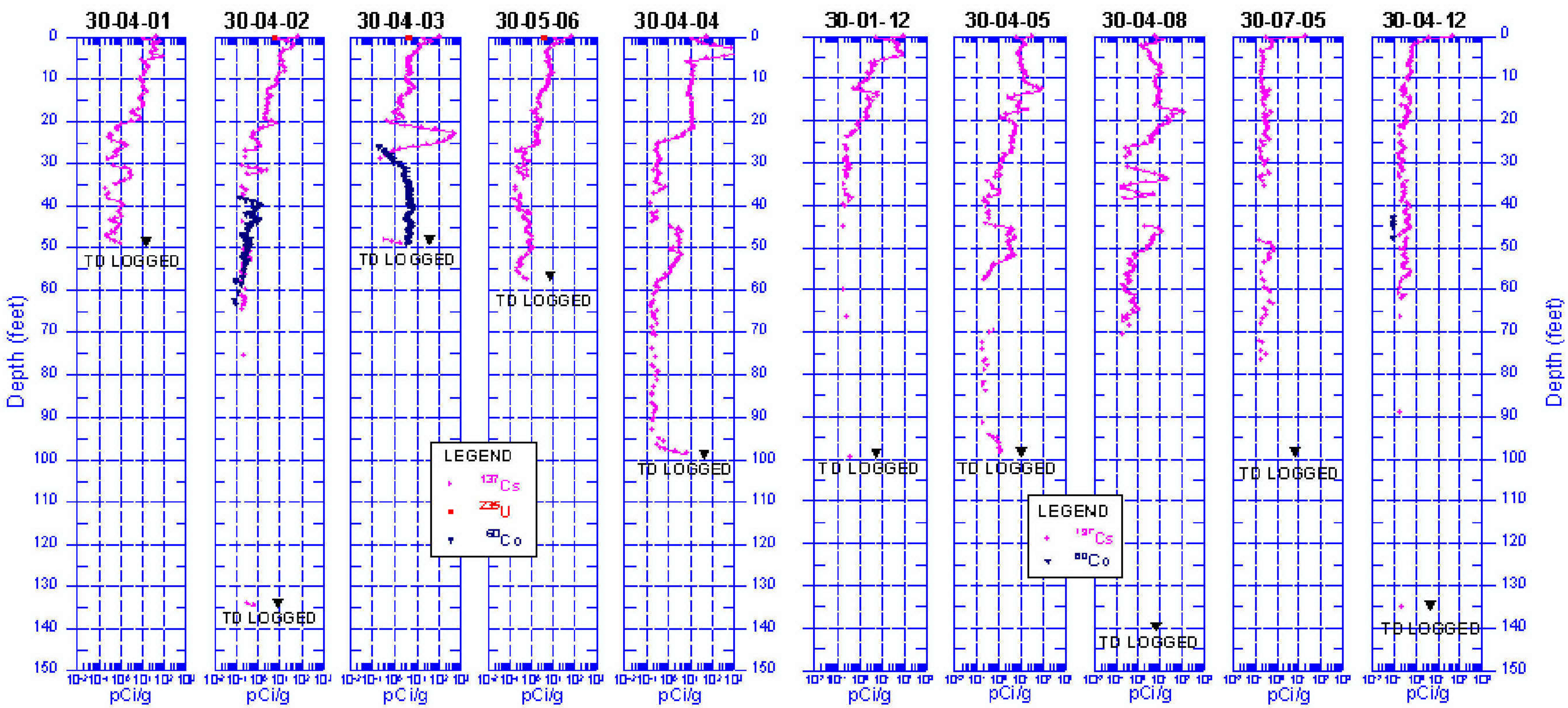


Figure C3-4. 1997 SGLS Logging Near Tank C-104 (GJ-HAN-87)



Occurrence reports relating to C-103 drywell readings include the following:

OR-74-120: Drywell Radiation Increase
Drywell 30-04-02, located halfway between C-104 and C-105, showed an increase in radiation at the 40 foot depth during March, 1974. Five planned monitoring wells (100 feet deep) and five shallow (50 to 68 feet deep) were drilled to better define the source of the activity. There was no accompanying leak indication from liquid level measurements.

C4.0 TANK 241-C-106

Figure C4-1 details waste transfers for Tank C-106.

Tank 241-C-106 (C-106) currently contains 10,488 L (2,771 gal) of residual waste. Because tank C-106 waste sludge underwent sluicing and oxalic acid dissolution during waste retrieval operations, it is assumed that the residual waste sludge material does not resemble any of the original waste types (UR, CWP, AR, and BL). Similarly, the original supernatant in tank C-106 was replaced as a result of the 1998-1999 and 2003 waste retrieval campaigns. The residual liquid at the end of retrieval was primarily a caustic solution added for tank corrosion control purpose.

Two retrieval technologies have been deployed at tank C-106. The first sluicing campaign started in November 1998 and reached the limit of its capability in October 1999. In April 2003, a second retrieval campaign was initiated with the pumping of 18,000 gal of liquid from tank C-106. The second retrieval technology deployed in SST C-106 as a retrieval technology demonstration under the HFFACO was modified sluicing with acid dissolution. This technology reached the technical limit of its capability in December 2003.

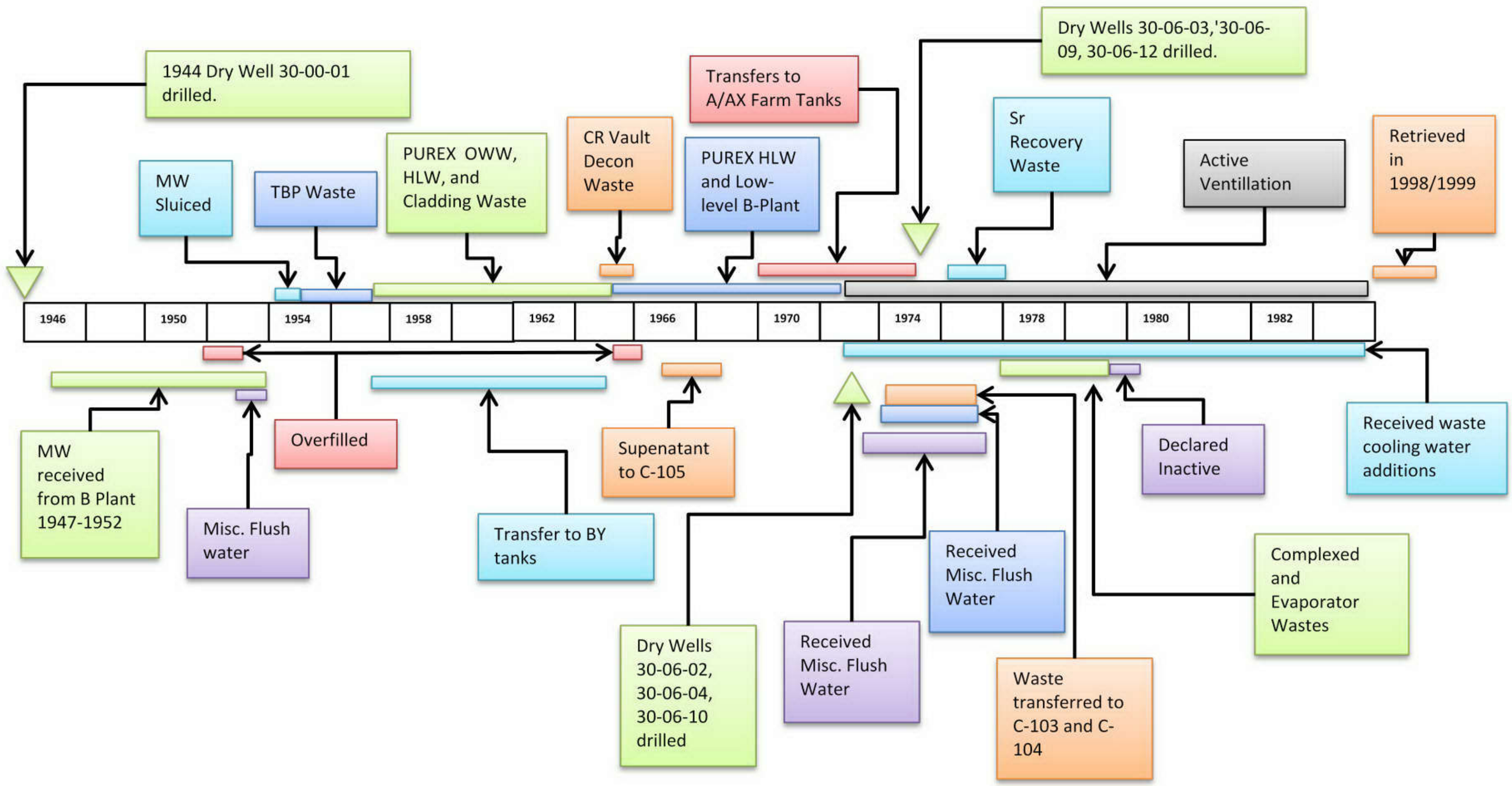
C4.1 HISTORY

Tank C-106 commenced waste storage service in July 1947, as the third tank in the cascading series of three single-shell tanks. The tank initially received metal waste (MW) from the Bismuth Phosphate Process. MW contained all of the uranium, approximately 90% of the original fission products activity and approximately 1% of the nuclear material (plutonium). This waste was brought just to the neutral point with 50% caustic and then treated with sodium carbonate.

MW additions continued until November, 1947 when the waste volume reached the tank maximum of 528,000 gallons. In the third quarter of 1953, the tank was emptied as much as practical of its wastes when a sluice mining program for the recovery of uranium started. In the third quarter of 1954, Tank 106-C was filled with tributyl phosphate (TBP) waste.

Tank C-106 was pumped to a 37,000 gal heel (12,000 gal sludge) in the second quarter of 1957. It began to receive PUREX coating waste in the third quarter of 1957. In mid-1963, tank C-106 was pumped to the heel and then filled with PUREX neutralized high level waste. The tank remained full from the fourth quarter of 1963 until the fourth quarter of 1967. In the fourth quarter of 1967, the tank was pumped to a 70,000 gal heel, which included 68,000 gallons of sludge. In the first quarter of 1969, Tank C-106 began to receive PUREX sludge slurry (PSS) wash water. Tank C-106 was decanted to Tank 241-C-105, which was then decanted to B Plant. In the mid-1970's, sludge temperatures above 212 ^{o}F were observed in Tank C-106. This tank was not equipped for boiling waste. As a result, its service as a PSS receiver was terminated.

Figure C4-1. Tank 241-C-106 Waste Operations Summary



From inventory discrepancies, tank C-106 was estimated to store approximately 12 million curies of strontium as a PSS receiving tank. In the fourth quarter of 1971, Tanks C-105 and C-106 were placed on vessel ventilation systems. The recorded volume in Tank C-106 at that time was about 240,000 gallons with 150,000 gallons of sludge. Until the third quarter of 1974, no waste was transferred in or out of tank C-106, with the exception of water additions for evaporative cooling. During the third quarter of 1974, tank C-106 began to operate as a receiver for complexed waste from B Plant cesium recovery ion exchange. The last transfer occurred on March 18, 1979, with the addition of 18,000 gallons of dilute waste and cooling water.

C4.2 SURFACE LEVEL DATA

Tank C-106 was over filled twice, to 551 kgal in 1951 when water was added to metal waste (MW2) and up to 549 kgal during the time period of December 1965 – March 1966 with PUREX P2 HLW supernate. The tank does not contain a cascade overflow. Figure C4-2 shows historical quarterly waste levels for tank C-106 from 1946 to 1996, while Figure C4-3 shows surface level data from 1980 to present.

Occurrence reports relating to C-102 liquid levels include the following:

EM-RL-WHC-TANKFARM-1990-0193: Liquid Level Increase
After an exhauster failed on October 8, 1990, a gradual 0.30 inch raised the liquid level in the tank to the maximum operating limit.

C4.3 DRYWELL DATA

Eight vadose zone monitoring drywells surround tank C-106. These are 30-06-02, 30-00-01, 30-06-03, 30-06-04, 30-05-02, 30-06-09, 30-06-10, and 30-06-12. Figure C4-4 details spectral gamma-ray logging results for these drywells. The SGLS detected a significant amount of near-surface, shallow subsurface and very high at the ground surface Cs-137 activity in all the drywells. Isolated Eu-154 and U-235 occurrences were also detected at the ground surface in the drywells along the west side of tank C-106 (GJO-HAN-84).

Figure C4-2. Tank 241-C-106 Quarterly Surface Levels

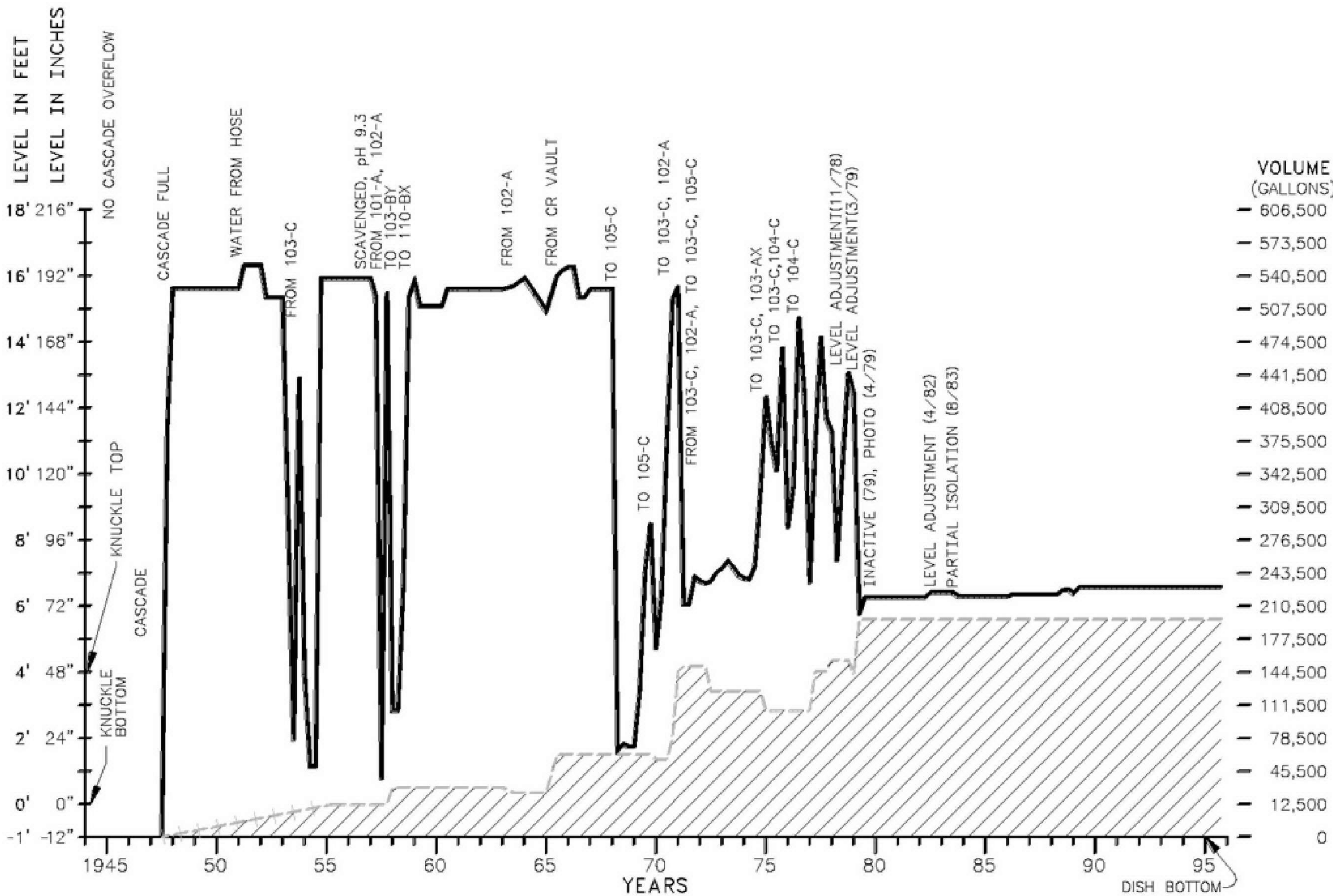


Figure C4-3. Tank 241-C-106 Surface Level Data

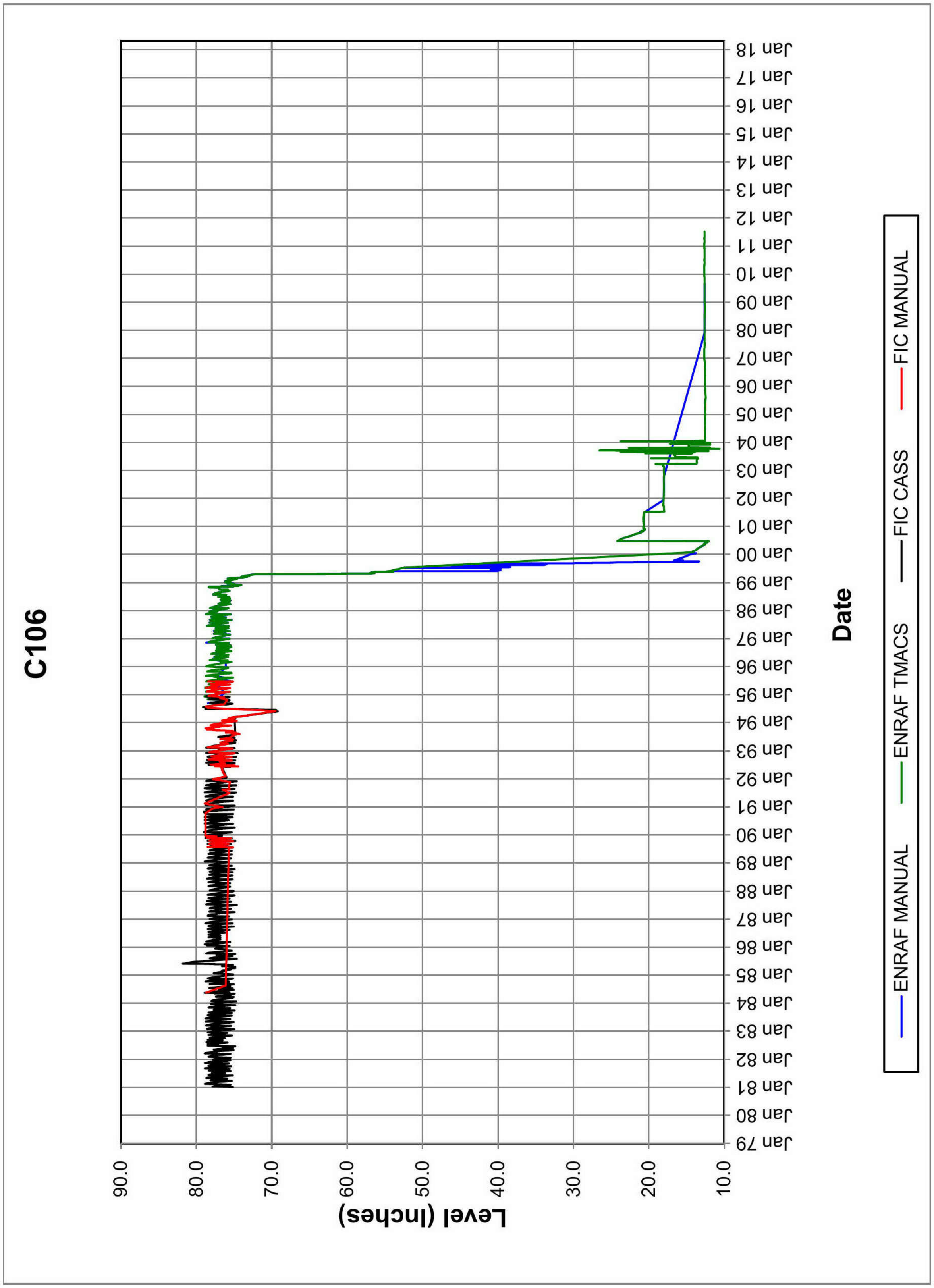
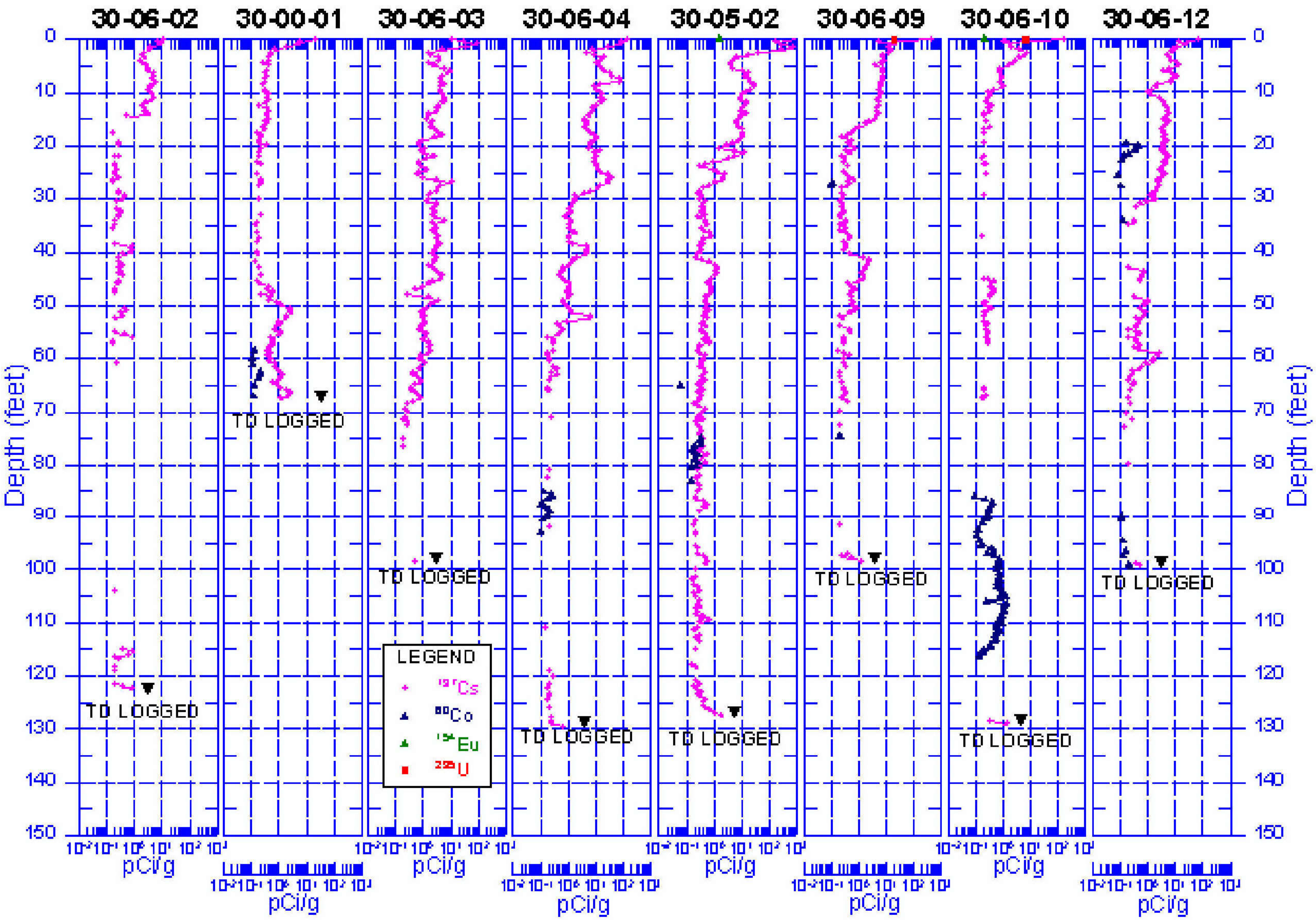


Figure C4-4. 1997 SGLS Logging Near Tank C-106 (GJ-HAN-84)



C5.0 TANK 241-C-107

Figure B5-1 details historical waste transfers for Tank C-107.

Tank 241-C-107 (C-107) total waste volume is estimated to be 935 kL (247 kgal) based on the ENRAF reading. The BBI estimate of the waste volume of the various sludge waste types [such as the SRR sludge was estimated to be 339 kL (90 kgal)] are based on the average solids recovery from the associated core sample segments. The remaining solids (596 kL or 157.5 kgal) are comprised of CWP2 and 1C wastes (RPP-RPT-43034, Rev.0, *2009 Auto-TCR for Tank 241-C-107*). Tank C-107 was designated as interim stabilized in September, 1995, and intrusion prevention was completed in September, 1996.

C5.1 HISTORY

Tank C-107 went into service during the second quarter of 1946 when it began receiving first-cycle decontamination waste (1C) generated from the bismuth phosphate process (Anderson 1990). In September 1947, tank C-107 was full and began cascading waste into tank 241-C-108 and tank 241-C-109 with this three tank cascade series being filled to capacity in September 1948. In 1952, with approximately 496 kL (131 kgal) of waste transferred out previously, tank C-107 received tri-butyl phosphate (UR/TBP) liquid waste until full. In October 1956, approximately 587 kL (155 kgal) of waste was transferred out of tank C-107 for cesium scavenging. During 1957 and 1958, 1C waste and numerous line flushes were received. The flush water was generated while clearing a plug in the cascade outlet leading to tank 241-C-108. From the fourth quarter of 1961 through the second quarter of 1963, the tank received cladding removal waste from the Plutonium-Uranium Extraction (PUREX) facility. From the fourth quarter of 1964 through the fourth quarter of 1967, tank C-107 received waste primarily from the hot semi-works with additional waste from the CR vault and Site laboratories. In 1970, the tank received waste from tank 241-BX-104, and in 1972 and 1973, the tank exchanged supernatant waste with tank 241-C-104. Tank C-107 was saltwell pumped in 1976 and 1977. Finally, tank C-107 received strontium-rich sludge in 1977 and was then declared inactive in 1978. Jet pumping campaigns were performed from November 1991 through January 1992 and September 1994 through July 1995 to remove the supernatant and some interstitial liquid to limit potential leaks.

C5.2 SURFACE LEVEL DATA

Figure C5-2 shows historical quarterly waste levels for tank C-107 from 1946 to 1996, while Figure C5-3 shows surface level data from 1980 to present. Tank C-107 was filled to 547 kgal at the end of 1952 with TBP waste and again to 547 kgal starting in the 3rd quarter of 1970 through 1971 with CW-IX waste. The tank was filled above the cascade level (Figure C5-2) in 1953 and 1971.

Figure C5-1. Tank 241-C-107 Waste Operations Summary

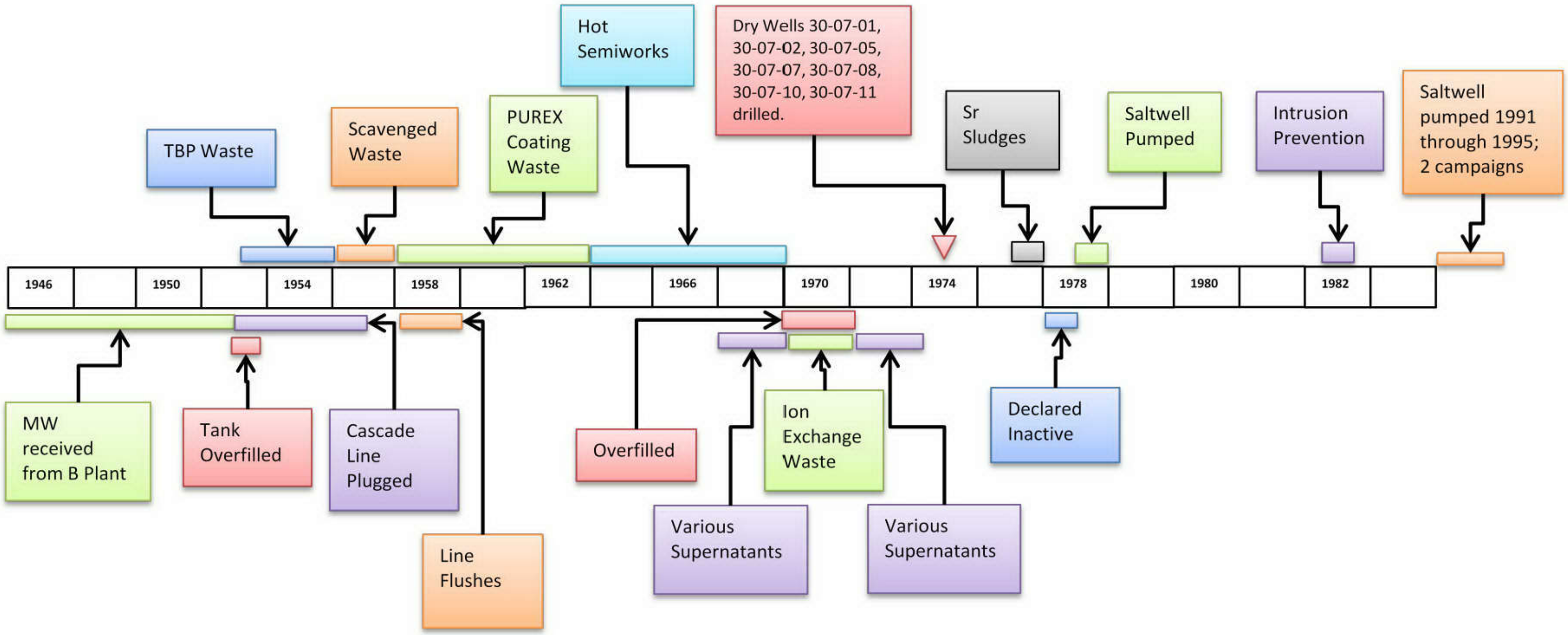


Figure C5-2. Tank 241-C-107 Quarterly Surface Levels

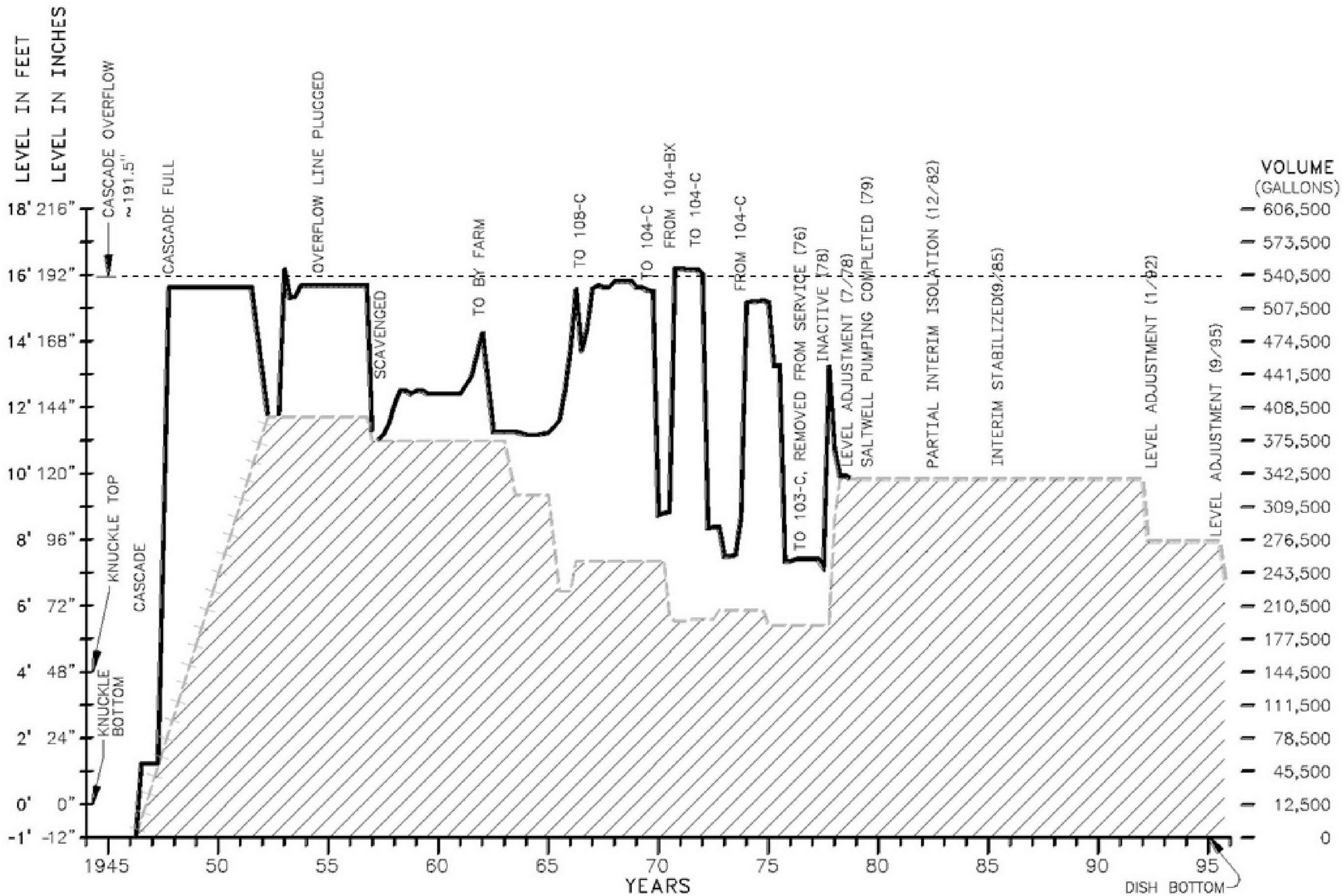
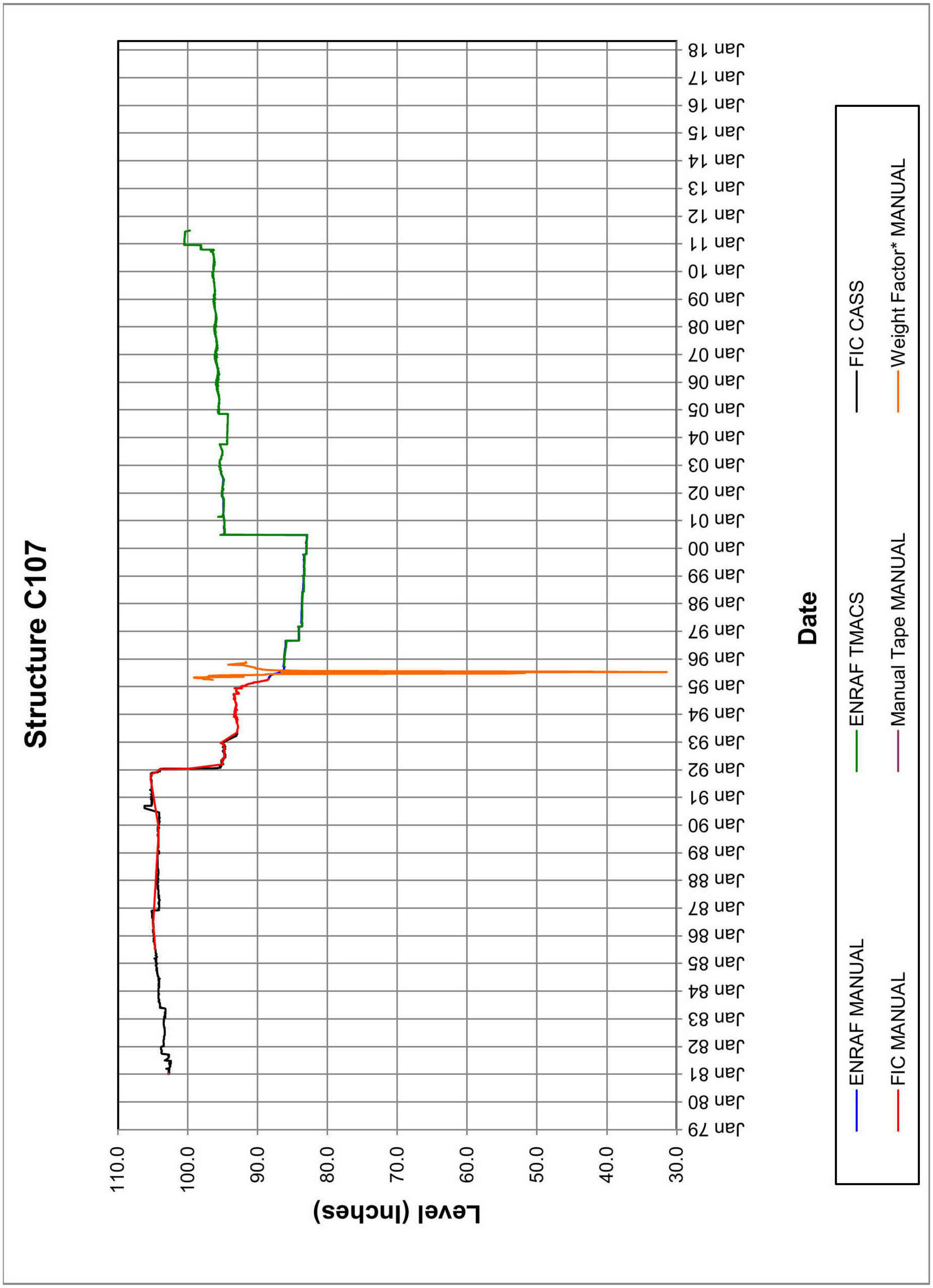


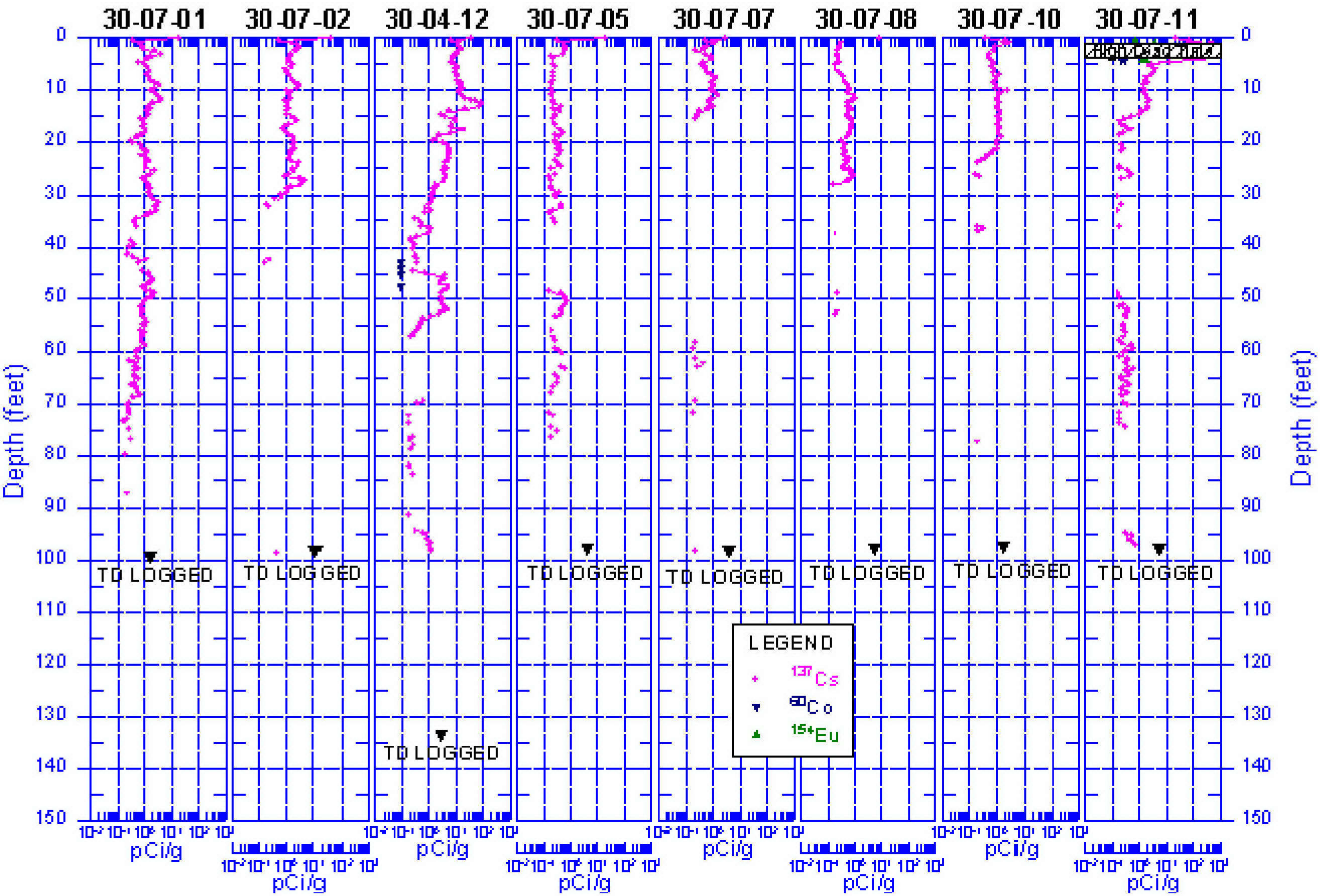
Figure C5-3. Tank 241-C-107 Surface Level Data



C5.3 DRYWELL DATA

Eight vadose zone monitoring drywells surround tank C-107. These are 30-07-01, 30-07-02, 30-04-12, 30-07-05, 30-07-07, 30-07-08, 30-07-10, and 30-07-11. Figure C5-4 details spectral gamma-ray logging results for these drywells. The ^{60}Co, ^{154}Eu, and a large portion of the ^{137}Cs activity in the upper 5 ft of drywell 30-07-11 appears to be associated with a transfer pipe near this drywell (GJ-HAN-88).

Figure C5-4. 1997 SGLS Logging Near Tank C-107 (GJ-HAN-88)



C6.0 TANK 241-C-108

Figure C6-1 details waste transfers for Tank C-108.

Retrieval of tank C-108 was initiated using modified sluicing on December 20, 2006. Sluicing operations were halted after April 26, 2007 because it appeared that the limits of sluicing technology had been reached. The total volume of waste remaining was estimated to be 7,700 gallons. The solids volume was estimated to be 27.3 kL (7.2 kgal) (RPP-CALC-33487, *Estimate of Waste Volume and Percent Retrieved for Tank 241-C-108*). Supernatant was pumped to tank 241-C-103 during 1975 and early 1976. Tank C-108 was removed from service in 1976 and is listed as sound. Saltwell pumping was completed in 1978, and intrusion prevention was completed on December 15, 1982 (Welty 1988). The tank was designated as interim stabilized on March 9, 1984. This tank was added to the Ferrocyanide Watch List in January 1991 and was removed June 1996 (RPP-RPT-43035).

C6.1 HISTORY

Tank 241-C-108 (C-108) entered into service in 1947. First-cycle decontamination (1C) waste from the bismuth phosphate process began cascading from tank 241-C-107 during the third quarter of 1947 (Agnew et al. 1997b). Tank C-108 was filled, and waste began overflowing via the cascade line to tank 241-C-109 during the second quarter of 1948. The entire cascade was filled by September 1948. Supernatant was pumped from tank C-108 during 1952, leaving behind about 129 kL (34 kgal) of waste. The tank began receiving uranium recovery (UR) waste via the cascade line from tank 241-C-107 during 1952. During 1953, the tank was filled and the waste began cascading to tank C-109. After 1953, the tank received no further transfers of UR waste.

Uranium Recovery waste from tank C-108 was transferred to tanks 241-C-109 and 241-C-111 for in-tank ferrocyanide scavenging during the first quarter of 1956. Agnew (1993) estimates a layer of solids settled from the UR waste in tank C-108. This layer would have been added to another layer of 1C solids predicted to have settled on the bottom of the tank during its early history. Beginning in May 1955, UR was routed to the 244-CR Vault for scavenging with nickel ferrocyanide (Agnew 1993). The scavenged waste was returned to tanks to allow the waste to settle and was then sampled and decanted to a crib (for a further discussion of ferrocyanide scavenging, see WHC-SD-WM-TI-648, *Tank Characterization Reference Guide* [De Lorenzo et al. 1994]). Tank C-108 was used as a primary settling tank from 1956 through 1957, receiving scavenged waste from tanks in the C, B, and BX Tank Farms. During this time, the tank received in-farm ferrocyanide scavenging (TFeCN) waste; a portion of this waste remained in the tank in early 1958 following the conclusion of the scavenging campaign (Agnew et al. 1997b). Agnew (1993) estimates that the settling of TFeCN waste added an additional sludge layer to tank 241-C-108. However, most of the TFeCN sludge is predicted to have been removed from the tank in a later transfer. During 1960 and 1961, the tank received supernatant (most likely Plutonium-Uranium Extraction [PUREX] cladding waste [CWP] supernatant) from tank 241-C-105 and apparently CWP directly from PUREX. During the same period, supernatant was transferred from tank C-108 to tanks 241-BY-101 and 241-BY-105. Agnew (1993) predicts a sludge layer resulted from the CWP waste.

During 1964, supernatant was transferred from tank C-108 to tanks in the 241-BX Tank Farm. During 1965 and 1966, the tank received waste from the Hot Semiworks Plant (HS) waste and HS supernatant from tank 241-C-107. From 1965 to 1969, supernatant was intermittently transferred from tank C-108 to tank 241-C-102.

During 1970 and 1973, tank C-108 received supernatant wastes from tanks 241-C-110 and 241-C-104. Records indicate these supernatants were likely a mixture of wastes, including PUREX organic wash waste, ion exchange waste, reduction oxidation waste, N Reactor waste, decontamination waste, and laboratory waste (Agnew et al. 1994).

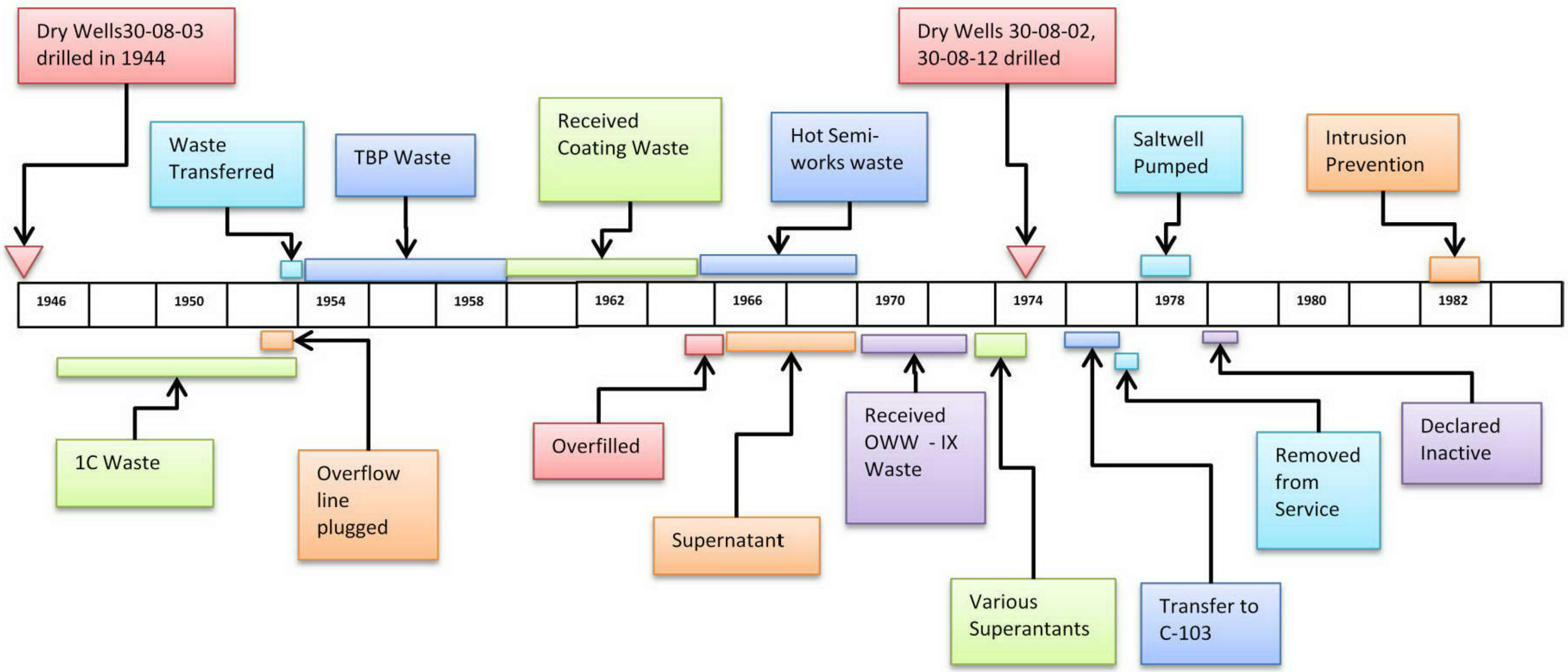
C6.2 SURFACE LEVEL DATA

Figure C6-2 shows historical quarterly waste levels for tank C-108 from 1946 to 1996, while Figure C6-3 shows surface level data from 1980 to present. Tank C-108 was over filled to 568 kgal the 2nd quarter 1965 with CW-HS waste. The tank was also filled above the cascade overflow level in 1965 (Figure C6-3).

Occurrence reports relating to C-108 liquid levels include the following:

OR-76-104: Liquid Level Decrease
On July 20, 1976 a liquid level decrease of 0.50 inches occurred, meeting the action criteria. The decrease was attributed to residual settling of the surface after saltwell pumping in April, 1976.

Figure C6-1. Tank 241-C-108 Waste Operations Summary



C6.3 DRYWELL DATA

Eight vadose zone monitoring drywells surround tank C-108 (Figure C6-4). These are 30-08-02, 30-09-07, 30-08-03, 30-05-10, 30-07-02, 30-07-01, 30-11-05, and 30-08-12. The SGLS detected moderate to high concentrations of Cs-137 at the ground surface in all the drywells. Isolated occurrences of 235-U were detected at the ground surface in drywells 30-08-03 and 30-05-10.

Occurrence reports relating to C-108 drywell readings include the following:

Occurrence Report 74-148: Drywell Activity Increase
Increasing activity in dry well 30-08-02 was observed in 1974. The occurrence report attributed the activity to lateral movement of existing activity.

Figure C6-2. Tank 241-C-108 Quarterly Surface Levels

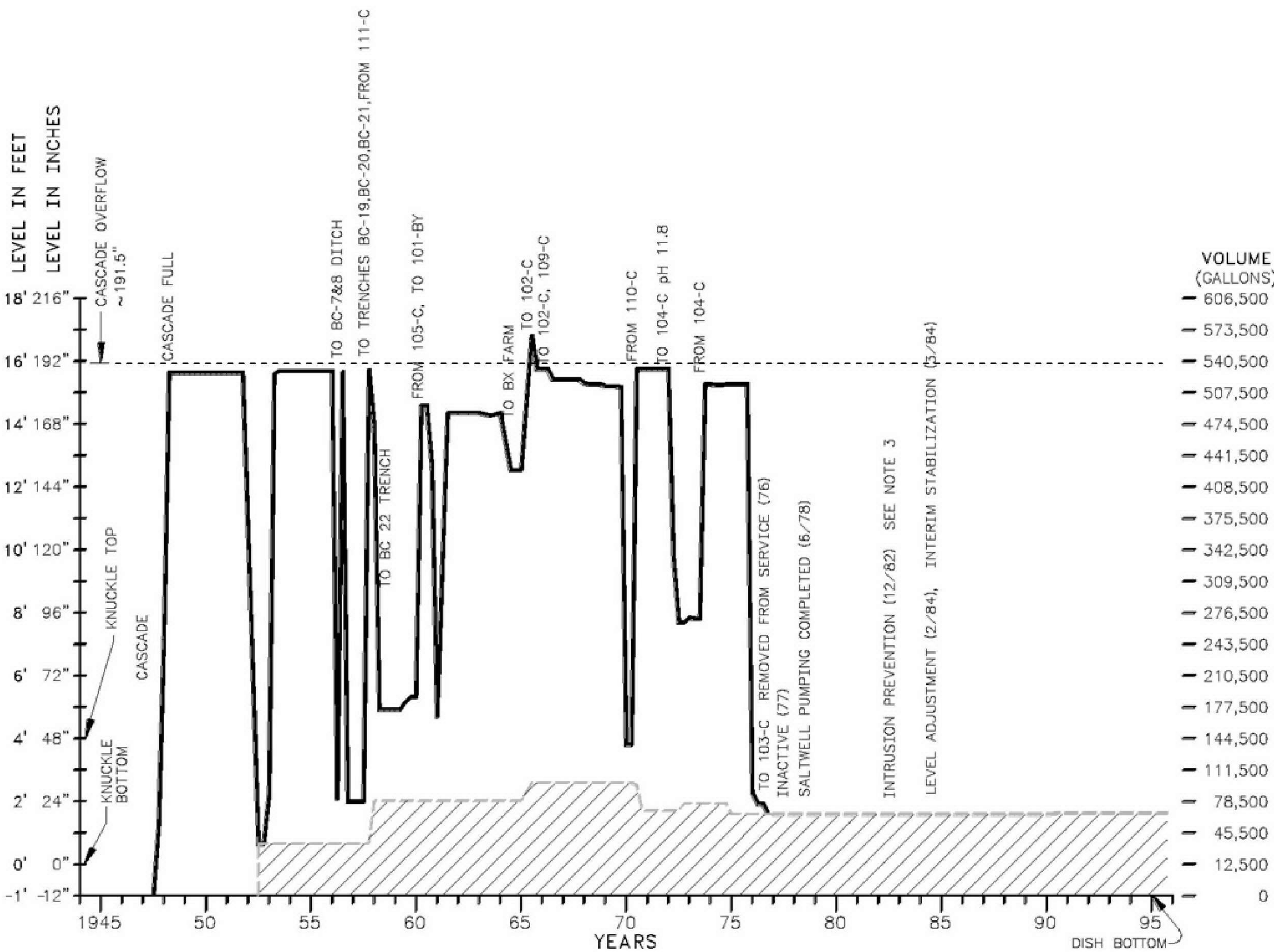


Figure C6-3. Tank 241-C-108 Surface Level Data

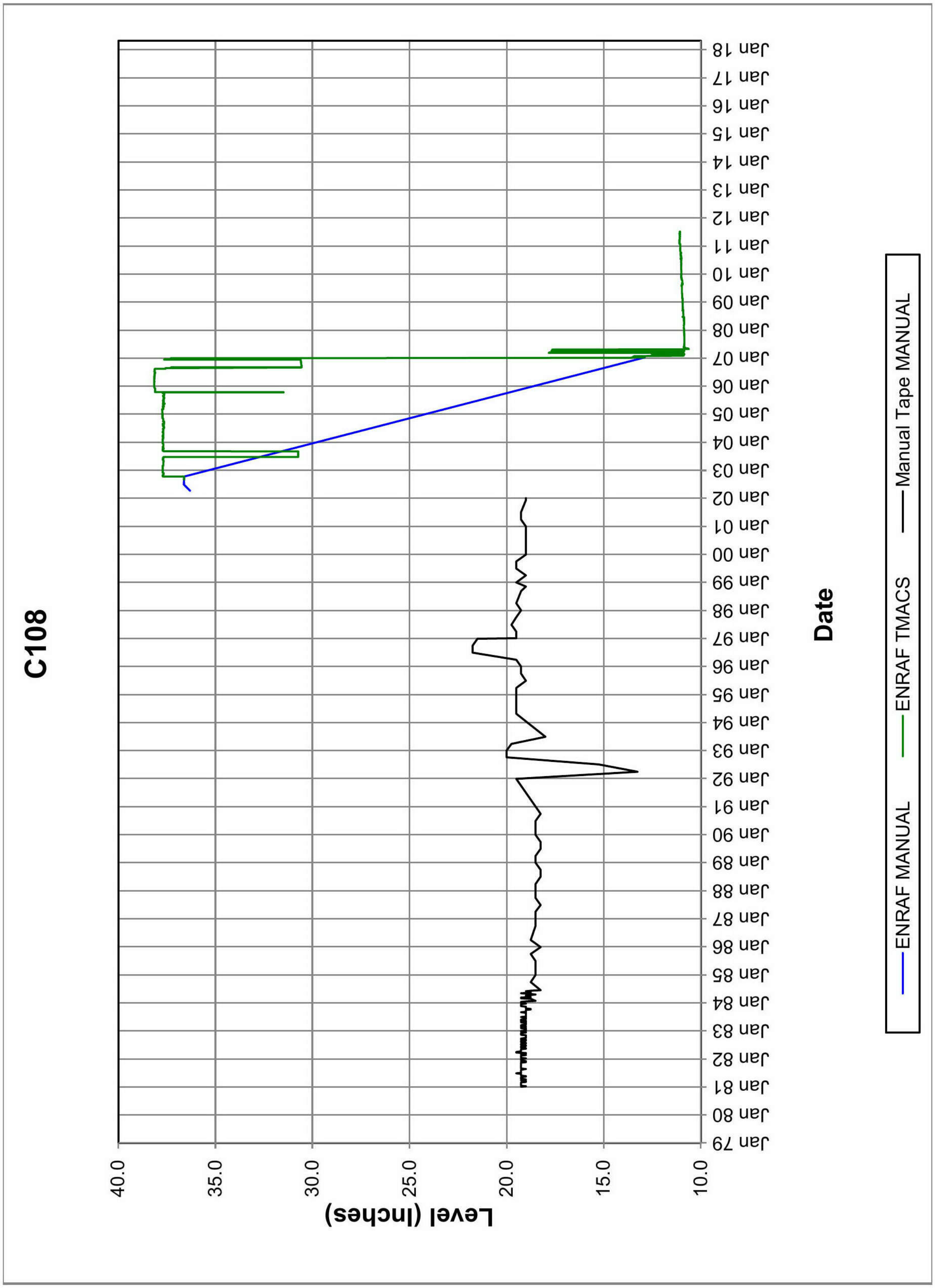
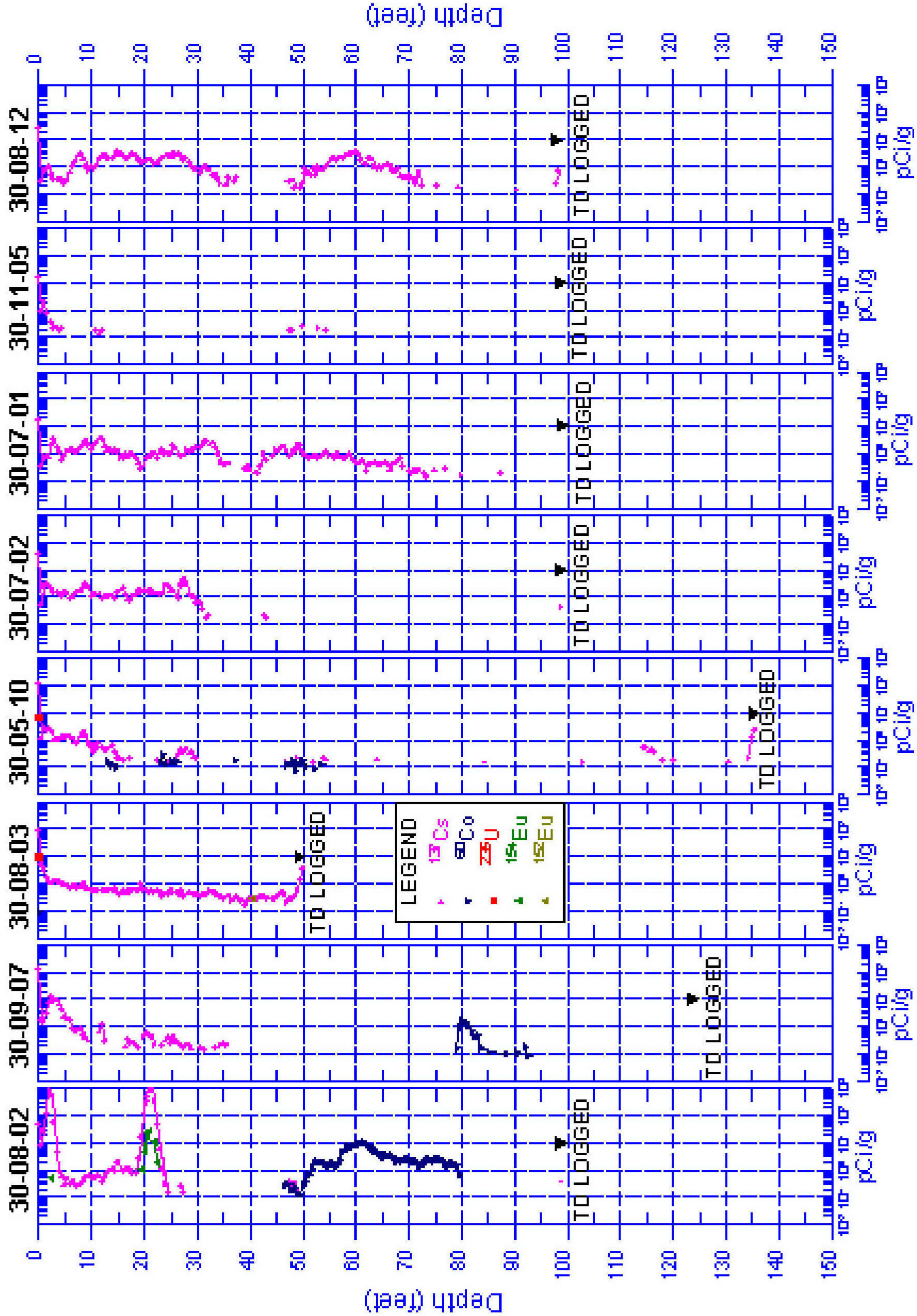


Figure C6-4. 1997 SGLS Logging Near Tank C-108 (GJ-HAN-90)



C7.0 TANK 241-C-109

Figure C7-1 detail waste transfers for Tank C-109.

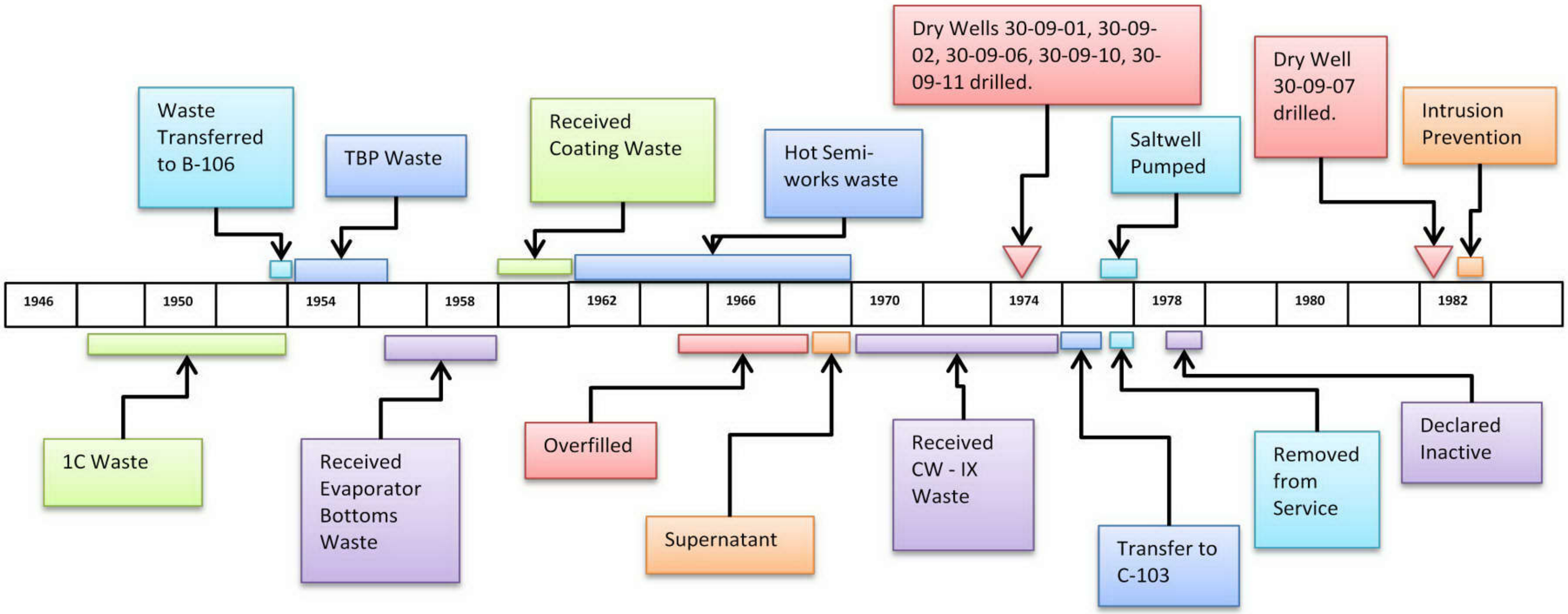
Waste retrieval operations were initiated using modified sluicing in June 2007. Approximately 202 kL was retrieved by this method. With modified sluicing, waste is preferentially removed from the top layers, therefore the remaining waste was assumed to consist primarily of 1C waste. On June 2, 2008, a FoldTrack Mobile Retrieval Tool began operations to assist in the sluicing of the remaining tank waste. The current total waste volume is estimated to be 30 kL (7.8 kgal). Tank C-109 was removed from service in 1976. Intrusion prevention was completed in 1982, and the tank was interim stabilized in 1983 (RPP-RPT-43036).

C7.1 HISTORY

Tank 241-C-109 (C-109) was brought into service during 1948 with a cascade from tank 241-C-108 of first-cycle decontamination (1C) waste from the bismuth phosphate process (Brevick et al. 1997). The waste was transferred to tank 241-B-106 in 1952, leaving an estimated 38 kL (10 kgal) heel. The tank was refilled through the cascade line with unscavenged uranium recovery (UR) waste in 1953. Beginning in May 1955, unscavenged UR waste already stored in 200 East Area underground tanks at the Hanford Site was routed to the 244-CR vault for scavenging.

From late 1955 until 1958, tank C-109 was used for settling scavenged ferrocyanide waste. During ferrocyanide-scavenging operations, waste was not cascaded through the tanks 241-C-107, 241-C-108, and C-109 series. Tank C-109 received the waste slurry in direct transfers from the process vessel (General Electric 1958). The settling tanks for this in-farm ferrocyanidescavenging (TFeCN) waste were tanks 241-C-108, 241-C-109, 241-C-111, and 241-C-112. In-Farm scavenging was completed in December 1957 (General Electric 1958). Agnew et al (1997a) records an additional transfer out of this tank to a crib in the first quarter of 1958. From 1956 to 1958, several transfers of supernatant went to B-Cribs. Cladding waste supernatant was transferred to tank C-109 from tank 241-C-105 in 1959. After the end of scavenging in early 1958, tank C-109 remained in active service. However, the tank had relatively limited activity from 1958 to the end of its service life in 1980. In 1959, highly alkaline cladding waste and evaporator bottoms were added to the tank, but the reported solids inventory did not change possibly due to a transcription error (Agnew et al. 1996). In 1962, waste was transferred to the BY-Farm from tank 241-C-109. Waste from the strontium semiworks/hot semiworks (HS) was then added at different times to the tank from 1962 to 1965. The reported waste volume remained essentially unchanged until a receipt of waste from tanks 241-C-108, 241-C-110, and 241-C-203, and a transfer to tank 241-C-104 in 1970. This transfer left a heel of sludge, because there was no mixing equipment in tank C-109 to move the settled ferrocyanide solids into the overlying solids layer. In 1970, an additional transfer of waste from tank 241-C-110 was received. Between 1970 and 1975, the reported solids volume fluctuated widely (Agnew et al. 1996). In 1975, supernatant waste was transferred to tank 241-C-103. Overall sludge volume in the tank may have decreased somewhat between 1958 and 1975 with further settling and compaction from the weight of overlying solids.

Figure C7-1: Tank 241-C-109 Waste Operations Summary



C7.2 SURFACE LEVEL DATA

Figure C7-2 shows historical quarterly waste levels for tank C-107 from 1946 to 1996, while Figure C7-3 shows surface level data from 1980 to present. Tank C-109 did not have a cascade overflow outlet. The tank was overfilled to 549 kgal in 1961, and to as high as 565 kgal between 1965 and 1968.

Occurrence reports relating to C-109 liquid levels include the following:

OR-76-14: Liquid Level Decrease
Following a transfer out of tank C-109, the liquid level dropped 0.10 inch between November 7, 1975 and January 24, 1976. The liquid level then continued dropping to 0.90 inches below the previous established baseline before beginning to recover. Drywells appeared stable throughout the decrease. The FIC plummet showed evidence of pitting corrosion at the tip.

C7.3 DRYWELL DATA

Eight vadose zone monitoring drywells surround tank C-109. These are 30-09-01, 30-09-02, 30-06-10, 30-09-06, 30-09-07, 30-08-02, 30-09-10, and 30-09-11. Figure C7-4 details spectral gamma-ray logging results for these drywells. The SGLS detected moderate to high concentrations of ^{137}Cs at the ground surface in all the drywells. Isolated occurrences of U-235 were detected at the ground surface in drywells 30-06-10 and 30-09-06.

The data obtained using the SGLS and the geologic and historical information available from other sources do not identify any large active leaks from tank C-109. However, the data do indicate the following.

- Shallow ^{137}Cs activity resulting from surface spills is distributed in the backfill material around the tank.
- Zones of elevated ^{137}Cs activity are distributed in the formation below the base of the tank farm excavation.
- Extensive ^{60}Co activity exists at considerable depth below the majority of the ^{137}Cs activity; the source of this activity is unknown. Areas of ^{60}Co activity are continuing to migrate through the vadose zone.

Occurrence reports relating to C-109 drywell readings include the following:

OR-82-01: Drywell Radiation Increase
Drywell surveillance on December 31, 1981 revealed a drywell radiation peak (215 cps) at a depth of 78 feet bgs in drywell 30-09-06. The peak exceeded the increase criteria of 200 cps). The increase was attributed to migration of existing soil activity from the vicinity of 30-08-02 near tank C-108.

Figure C7-2. Tank 241-C-109 Quarterly Surface Levels

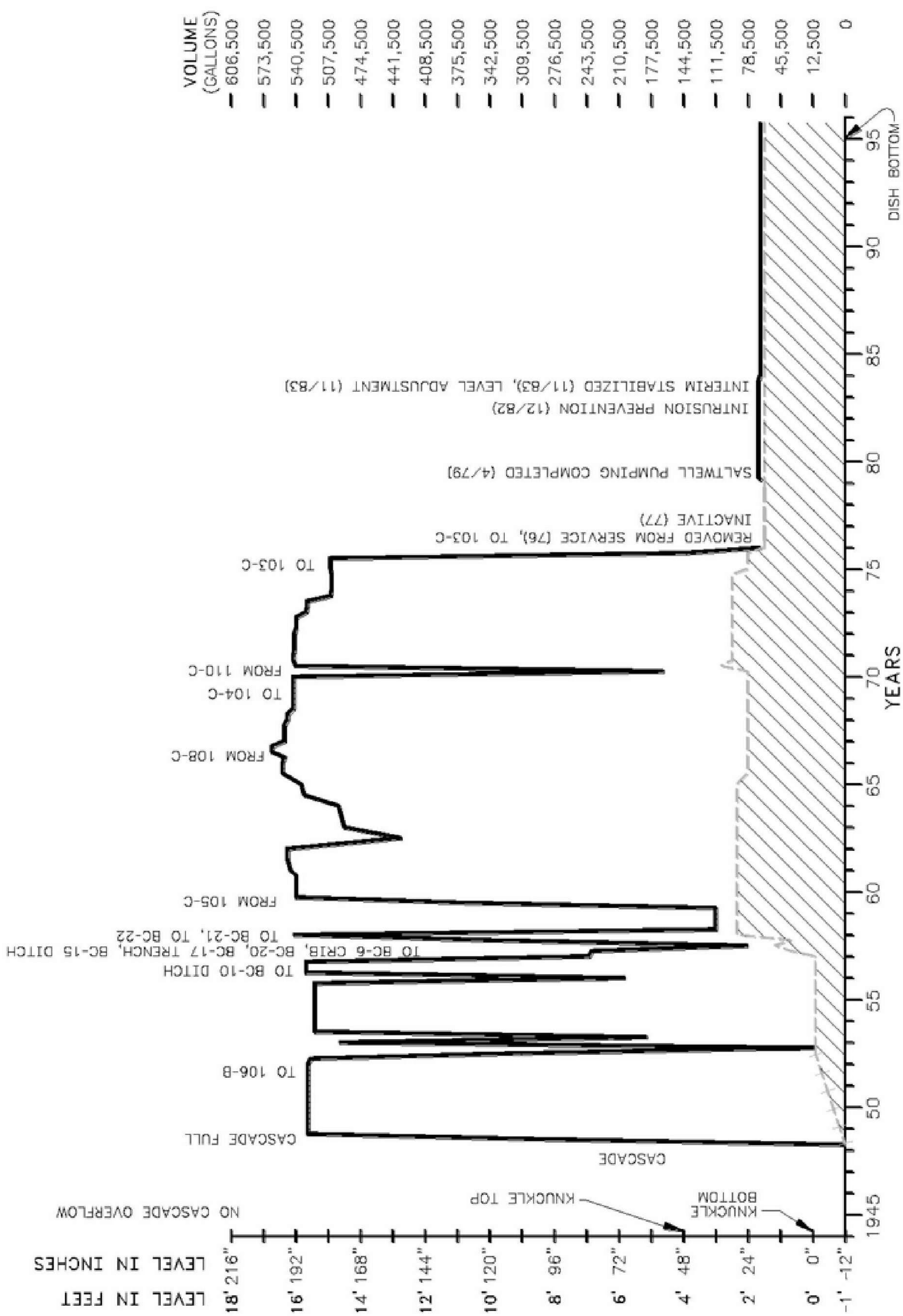


Figure C7-3. Tank 241-C-109 Surface Level Data

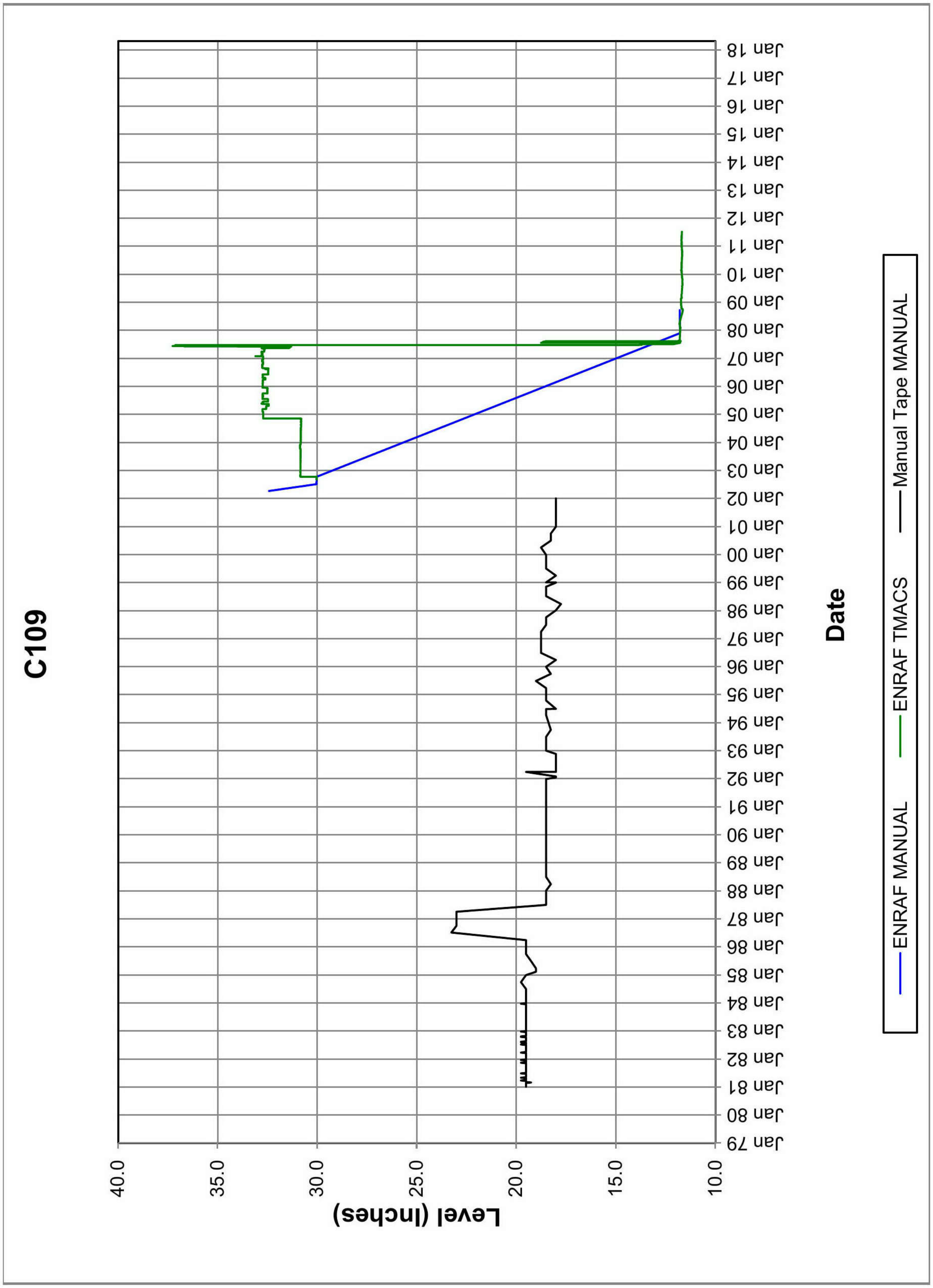
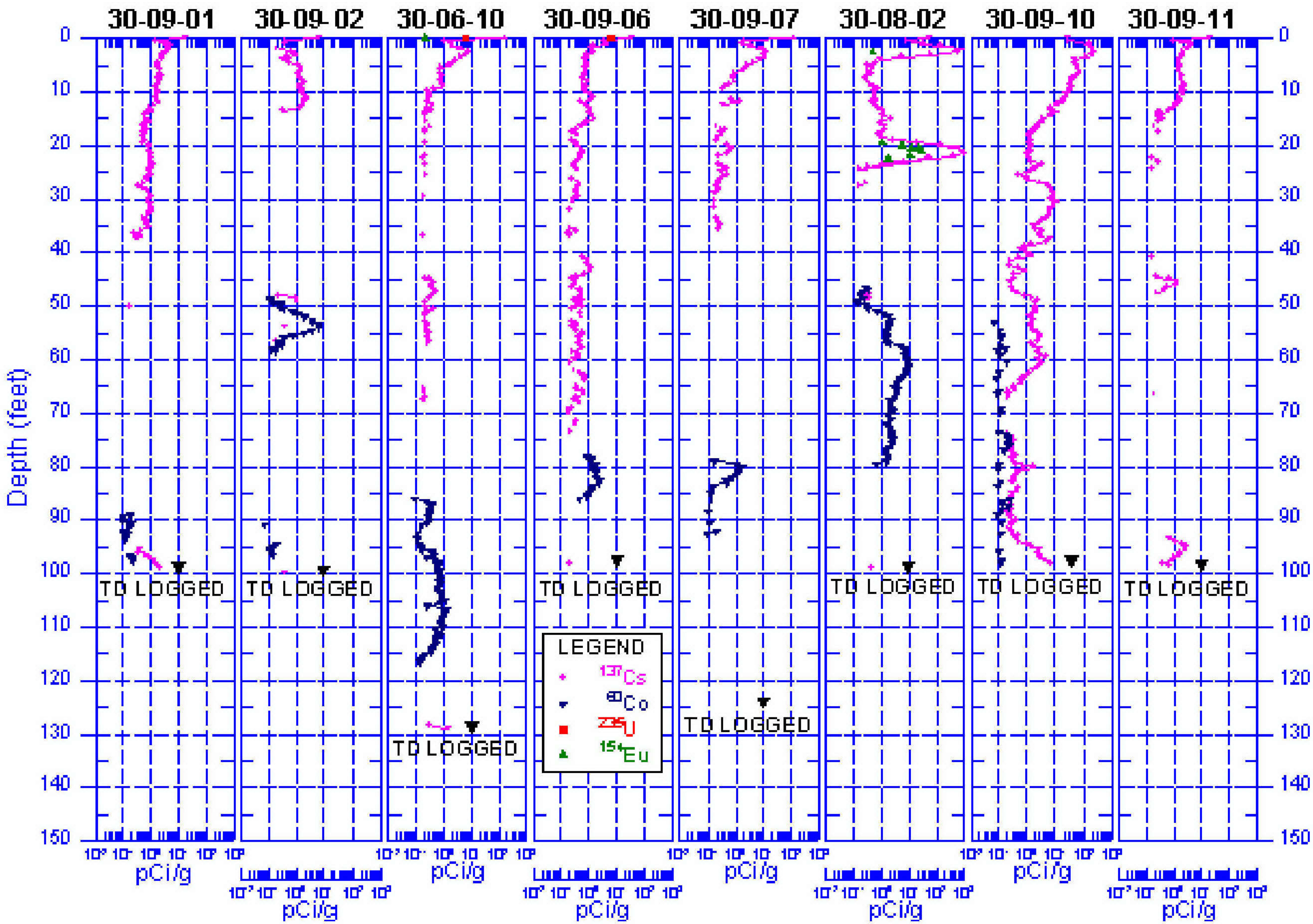


Figure C7-4. 1997 SGLS Logging Near Tank C-109 (GJ-HAN-91)



C8.0 TANK 241-C-112

Figure C8-1 details Tank C-112 waste transfers.

The interim stabilization letter for tank 241-C-112 (C-112) (HNF-SD-RE-TI-178, *Single-Shell Tank Leak Stabilization Record*) showed a volume of 393 kL (104 kgal), providing the basis for the total tank volume for this BBI effort. The volume was calculated from the manual tape reading of 33.25 inches, measured from the bottom of the sidewall, following the stabilization of the tank. LA-UR-96-3860 also included estimates of the tank 241-C-112 waste volume at 393 kL (104 kgal). On April 1, 2007 the ENRAF™ surface level measurement for tank C-112 was 45.58 inches from the bottom center of the tank, which converts to a total waste volume of 397 kL (105 kgal) Current surface level measurement is at 45.44 inches [Tank Waste Information Network System (TWINS), Queried 12/07/10], consistent with the stabilization record.

C8.1 HISTORY

Tank C-112 started receiving waste in November 1946, when it received a cascade from tank 241-C-111 of first-cycle decontamination waste (1C1) from the bismuth phosphate process. The first cascade transfer was finished in April 1947. The tank remained static until the majority of the supernatant was transferred to tank 241-B-106 in 1952 (Agnew et al. 1997b). In 1953, tank C-112 received a cascade from tank 241-C-111 and more supernatant was transferred to tank 241-B-106. The tank received unscavenged uranium recovery (UR) waste from the UR process in 1954 (Agnew et al. 1997b). In late 1955, tank C-112 began to be used for settling scavenged ferrocyanide waste. The scavenged supernatant was decanted and sent to several cribs, and the ferrocyanide sludge was retained in the tank until the first quarter of 1958 when in-farm scavenging was completed (General Electric 1958). Small transfers of flush water and cladding waste were received from 1958 through the second quarter of 1961. A small amount of waste from the strontium semiworks/hot semiworks was added to the tank in late 1961 and early 1962. In 1970 and 1975, B Plant ion-exchange waste from tank 241-C-110 and drainage to C-301 catch tank was added to tank 241-C-112. Tank C-112 was suspected of leaking and was emptied of pumpable liquid to tank 241-C-103 in 1975 and 1976 (Anderson 1990). Later surveillance could not confirm the suspected leak, and the tank is currently considered sound. Tank C-112 was removed from service in 1976, and the remaining supernatant (4 kgal) was sent to tank 241-C-103 (Agnew et al. 1997b). Finally, in 1983, 5 kgal of waste (from saltwell pumping) was transferred to double-shell tank 241-AN-103. The tank was administratively interim stabilized in September 1990.

C8.2 SURFACE LEVEL DATA

Figure C8-2 shows historical quarterly waste levels for tank C-112 from 1946 to 1996, while Figure C8-3 shows surface level data from 1980 to present. Tank C-112 does not contain a cascade overflow line, as seen in Figure C8-2. In 1964 waste highest waste level in tank C-112 was 547 kgal, above the spare inlet lines, and the tank was storing TBP-CW-HS waste.

Figure C8-1. Tank 241-C-112 Waste Operations Summary

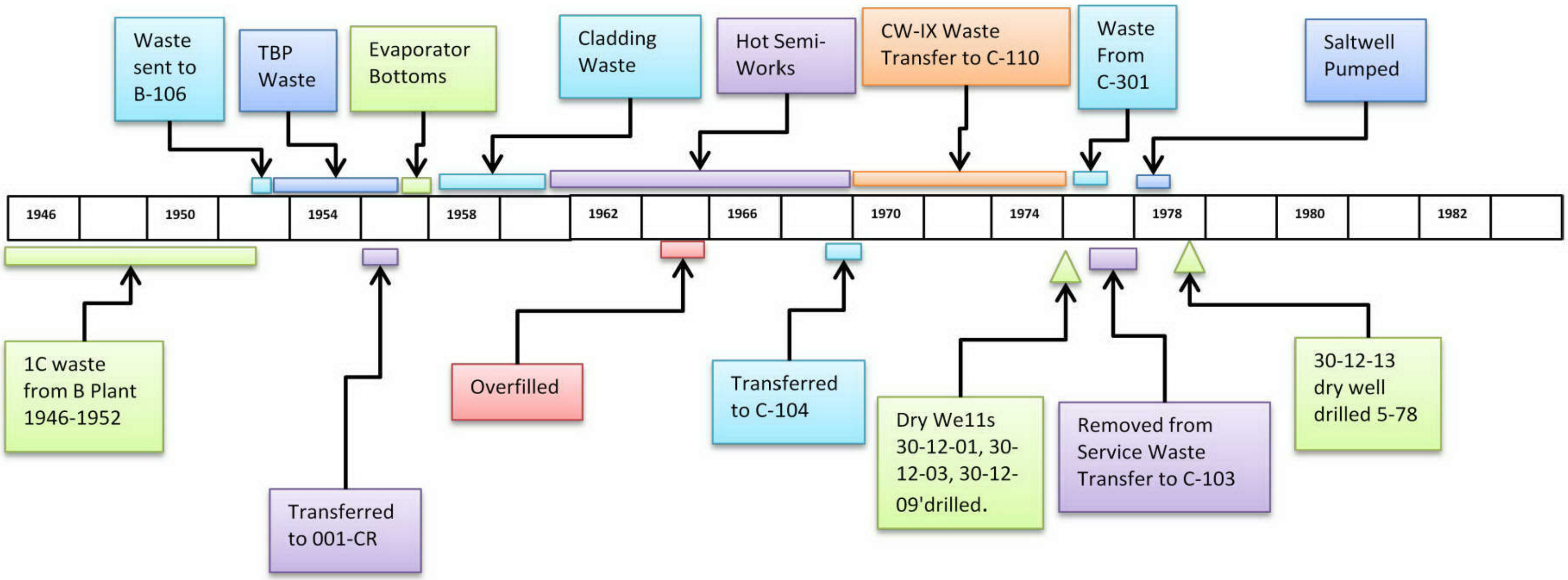


Figure C8-2. Tank 241-C-112 Quarterly Surface Levels

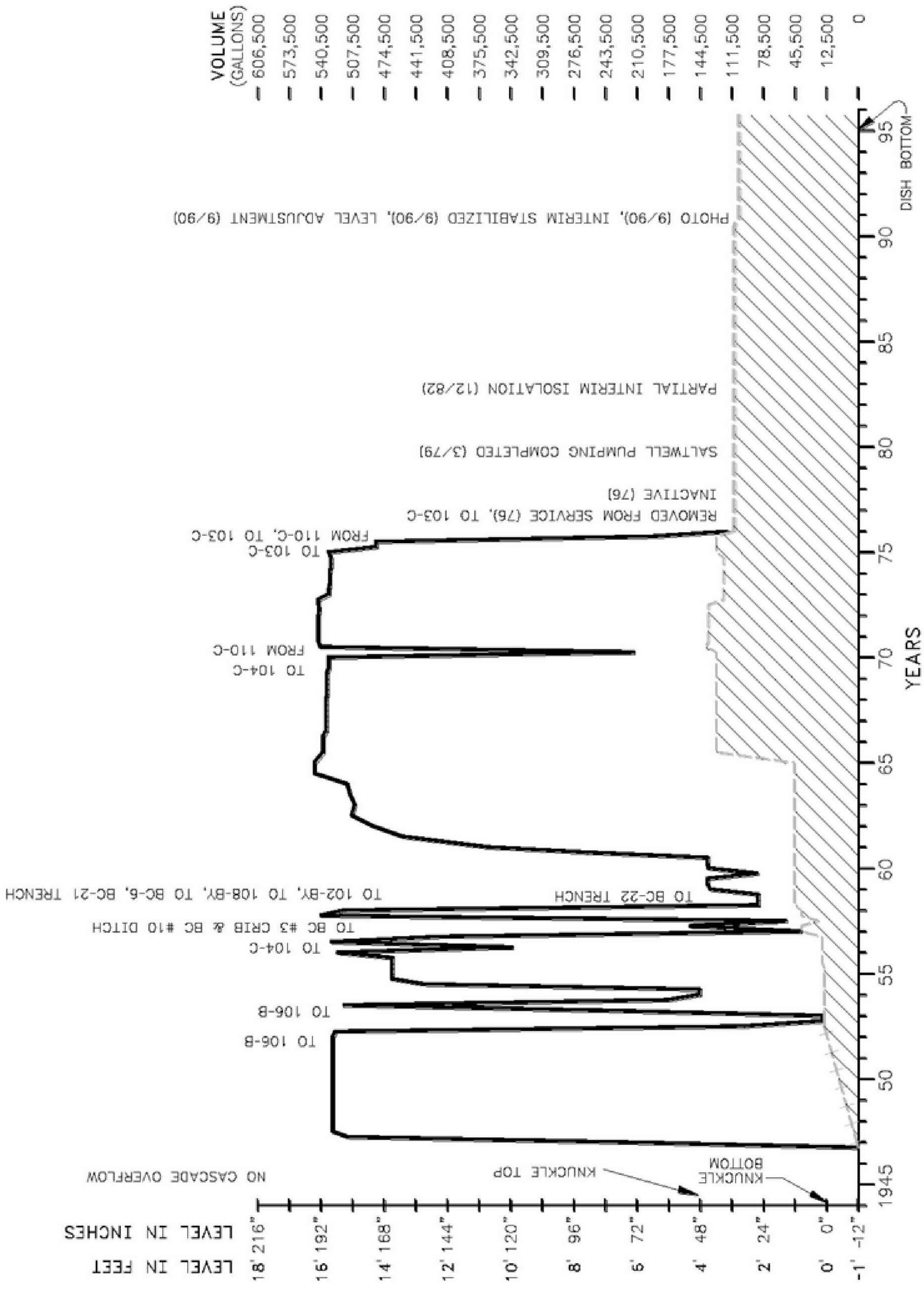
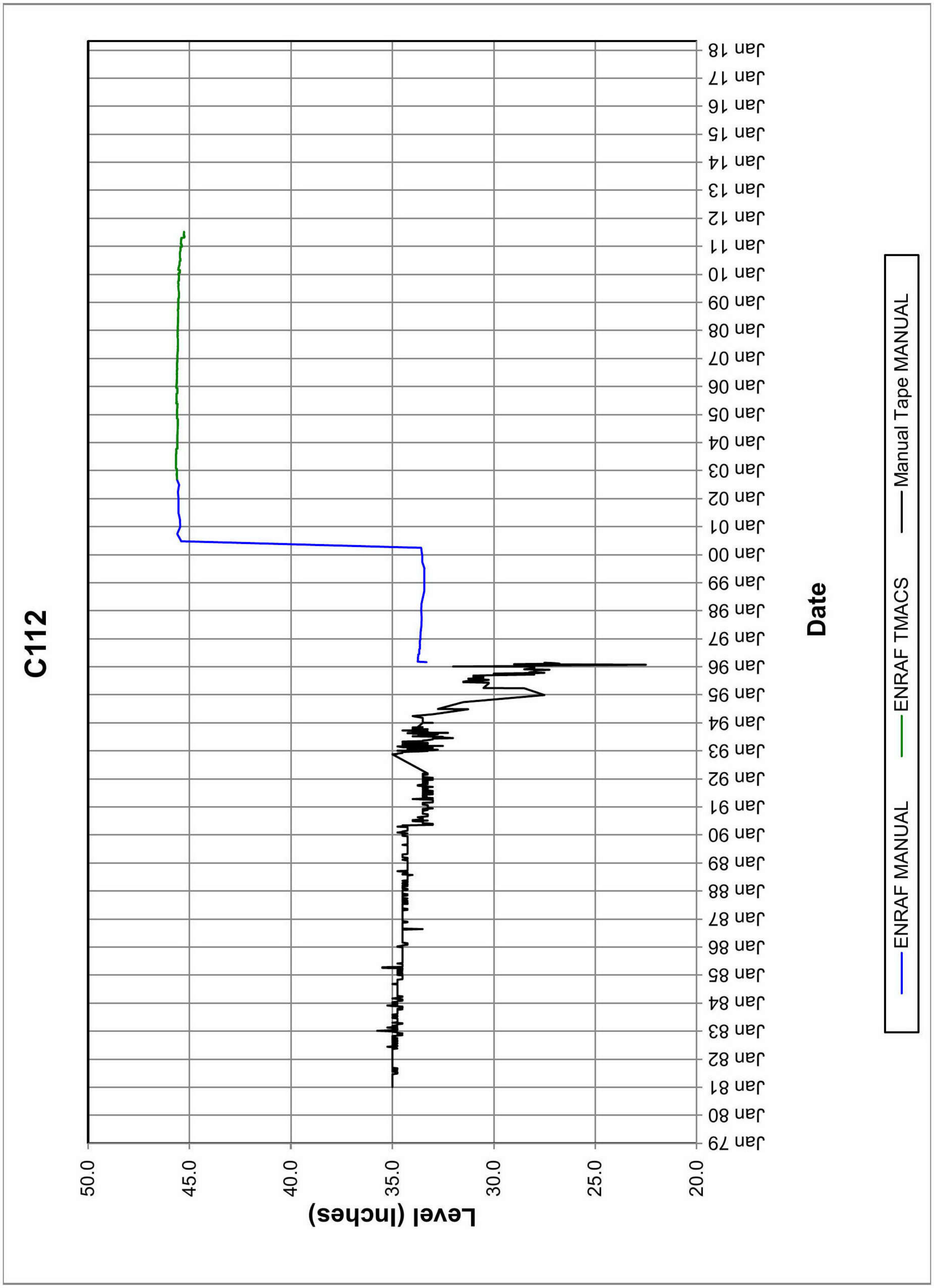


Figure C8-3. Tank 241-C-112 Surface Level Data



C8.3 DRYWELL DATA

Nine vadose zone monitoring drywells surround tank C-112. These drywells are 30-12-13, 30-12-01, 30-12-03, 30-00-12, 30-09-11, 30-09-10, 30-11-01, 30-12-09, and 30-00-13. Figure C8-4 details spectral gamma-ray logging results for these drywells.

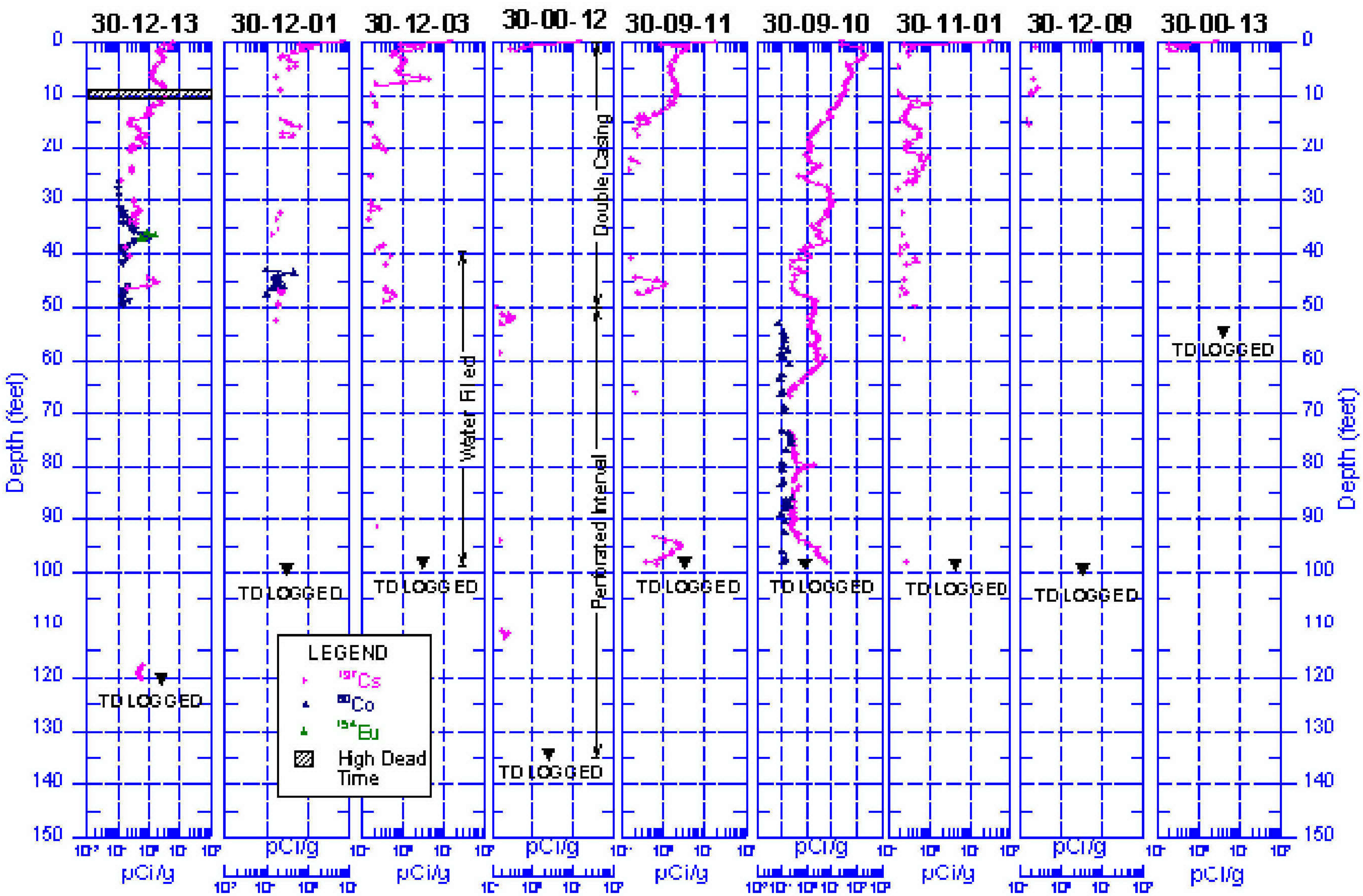
The SGLS detected low to moderate Cs-137 concentrations at the ground surface in all of the drywells. Most of the activity around tank C-112 was detected in the vicinity of drywells 30-09-10 and 30-09-11. The activity in the upper 25 ft of these drywells is associated with a surface spill that migrated into the backfill sediments.

In 1978, the historical gross gamma log data show an anomalous zone of activity at a depth of about 41 ft around drywell 30-12-01. Drywell 30-12-13 was installed in an apparent attempt to determine whether tank C-112 was the source of this activity. The first historical gross gamma log data for drywell 30-12-13 indicate activity was present from 5 to 10 ft and 32 to 41 ft after construction was completed. During this time period, tank C-112 was undergoing salt-well pumping. "As-Built" drawings of the C Tank Farm and tank C-112 indicate the salt-well pump pit is located in the center of this tank. It is possible the activity detected around drywells 30-12-13 and 30-12-01 resulted from a leak in the salt-well pump pit or associated subsurface pipelines and migrated along the tank dome to its present location. However, historical tank farm operations documentation was not available to substantiate this conclusion.

At drywell 30-12-01 and 30-12-13 show a ^{60}Co peak was detected at 30-50 bgs. These drywells are located in proximity to a known release from the salt-well pump pit located on top of the tank and could also be seeing a release from a transfer line leak from 252-C Diversion Box to tank C-112. The diversion box waste release likely occurred prior to 1974; waste type in tank C-112 was CW-IX (Anderson 1990).

Drywells 30-12-01 and 30-12-13 show a ^{60}Co peak at 30-50 bgs. These drywells are located in proximity to a known release from the salt-well pump pit located on top of the tank, and they could also be seeing a release from a transfer line leak from 252-C Diversion Box to tank C-112. The diversion box waste release likely occurred prior to 1974.

Figure C8-4. 1998 SGLS Logging Near Tank C-112 (GJ-HAN-94)



APPENDIX D

APPROACH TO ESTIMATE WASTE RELEASES BASED ON DRYWELL DATA

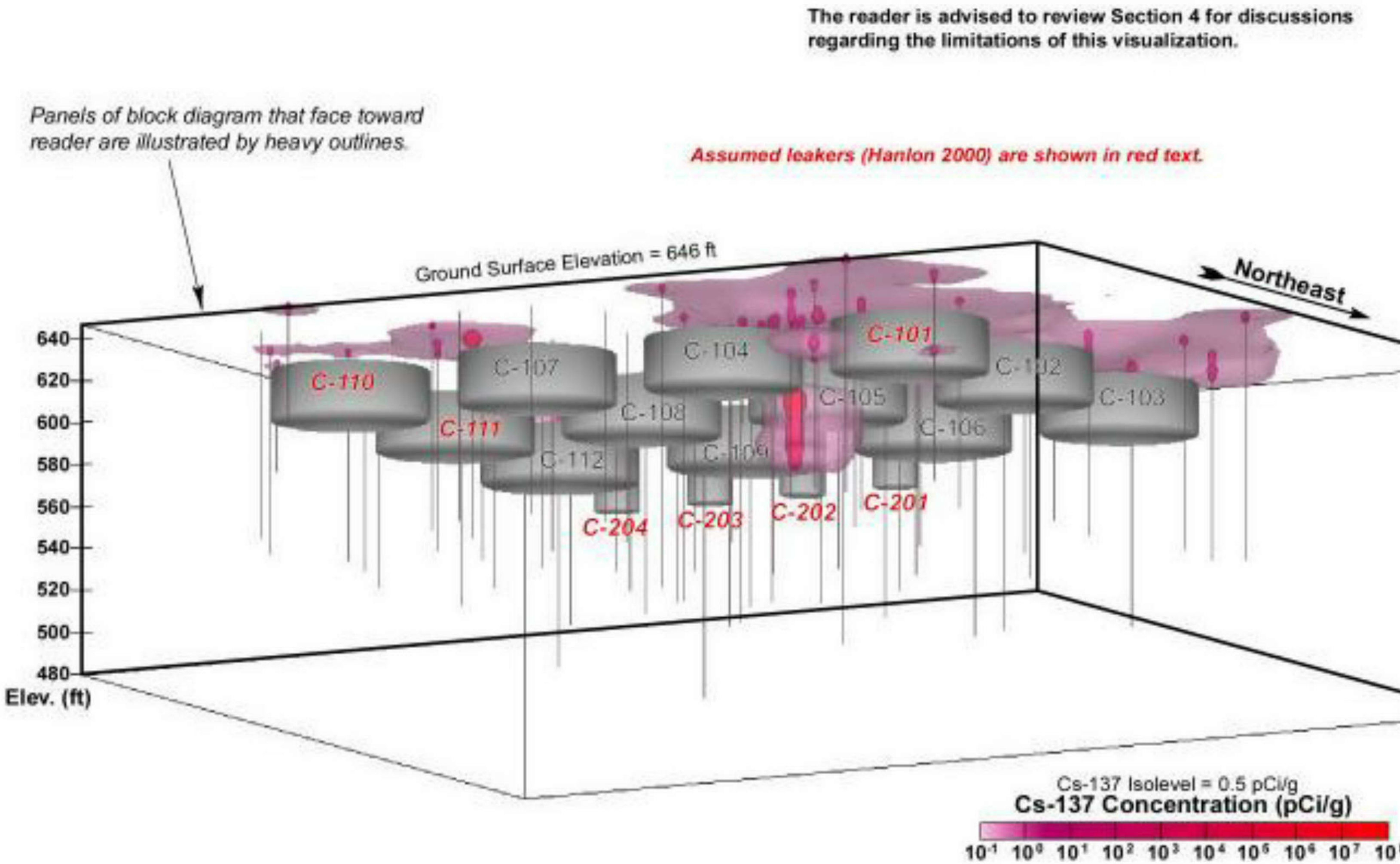
1.0 APPROACH TO ESTIMATE WASTE RELEASED

Waste release estimates were not developed previously for most overflows or pipeline leaks. The primary intent of this approach was to attempt to estimate the volume and inventory of these releases. In addition, the inventory estimates in previous revisions of this report were revistited. Inventory estimates were based on gamma activity observed in the soil and process knowledge of the waste believed to be in tanks or pipelines at the time of the release.

Gamma activity obtained as part of the baseline characterization work that used High resolution spectral gamma-ray logging provide the primary basis for the assessments (GJO-98-39-TARA/GJO-HAN-18). The C Farm GJO report estimates the volume of contaminated soil and total activity inventory. The waste release volume estimates were prepared by numerically integrating the volume within the specified isosurface. Contaminant inventories (in curies) were calculated by numerically integrating the total mass within the isosurface. These estimates were based on values extrapolated from the interpreted data set (kriged values), where concentration values were averaged over 5-ft intervals. They represent the volumes of the contaminated formation and total radioactivity for ^{137}Cs, ^{60}Co, and europium-154 (^{154}Eu). The total activity represents values at the time of the baseline logging in 1997 or additional data collected by the High Rate Logging System (HRLS) in 1999. Estimates were not corrected for decay. These estimates are based entirely on the data from the baseline SGLS characterization program, with HRLS data included in zones of detector saturation. The data sets used for the volume and total activity inventory estimates did not include any data from historical gross gamma logs, or any soil sample data, but a review of that information was conducted for anomalies.

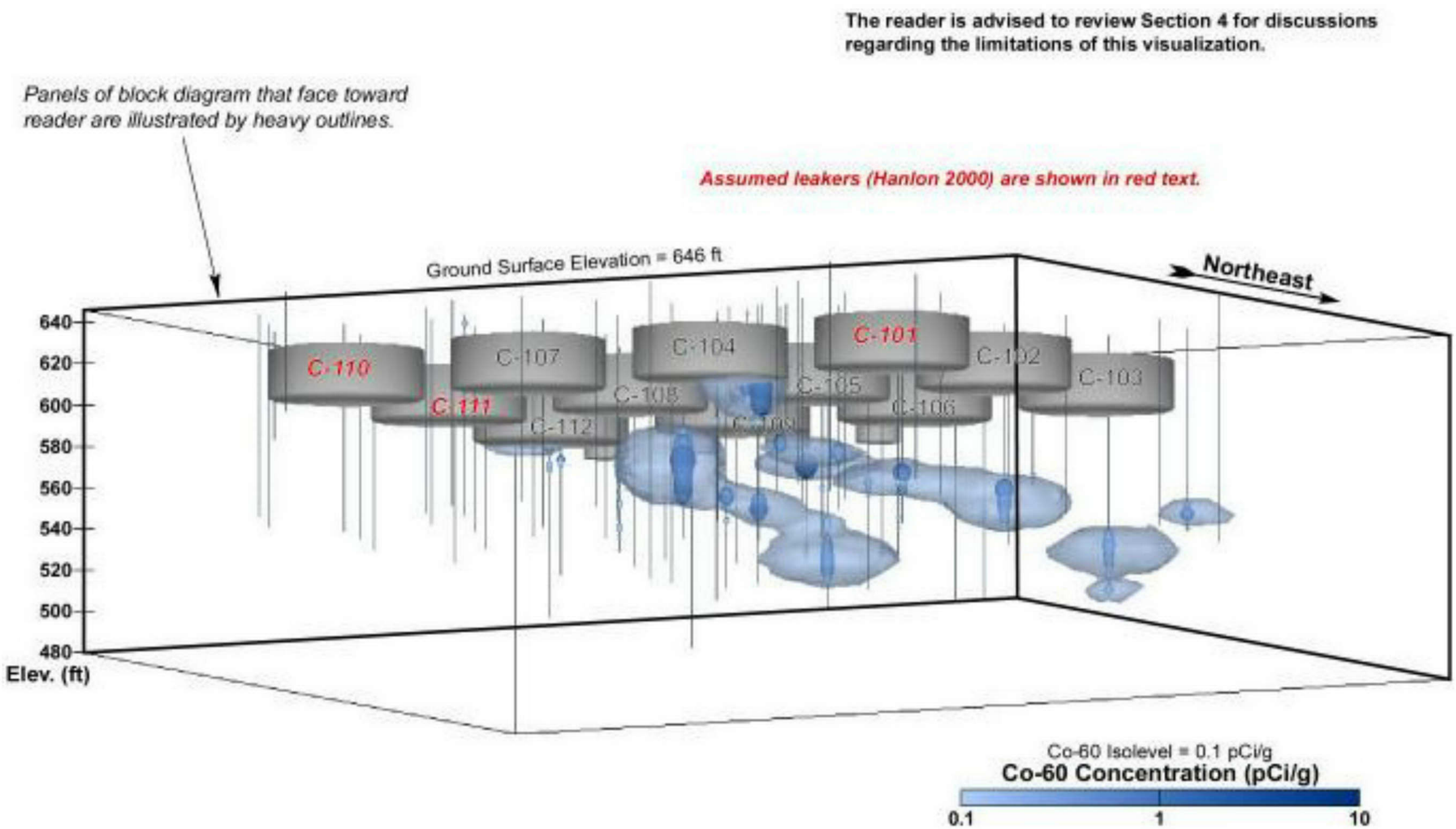
Figure D-1 shows a visualization for the observed ^{60}Co plume beneath C-Farm and Figure D-2 shows a visualization for the observed ^{137}Cs plume beneath C-Farm.

Figure D-1. 241-C Tank Farm Cobalt-60 Activity Visualization



Reference: GJO-98-39-TARA/GJO-HAN-18, *Hanford Tank Farms Vadose Zone Addendum to the C Tank Farm Report*.

Figure D-2. C Tank Farm Cesium-137 Activity Visualization



Reference: GJO-98-39-TARA/GJO-HAN-18, *Hanford Tank Farms Vadose Zone Addendum to the C Tank Farm Report*.

The contribution from ^{60}Co and ^{154}Eu may be underestimated because these data are not always measured accurately by the HRLS in zones of high gamma flux. A further limitation of this inventory is that no data are available from directly under the tanks where high concentrations of radionuclides may exist. In addition, substantial gamma activity may exist in the vadose zone at depths below the bottoms of many of the drywells. The ^{137}Cs concentrations may be underestimated for smaller or slower releases not detected by the drywells.

2.0 Waste Types

Table D-1 lists the threshold levels, the contaminated soil volumes, and total activity in C Farm at or above each level for ^{137}Cs, ^{60}Co, and ^{154}Eu (GJO-98-39-TARA/GJO-HAN-18).

Table D-1. Estimated Volume and Activity for Cesium-137, Cobalt-60, and Europium-154 in the 241-C Tank Farm Vadose Zone

Contaminant	Contaminant Threshold (pCi/g)	Contaminated Volume (Cubic Meters)	Total Activity (Curies)
Cesium-137	0.5	18,260	7.32
	5	6,118	7.22
	50	1,214	6.94
	500	459	6.34
	5,000	179	4.89
	10,000	113	3.95
	20,000	59.9	2.71
	25,000	46.9	2.29
Cobalt-60	0.1	19,740	6.76×10^{-3}
	0.3	2,527	2.42×10^{-3}
	0.5	1,063	1.51×10^{-3}
	1	288	6.85×10^{-3}
	2	65.8	2.36×10^{-4}
Europium-154	0.1	1,966	5.10×10^{-4}
	0.3	141	8.71×10^{-5}
	0.4	83	6.19×10^{-5}

Based on the measured ^{137}Cs alone the maximum estimate for waste released to C-Farm was small. Using the ^{60}Co maximum contaminated volume of 19,740 m^3, and assuming that a moisture content increase of this volume in the soil resulting from a waste release was a

5% difference (from measured moisture of a baseline of 4% to that of 9% [RPP-RPT-48029, *Completion Report for Direct Push Characterization at Four Sites in 241-C Tank Farm*]), would result in an estimated ~250,000 gal of additional retained liquid in this amount of soil. Knowledge of different gamma contaminants in the soil, an idea of the type of waste released, and consideration of the maximum release that could occur based on soil water content allows for the consideration of alternative conceptual models to estimate a volume and mass of waste that may have been released.

Table D-2 lists the concentrations of the prominent radionuclides of interest for some of the waste types received and stored in C-Farm tanks. Using the summary curie information provided in Table D-1 shows tabulated waste volumes for ^{60}Co in relation to various types of waste streams transferred to and from C-Farm tanks (RPP-19822). These waste volumes and compositions clearly show inconsistencies from the vadose data and the relative ratios of the three radionuclides indicated in Table 4-2 and waste stream composition reported in RPP-19822. Table D-3 shows the calculated waste volume of each prominent radionuclide relative to the general category waste type. Note that in Table D-3, if the entire release to the vadose zone was metal waste from the bismuth phosphate production, the ~0.007 Ci of cobalt would correspond to ~12,000 gal of waste released. Table D-3 shows the estimated technetium inventory for the cobalt estimated volumes for the listed waste types. Note the highest value is a total of ~0.02 Ci of ^{99}Tc. Multiple waste releases of different waste types may have occurred.

Table D-2. Listing of Waste Type Concentrations and Ratio to Cobalt-60 for Three Radionuclides*

	Concentration, Ci/L						
Waste Type	**Co-60**	**Eu-154**	**Cs-137**	**Tc-99**	**Eu/Co**	**Cs/Co**	**Tc/Co**
MW1	1.51E-07	6.44E-07	1.40E-02	6.86E-06	4	9.3E+04	45
1C1	1.11E-07	2.04E-07	3.12E-04	1.53E-07	2	2.8E+03	1
CSR	2.40E-05	8.16E-05	1.50E-02	1.44E-04	3	6.3E+02	6
CWP1	1.23E-05	2.73E-07	7.55E-04	2.84E-07	0	6.1E+01	0
TBP	1.85E-07	1.10E-06	1.15E-02	3.73E-06	6	6.2E+04	20
R1	2.04E-06	2.01E-05	7.50E-02	2.65E-05	10	3.7E+04	13
P1	1.23E-05	8.16E-05	2.84E-01	7.50E-05	7	2.3E+04	6
HS	2.07E-07	3.12E-04	2.20E-02	5.48E-06	1,507	1.1E+05	26
SRR	2.40E-05	8.16E-05	1.88E-01	4.13E-05	3	7.8E+03	2

*From RPP-19822, *Hanford Defined Waste Model – Revision 5.0*, Appendix A.

1C1 = Bismuth phosphate first cycle decontamination waste and coating waste (1944-1949)
CSR = Supernates from which the cesium has been removed by ion exchange. 241-C-801 cask station (1962-1967). B Plant Waste Fractionization (1967-1976).
CW = Cladding waste, aluminum clad fuel
CWP1 = Plutonium Uranium Extraction cladding waste, aluminum clad fuel (1956-1960)
HS = Hot Semiworks strontium purification waste (1961-1968)
MW1 = Bismuth phosphate metal waste (1944-1949)

Table D-2. Listing of Waste Type Concentrations and Ratio to Cobalt-60 for Three Radionuclides*

	Concentration, Ci/L						
Waste Type	**Co-60**	**Eu-154**	**Cs-137**	**Tc-99**	**Eu/Co**	**Cs/Co**	**Tc/Co**

P1 = Plutonium Uranium Extraction high level waste (1956-1962)
R1 = Reduction-Oxidation (S Plant) high level waste (1952 1958)
SRR = High activity waste from B Plant processing (1969-1985)
TBP = Tributyl phosphate process waste (1952-1958)

Table D-3. Listing of Waste Volume to Waste Type for Three Radionuclides Concentrations and the Technetium-99 Ratio to Cobalt-60 Volume*

Waste Type	Cobalt-60 (Vol. gal)	Europium-154 (Vol. gal)	Cesium-137 (Vol. gal)	Highest (Vol. gal)	Technetium-99 (Ci)
MW1	1.18E+04	2.09E+02	1.38E+02	1.18E+04	2.14E-02
1C1	1.61E+04	6.61E+02	6.20E+03	1.61E+04	6.50E-04
CSR	7.44E+01	1.65E+00	1.29E+02	7.44E+01	2.83E-03
CWP1	1.45E+02	4.94E+02	2.56E+03	1.45E+02	1.09E-05
TBP	9.65E+03	1.22E+02	1.68E+02	9.65E+03	9.51E-03
R1	8.75E+02	6.70E+00	2.58E+01	8.75E+02	6.13E-03
P1	1.45E+02	1.65E+00	6.81E+00	1.45E+02	2.88E-03
HS	8.63E+03	4.32E-01	8.79E+01	8.79E+01	1.27E-04
SRR	7.44E+01	1.65E+00	1.03E+01	7.44E+01	8.12E-04

*Based on Table D-2 radionuclide concentrations using Table D-1 ^{60}Co total inventory.

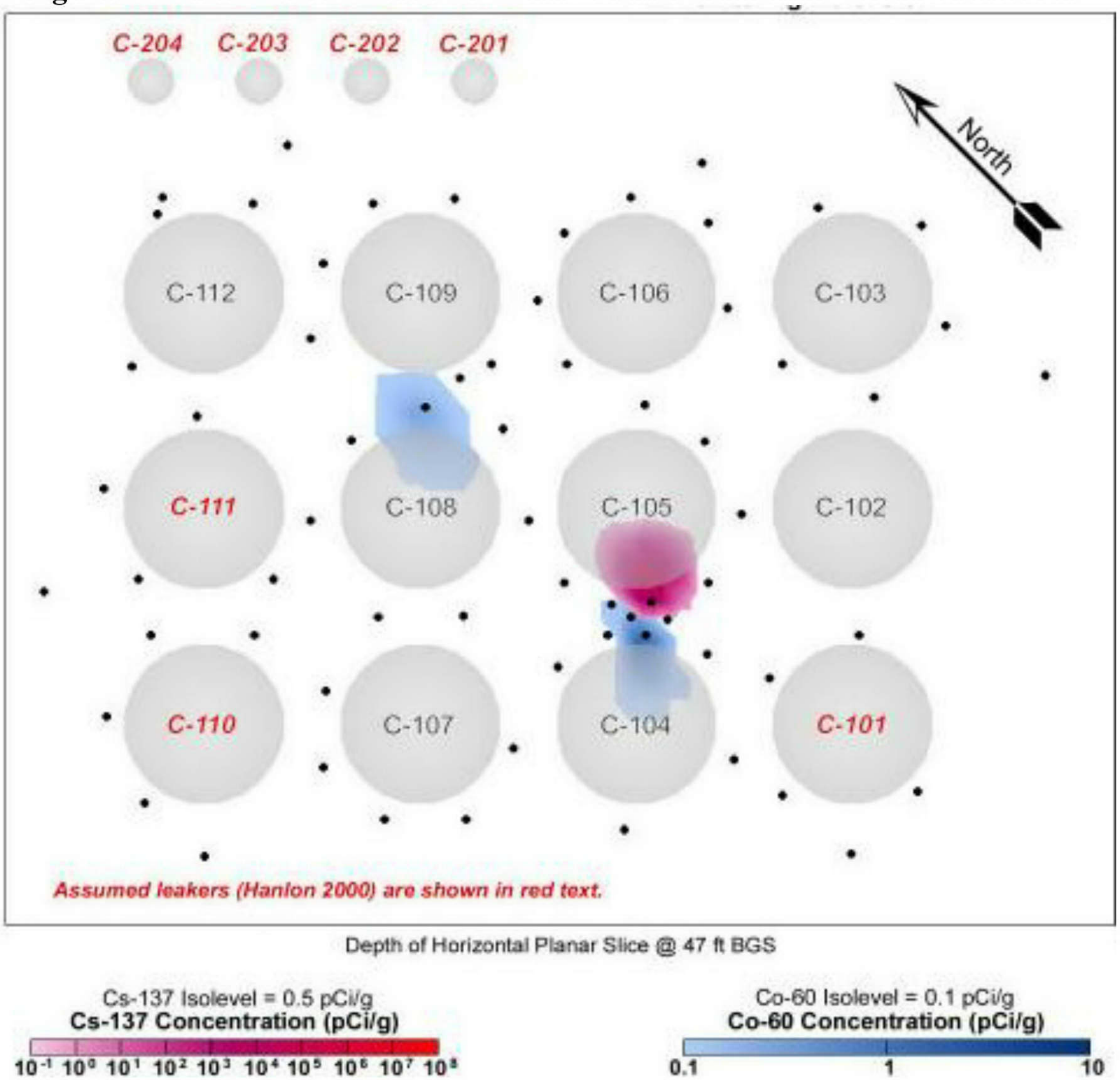
1C1 = Bismuth phosphate first cycle decontamination waste and coating waste (1944-1949)
CSR = Supernates from which the cesium has been removed by ion exchange. 241-C-801 cask station (1962-1967). B Plant Waste Fractionization (1967-1976).
CWP1 = Plutonium Uranium Extraction cladding waste, aluminum clad fuel (1956-1960)
HS = Hot Semiworks strontium purification waste (1961-1968)
MW1 = Bismuth phosphate metal waste (1944-1949)
P1 = Plutonium Uranium Extraction high level waste (1956-1962)
R1 = Reduction-Oxidation (S Plant) high level waste (1952 1958)
SRR = High activity waste from B Plant processing (1969-1985)
TBP = Tributyl phosphate process waste (1952-1958)

Using the approach described above, Table 4-5 in the main text estimates the volume and mass of waste that may have been released in C-Farm. These waste release volume estimates were based on drywell logging information associated with each identified tank, or the tank leak assessment. Prominent waste types at the time of the release and the radionuclide concentrations were decay corrected. The estimated total waste released volume was determined to be ~116,000 gal; ~ 20,000 Ci of ^{137}Cs, ~4 Ci of ^{60}Co, and ~8 Ci of ^{99}Tc. Those tanks not listed were found not to have associated and appreciable waste releases.

Figure D-3 displays a conceptual plume profile at 47 ft bgs based on drywell logging data. Note that at 47 ft bgs there are three distinct plumes shown: ^{60}Co plumes at tanks C-104 and C-108, and a ^{137}Cs plume at tank C-105. Simple geometric conceptual models were developed to estimate waste release volumes based on these and other such plume visualizations. The waste release volume conceptual models were used to quantify the waste release volumes listed in Table 4-5.
Reassessment results for each of the SSTs and for near-surface releases in or near C-Farm are discussed in Chapter 4 of this report. More detailed summary information for each tank assessed, including previous assessments, is included in Appendix B.

Two important principles that were considered in developing the drywell inventory estimates are the principles of ^{137}Cs sorption capacity and attenuation. These principles and applications are described in the following sections.

Figure D-3. 241-C Tank Farm Visualization at 47 Feet Below Ground Surface



Reference: GJO-98-39-TARA/GJO-HAN-18, *Hanford Tank Farms Vadose Zone Addendum to the C Tank Farm Report*.

3.0 Cesium-137 Sorption Capacity

Zachara et al (2002) shows that Cs-137 sorbs strongly, rapidly and irreversibly in Hanford soils. Because ^{137}Cs is less mobile than other gamma constituents, such as ^{106}Ru, ^{60}Co and Uranium isotopes it can be used as a tracer for leak volume estimates.

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. The plume may migrate downward preferentially depending on the permeability of the soil, but for a homogeneus soil is expected to migrate about the same distance in all directions horizontally.

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 D-4). Thus, these activity levels should be observed when a high-level waste plume approaches a drywell. The gamma data also indicate that high gamma 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. When lower activity Cs-137 is observed in a drywell the activity may be due to drag down in the well or may be attenuation. 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 1 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.

4.0 Attenuation

Because of the sorption properties and low mobility of ^{137}Cs in soils, when ^{137}Cs is observed at concentrations well below saturation capacity in a drywell one of three things can be assumed: 1. the ^{137}Cs activity is the result of a small release, very close to the measured location; if the release was large the activity level should be higher, 2. the ^{137}Cs activity is drag down in the drywell or 3. The ^{137}Cs activity is attenuation from a nearby larger source.

Because the drywells may be 5 to 30 ft from a release source, and the radius of measurement for the HGPE spectral gamma logging probe is about 1 to 2 feet, ^{137}Cs plumes that migrate downward preferentially due to soil permeability or small plumes may not be detected by the drywells. However, high gamma activity is attenuated or reduced in intensity in the soil and a

1,000 pCi/g spike may be the result of gamma activity several orders of magnitude higher only a few feet away.

5.0 Application of Sorption Capacity and Attenuation Principles

Based on the principles described above, a bounding ^{137}Cs plume can be estimated. For example, a ^{137}Cs spike of about 1,000 pCi/g was observed at 30 ft bgs in drywell 30-01-09, near tank C-101. A spare inlet overflow was determined to be a probable source of the gamma activity. Assuming that the ^{137}Cs plume traveled from the spare inlet and spread about the same distance in all directions, Figure D-5 shows a possible configuration of the plume. Because the gamma activity is well below saturation capacity, we can assume that the plume did not reach the drywell, but that the drywell is picking up activity (attenuated readings) from a plume several feet away. If the drywell is 13 ft from the tank, we can assume the radius of the plume is about 10 ft. because no activity was observed above or below 30 ft in the drywell, we assume the drywell sees the outer edge of a parabolic plume. This allows us to compute a volume for the ^{137}Cs. Assuming that the entire volume is at saturation capacity ($\sim 10^7$ pCi/g) total Ci can then be estimated.

The moisture plume conceptual model is discussed in Section 4.1.

Figure D-4: 1999 SX-108 Slant Borehole Log Plot

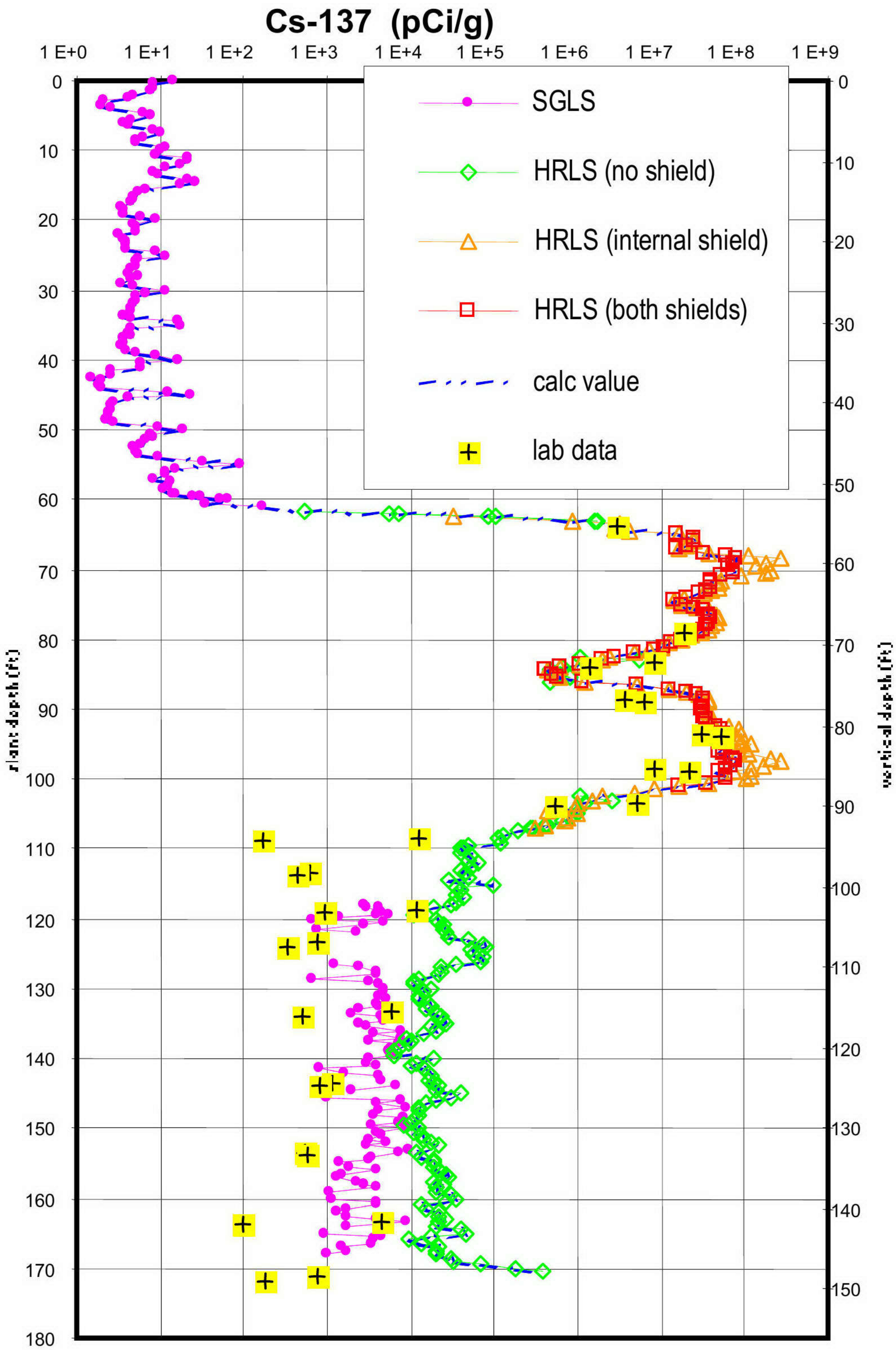


Figure D-5. Conceptual ^{137}Cs and Moisture Plume for Tank C-101 Spare Inlet Release