RPP-32681
Rev 0

PROCESS TO ASSESS TANK FARM LEAKS IN SUPPORT OF RETRIEVAL AND CLOSURE PLANNING

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Abbreviations and Acronyms

bgs	below ground surface
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
HDW	Hanford Defined Waste
ITS	in-tank solidification
ORIGEN	Oak Ridge Isotope Generation and Depletion Code
SIM	Soil Inventory Model
TRAC	Track Radioactive Components
TWRWP	Tank Waste Retrieval Work Plan
UPR	unplanned release
WMA	waste management area

Units

Ci	Curies
gal	gallons
pCi/g	picocuries per gram

1.0 INTRODUCTION

Numerous studies and investigations have attempted to estimate the volume and inventory of tank farm leaks to the vadose zone. Most efforts to date have focused on leak volume estimates. The inventories of leaks to the vadose zone are then estimated based on process knowledge of the composition of waste in the tank at the time the release occurred. For some major tank leaks, extensive in-tank and ex-tank measurements are available and provide a strong technical basis for leak volume and inventory estimates. However, for many tank leaks and unplanned releases (UPRs) little data is available.

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

In response to Ecology concerns regarding RPP-23405, the U.S. Department of Energy (DOE) committed to work collaboratively with the Washington State Department of Ecology (Ecology) to establish a process to update tank farm leak volume estimates, data interpretations, and the conclusions presented in RPP-23405 (DOE-ORP letter 06-TPD-059, dated August 18, 2006). Pursuant to that commitment, this document establishes a process to develop estimates of tank-farm leak loss inventories. This process will be used to assess the source of tank-farm leaks when necessary to help meet the need to justify tank waste retrieval technology selections (independent of tank integrity designation), re-assess volume estimates and inventories for previously identified tank leaks, and update tank leak and UPR volume and inventory estimates as emergent field data is obtained

DOE will request Ecology review and concurrence on this process document. DOE will also request Ecology input, review, and concurrence on tank leak assessments at various points when the process is invoked. Ecology concurrence on tank waste leak inventory estimates is necessary to support Ecology approval of tank waste retrieval actions, vadose zone corrective actions, and tank farm closure actions as described in HFFACO Appendix I.

Where information regarding treatment, management, and disposal of radioactive source, by-product material, and/or special nuclear components of mixed waste (as defined by the *Atomic Energy Act of 1954*, as amended) has been incorporated into this document, it is not incorporated for the purpose of regulating the radiation hazards of such components under the authority of the "Hazardous Waste Management Act", Section 70.105 of the *Revised Code of Washington* and its implementing regulations, but is provided for information purposes only.

Although leak inventory estimates are developed using the “best available” information, for many tank farm leak estimates there is a wide range of uncertainty in inventory and source of leaks. Therefore, tank farm leak assessments will help to identify where additional data is needed and leaks will be re-assessed as needed as additional data is obtained that may reduce uncertainties and provide a better technical basis for retrieval and closure planning.

The processes described in this report include:

- Selecting tanks or UPRs to re-assess
- Assessment procedure
- Types of information to collect for assessments
- Assessment protocol and guidelines
- Estimating uncertainty

2.0 OBJECTIVES AND SCOPE

The primary purpose of the tank farm leak assessment process is to achieve technically defensible estimates for tank farm leaks in support of retrieval and closure planning using an established methodology and consistent process.

Specific objectives of the process are to:

1. Ensure defensibility of assessments
2. Maintain current leak inventories, accounting for new information
3. Document findings
4. Report assessment results

Tasks required to meet these objectives are discussed in Section 4.0.

Questions to be answered during the process:

- What is the source of the release?
- When did the release occur?
- If a tank leak, is it a tank bottom or side leak; where is the leak located?
- What type of waste was released?
- What data are available to describe the release?
- What is the uncertainty of the data?
- Do all of the data support a release?
- What was the past estimate for the release volume and its uncertainty?
- What was the past estimate for the mass of contaminants released and its uncertainty?
- Were there previous analyses of waste released from this facility?
- What is the current assessment of this release?
- Why is the current analysis superior to past estimates?

Tank farm leak estimates for each event will include:

- Source and estimated time of tank leaks
- Waste type and waste composition estimates
- Volume and inventory estimates for leaks, spills, and other unplanned releases to the vadose zone from tank farm equipment and operations Uncertainty estimates or ranges for volumes, concentrations, and inventories
- Inventory calculations for select analytes requested by the assessment team and information to calculate inventory values for 25 chemicals and 46 radionuclides (decayed to January 1, 2004). The analytes (Table 2-1) are the same as those used for Best-Basis Inventory standard analytes in RPP-7625, *Best-Basis Inventory Process Requirements,* and account for approximately 99 weight percent of the chemical content

and over 99 percent of the radionuclide activity (Ci), in terms of short and long--term risk (WHC-SD-WM-TI-731, *Predominant Radionuclides in Hanford Site Waste Tanks*).

Table 2-1 Vadose Zone Inventory Analytes.

25 Chemicals		46 Radionuclides			
Al	NO2	3H	113mCd	226Ra	237Np
Bi	NO3	14C	125Sb	227Ac	238Pu
Ca	Oxalate	59Ni	126Sn	228Ra	238U
Cl	Pb	60Co	129I	229 Th	239Pu
Cr	PO4	63Ni	134Cs	231Pa	240Pu
F	Si	79Se	137Cs	232Th	241Am
Fe	SO4	90Sr	137mBa	232U	241Pu
Hg	Sr	90Y	151Sm	233U	242Cm
K	TOC	93Zr	152Eu	234U	242Pu
La	UTOTAL	93mNb	154Eu	235U	243Am
Mn	Zr	99Tc	155Eu	236U	243Cm
Na	TIC	106Ru			244Cm
Ni	TOC				

Notes:
TIC = total inorganic carbon
TOC = total organic carbon

3.0 SELECTING TANK LEAKS OR UPR'S TO REVIEW

The leak assessment process is invoked when a basis for re-evaluating current tank leak estimates is identified by Ecology, DOE, or DOE contractors. This may be a result of new data or re-interpretation of existing data, which could indicate a change to tank farm leak inventory estimates and may impact remediation or closure decisions. When making a decision to initiate this leak assessment process, consideration is given with regard to current agreements such as *Hanford Federal Facility Agreement and Consent Order* (Ecology 1998, informally known as the Tri-Party Agreement), milestones and schedules, and potential regulatory needs (e.g., future permitting and clean-up requirements).

The following steps will be followed for the reassessments.

- Upon identification of a potential need to re-evaluate a tank farm leak volume or inventory, the designated DOE contractor responsible for the tank farms vadose zone inventories will be requested to perform a preliminary evaluation.
- The DOE contractor will evaluate the new data/information to determine whether the new information could change current inventory estimates or uncertainties and what, if any, impact the information could have on remediation and closure decisions.
- Based on potential impacts and program needs, the environmental program lead for the DOE contractor will determine whether or not to proceed with an assessment (using the process described in Section 4.0) and will present findings to DOE and Ecology.

Initial assessments will be for tank leaks in C-tank farm (See Section 4.1).

4.0 ASSESSMENT PROCESS

The assessment process is shown in Figure 4-1. The following sections describe the individual steps outlined in this figure. Steps performed by the DOE contractor are illustrated in Figure 4-1 by the white fill-in boxes; the red fill-in boxes are for steps requiring input from Ecology. Steps that require Ecology review are illustrated in yellow, and steps requiring Ecology concurrence are shown in green. Table 4-1 summarizes the color coding of the various steps from the figure and the annotations of the following sections.

Table 4-1. Responsible Organizations for Assessment Process.

Color	Organization	Annotation on Section Title
Red	Input from Ecology	(R)
Yellow	Review by Ecology	(Y)
Green	Concurrence on released document by Ecology	(G)
White	Performed by Contractor	(W)

4.1 IDENTIFY CANDIDATE FACILITIES (R)

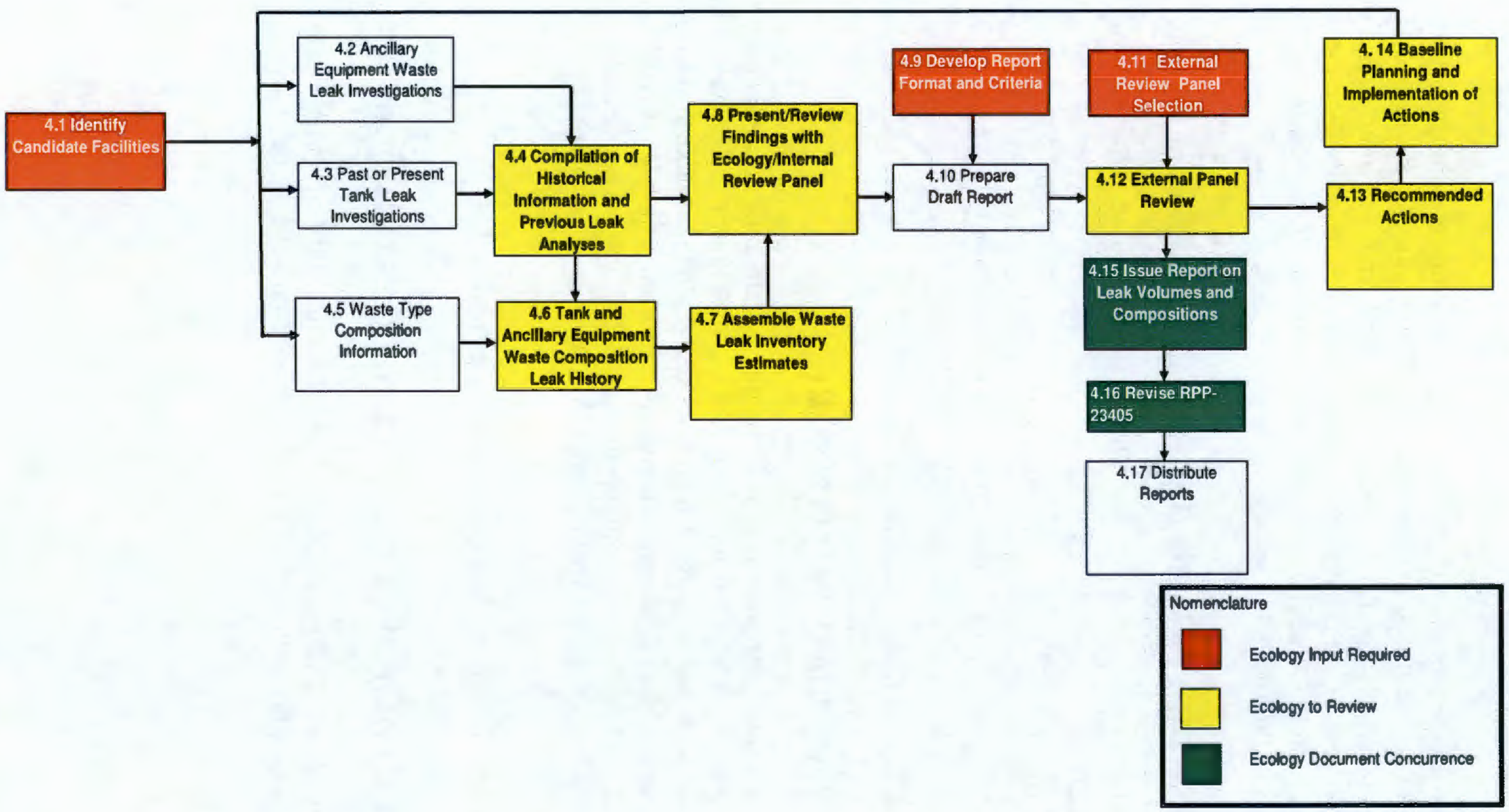
The first step in the assessment process is to determine which tanks or unplanned release events need to be reassessed. Initially, tank leaks and UPRs in the C farm will be assessed, focusing on differences between tank leak volume estimates in RPP-23405 and other historical estimates. Then data will be reviewed to determine whether to assess other tank leaks, UPRs, or potential new leaks in C farm. The process will be repeated farm-by-farm, as needed. The order and priority for future leak assessments will be determined based on tank retrieval and tank farm closure needs.

The selected facilities are reassessed following the steps outlined below.

4.2 ANCILLARY EQUIPMENT WASTE LEAK INVESTIGATIONS (W)

Data regarding any reported UPRs and waste leaks from ancillary equipment in the area of the facility being reassessed are collected. This data are collated with the information from Section 4.3.

Figure 4-1. Tank Farm Leak Assessment Process Diagram.



4.3 PAST OR PRESENT TANK LEAK INVESTIGATIONS (W)

Data regarding any past or present waste leaks for tanks assessed are collected, and collated with data for any reported ancillary equipment waste leaks from Section 4.2. Both of these inputs are fed into the activity of Section 4.4.

If a tank integrity evaluation is required per TFC-ENG-CHEM-D-42, leak volume and inventory will be estimated as part of the tank integrity assessment.

4.4 COMPILATION OF HISTORICAL INFORMATION AND PREVIOUS LEAK ANALYSES (Y)

All of the information from previously reported tank leaks and UPRs are compiled to identify probable leak sources and to estimate volume of tank waste that leaked to the vadose zone and the time leaks occurred. These estimates are then fed into the next step of the process (Step 4.5), which is to determine the waste composition at the time of the leak.

4.5 WASTE TYPE COMPOSITION (W)

Information regarding the waste composition at the time of a leak from the waste tank, ancillary equipment, or UPR is compiled from the available sources, such as waste transfer records, waste stream sample data, Hanford Defined Waste model, and so on, and is applied to the facility being reassessed. See Section 6.2 and 6.3 for a discussion of what is meant by "date of leak" and "waste composition" and how they are determined.

4.6 TANK AND ANCILLARY EQUIPMENT WASTE COMPOSITION LEAK HISTORY (Y)

A waste history is prepared to show the waste types in a facility at the estimated time(s) for a leak to determine the composition of the radionuclides and chemicals leaked to the soil.

4.7 ASSEMBLE WASTE LEAK INVENTORY ESTIMATES (Y)

When all of the available data has been compiled, estimations of the waste volume leaked and the waste composition at the time of the leak are combined to calculate a waste inventory. A leak information report and summary table are prepared, including observations and information collected in Steps 4.4, 4.6, and 4.7 (See example for tank C-101 in Appendix A).

4.8 PRESENT/REVIEW FINDINGS WITH ECOLOGY AND INTERNAL REVIEW PANEL (Y)

After the leak information report and summary table are prepared, the report is presented and discussed by a panel appointed by the Environmental Programs Lead of the DOE contractor with concurrence from DOE and Ecology. The panel shall include an assessment lead and individuals with the following expertise.

- In-tank data: person or persons with knowledge and experience in reviewing, analyzing, and interpreting in-tank (i.e., surface liquid level and liquid observation well) data.
- Ex-Tank data: person or persons with knowledge and experience in reviewing, analyzing, and interpreting drywell, lateral survey, and/or high resolution resistivity (HRR) data.
- Tank operations and processes: person or persons with knowledge and experience with operations of the tank, tank history, tank waste characteristics, and in-tank processes.
- Other personnel as deemed necessary.

The same person may provide expertise in more than one area and the makeup of the panel may be adjusted to complement the available data. (e.g., if no ex-tank data are available, a facility configuration specialist could be selected in place of the ex-tank specialist.) A member of the panel assigned by the panel lead will present the information assembled (Section 4.7) and panel members will determine answers to the questions in Section 2.0.

4.9 DEVELOP REPORT FORMAT AND CRITERIA (R)

Using input from Ecology, the format and content for a reassessment report and the criteria to be included in it will be developed by the DOE contractor. The report will include information presented, assessment findings and results, and panel conclusions as to the range of waste volume leaked, composition of the waste, and inventory estimates for selected constituents.

4.10 PREPARE DRAFT REPORT (W)

Reports documenting assessments will be prepared by the assessment panel and reviewed by DOE and Ecology. Reports will be revised to include additional assessments as assessments are completed within a tank farm. A separate report will be prepared for each tank-farm assessed.

4.11 EXTERNAL REVIEW PANEL SELECTION (R)

If necessary, based on input received from DOE and Ecology after their review of the reassessment report, an external review panel will be selected. The members of this review panel will be selected with concurrence from DOE and Ecology.

4.12 EXTERNAL PANEL REVIEW (Y)

If necessary, the reassessment report developed in Step 4.10 "Prepare Draft Report" will be presented to the external review panel for their review.

4.13 RECOMMENDED ACTIONS (Y)

Any corrective actions deriving from the external review of the reassessment report will be reviewed by DOE and Ecology for their determination as to whether any of these recommendations should be carried forward into the following sections.

4.14 BASELINE PLANNING AND IMPLEMENTATION OF ACTIONS (Y)

When the review comments from the internal review panel, and (if activated) the external review panel, have been resolved to the satisfaction of DOE and Ecology, any actions deriving from the review will be incorporated into the baseline planning for subsequent reassessments.

4.15 ISSUE ASSESSMENT REPORT ON LEAK VOLUMES AND COMPOSITIONS (G)

With review comments resolved, the DOE contractor will issue the assessment report for the facility being assessed. This report will be concurred on by DOE and Ecology before the revision of RPP-23405 can occur. Completion of this step meets objectives 1 "Ensure Defensibility of Assessments" and 3 "Document Findings" presented in Section 2.0.

4.16 REVISE TANK FARM VADOSE ZONE CONTAMINATION ESTIMATES (RPP-23405) (G)

The DOE contractor will use the revised waste leak volume and composition, as applicable, to update RPP-23405 on an annual basis, as necessary. Information from the reassessment reports will be gathered as they are completed and may be entered into RPP-23405 as page changes between revisions. The revised document will then be concurred on by DOE and Ecology. Revisions to RPP-23405 may also be driven by future revisions to the Tri-Party Agreement or individual permits may contain verbiage relating to updates to RPP-23405. Completion of Steps 4.16 and 4.17 meets objective 2, "Maintain current inventories, accounting for new information" and 4, "Report assessment results."

4.17 DISTRIBUTE REPORTS (W)

The DOE contractor will issue and distribute reassessment reports and RPP-23405 updates to DOE and Ecology. The reports will be used to determine appropriate methods for retrieval to be defined in Tank Waste Retrieval Work Plans (TWRWPs) and to update tank farms performance and risk assessments and other documents, as applicable.

5.0 INFORMATION TO COLLECT FOR ASSESSMENT

As applicable, the information shown in Table 5-1 and other applicable information will be collected by the assessment lead and factored into information discussions by the assessment team.

Table 5-1. Types of Information and Sources for Tank Farm Leak Assessments (3 pages).

Type of Information	Examples
In-tank liquid level measurements	Surveillance Analysis Computer System.
	Hanford Works Process records
Waste transfer records	RPP-19822, 1997, Hanford Defined Waste Model-Rev. 5
	WHC-MR-0132, 1990, The History of the 200 Area Tank Farm
Tank process reports and assessments	HNF-EP-0182, Waste Tank Summary reports and associated references
	RPP-RPT-29191, 2006, Supplemental Information for Tank Leaks
	Tank process records
	Occurrence Reports
	8901832B, 1989, Single-Shell Tank Leak Volumes, Rev. 1
	HNF-2603, 1998, A Summary and Evaluation of Hanford Site Tank Farm Subsurface Contamination
	HNF-4872, 1999, Single-Shell Tank Leak History Compilation
	SD-WM-TI-356, 1988, Waste Storage Tank Status and Leak Detection Criteria
	RHO-CD-896, 1980, Review of Classification of Nine Hanford Single-Shell "Questionable Integrity" Tanks
	RPP-10435, Single-Shell Tank Integrity Assessment Report
	WHC-MR-0132, 1990, A History of the 200 Area Tank Farm,
	WHC-MR-0264, 1991, Tank 241-A-105 Leak Assessment
	WHC-MR-0300, 1992, Tank 241-SX-108 Leak Assessment
	WHC-MR-0301, 1992, Tank 241-SX-109 Leak Assessment
	WHC-MR-0302, 1992, Tank 241-SX-115 Leak Assessment
Vadose Zone Program field investigation results	Farm and Tank Specific Grand Junction Reports and Addendums (GJ-HAN).
	HNF-4936/ 1999, Subsurface Conditions Description Report for the S-SX Waste Management Area,
	HNF-5507, 2000, Subsurface Conditions Description Report for the B & BX & BY Waste Management Area,
	RPP-7123, 2001 Subsurface Conditions Description Report for the T & TX-TY Waste Management Areas,
	RPP-14430, 2003 Subsurface Conditions Description Report for the C & A-AX Waste Management Areas

Table 5-1. Types of Information and Sources for Tank Farm Leak Assessments (3 pages).

Type of Information	Examples
	RPP-15808, 2003, Subsurface Conditions Description Report for the U Waste Management Area
	HNF-5231, 1999, Historical Vadose Zone Contamination from B, BX, and BY Tank Farm Operations
	RPP-6285, 2000, Inventory Estimates for Single-Shell Tank Leaks in S and SX Tank Farms,
	RPP-7218, 2000, Preliminary Inventory Estimates for Single-Shell Tank Leaks in T, TX, and TY Tank Farms
	RPP-7389, 2001, Preliminary Inventory Estimates for Single-Shell Tank Leaks in B, BX, and BY Tank Farms,
	RPP-7494, 2001, Historical Vadose Zone Contamination from A, AX, and C Tank Farm Operations
	RPP-7580, 2001, Historical Vadose Zone Contamination from U Farm Operations
	RPP-7884, 2002, Field Investigation Report for Waste Management Area S-SX
	RPP-10098, 2003, Field Investigation Report for Waste Management Area B-BX-BY
	RPP-23752, 2005, Field Investigation Report for Waste Management Area T-TX/TY
	RPP-20820, 2004, Waste Retrieval Leak Evaluation Report: Single-Shell Tanks
	DOE/ORP-2005-01, 2006, Preliminary SST Performance Assessment for the Hanford Site
	RPP-26744, Hanford Soil Inventory Model, Rev. 1
	GJO-2003-545-TAC, Draft B-BX-BY WMA and Adjacent Waste Sites Summary Report
	Tribe and Stakeholder correspondence and related reports
Gross gamma and spectral gamma logging data	RPP-8820, 2003, Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-A Tank Farm – 200 East
	RPP-8821, 2003, Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-AX Tank Farm – 200 East
	HNF-5433, 2000, Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-B Tank Farm – 200 East
	HNF-3531, 1999, Analysis of Historical Gross Gamma Logging Data from BX Tank Farm
	HNF-3532, 1999, Analysis of Historical Gross Gamma Logging from BY Tank Farm
	RPP-8321, 2001, Analysis and Summary Report of Historical Dry Well Gamma Logging Logs for the 241-C Tank Farm – 200 East Area

Table 5-1. Types of Information and Sources for Tank Farm Leak Assessments (3 pages).

Type of Information	Examples
	HNF-4220, 1999, Analysis and Summary of Historical Dry Well Gamma Logs for S Tank Farm – 200 West
	HNF-3136, 1999, Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs
	RPP-6088, 2000, Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-T Tank Farm – 200 West
	RPP-6353, 2000, Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-TX Tank Farm – 200 West
	HNF-3831, 1999, Analysis of Historical Gross Gamma Logging Data from 241-TY Tank Farm
	RPP-7729, 2001, Analysis and Summary Report of Historical Dry Well Gamma Logging Logs for the 241-U Tank Farm 200 West Area
	Annual Monitoring Reports
Groundwater data	Annual and quarterly groundwater reports and Hanford Environmental Information System (HEIS) data
Lateral data	RPP-RPT-27605, Gamma Surveys of Single-Shell Tank Laterals for A and SX Tank Farms
SGE/direct push data	RPP-RPT-28955, 2006, Surface Geophysical Exploration of T Farm at the Hanford Site
	SGE and direct push data for completed farms

6.0 KEY ASSESSMENT PARAMETERS AND GUIDELINES

The following sections describe key assessment parameters to determine vadose zone inventory values and guidelines to assess information. The process used to determine tank leak inventories is shown in Figure 6-1.

The key parameters are listed below.

- The volume of leak
- The date of leak
- The supernatant liquid composition
- Leak inventory

Tank leak inventory is determined by multiplying the volume of leak by the supernatant liquid composition at the time of a leak. Figure 6-1 shows a general schematic of the process.

6.1 LEAK VOLUMES

Tank leak volume estimates for tanks classified as assumed leakers are summarized in HNF-EP-0182. The basis for these estimates and criteria for designating tanks as assumed leakers is documented in SD-WM-TI-356. As of July 2006, these leak volume estimates remained unchanged since 1990.

Vadose zone field investigations, reassessment of data and available information, and efforts to develop tank leak inventories have resulted in questioning some of the earlier volume estimates. The logic and process for assessing tank leak volumes follows.

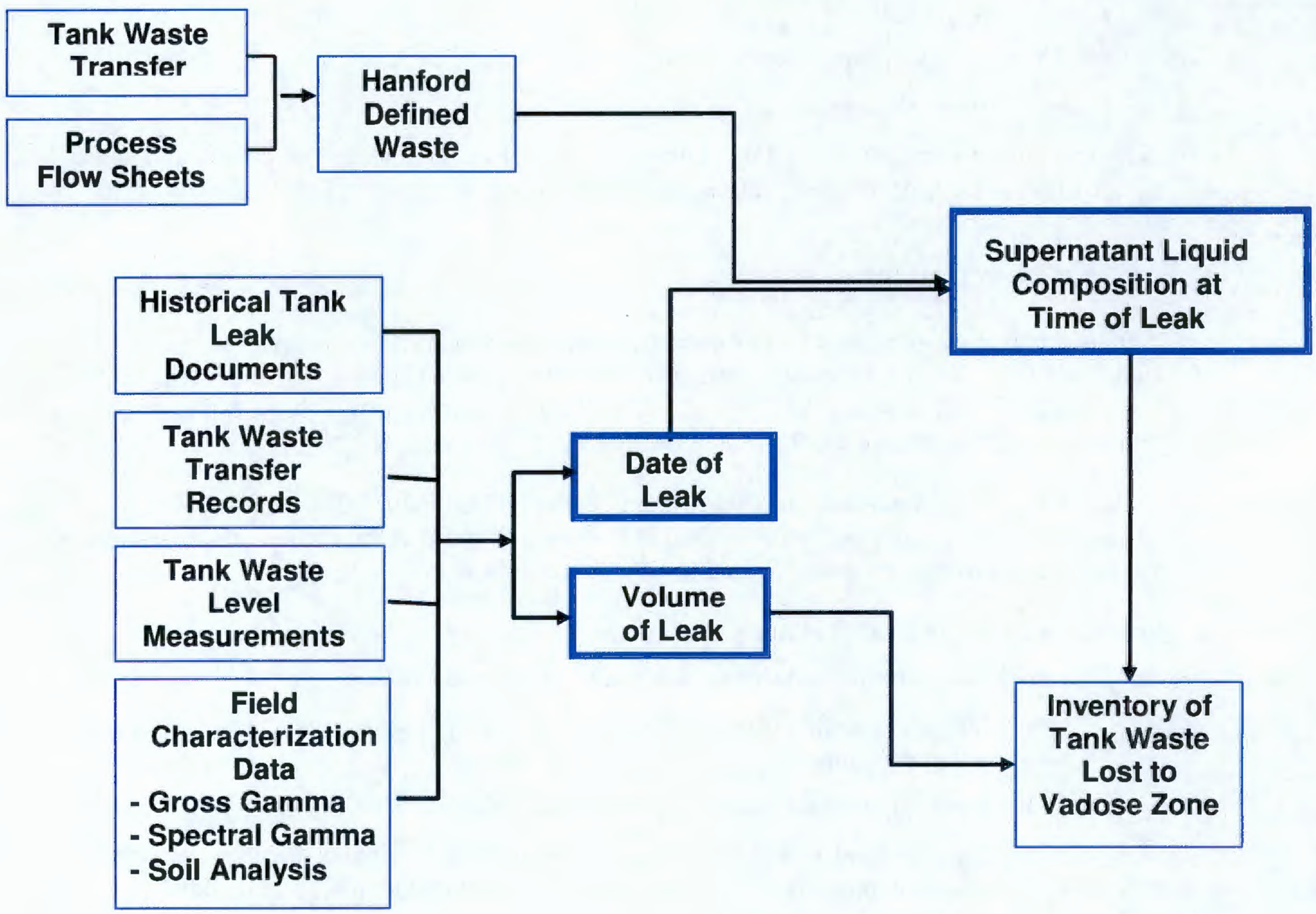
Process to Evaluate Leak Volume Estimates

1. Determine the basis used for previous leak volume estimates.
    a. Identify specific information (data/analyses/reports) used as a basis for these leak volume estimates.
    b. Identify how data were used to estimate volumes.
    c. Identify the date and the technology used in the original evaluation and whether that technology is acceptable today or has been either discredited and/or significantly improved.
2. Identify additional information (either generated before but not necessarily used for the tank leak or UPR volume estimates, or subsequently derived information about the leak event) that also relates to leak volume estimates.
3. Examine the collective set of information. Begin with a comparison of waste composition assumptions and volume estimates with nearby drywell/laterals spectral

gamma data and earlier gross gamma data. Table 5-1 identifies data sources and waste volume data types to be examined.

4. Determine the nature and validity of data and previous assessments (e.g., determine which information is unsubstantiated, ambiguous, or irrelevant to estimates of volume losses into the vadose zone).
5. Use the valid information to estimate leak volumes and uncertainty ranges.

Figure 6-1. Process to Determine Vadose Zone Inventory.



6.2 DATE OF LEAK

The parameter "date of leak" is when the leak is estimated to have started. The "date of leak" is important because tank waste compositions have changed during decades of tank farm operation as different waste types were routed through the tank farm system. The "date of leak" is less important if waste transfers to a tank were infrequent and the supernatant composition was relatively constant. In most cases involving large confirmed leaks, a liquid level decrease was observed in a tank. For small leaks or assumed leaks based only on detected radioactivity increases in nearby drywells the "date of leak" may be highly uncertain depending on the frequency of drywell monitoring. It is difficult to detect and/or measure small liquid level decreases associated with small leaks. The date of the first detection may be quite different from the date of release; e.g., a small volume release may take months to years to reach a drywell, and in the interval, the composition of the supernate may have changed.

The "date of leak" is used in the Soil Inventory Model (SIM) to determine the waste composition at the time of a leak. In general, the "date-of-leak" used in the SIM is just after the last waste transfer into a tank prior to an estimated leak date or when waste status transfer records in the Hanford Designed Waste (HDW) model indicate an unexplained liquid-level decrease. When in doubt, a year was selected in which a tank or UPR had a conservatively high waste composition (i.e., a high radioactivity). The "date of leak" is not necessarily the year when a leak was declared (as shown in HNF-EP-0182) and not necessarily when a leak was assumed to have occurred.

6.3 WASTE COMPOSITION

The "supernatant liquid composition at the time of leak" is complicated by the many different waste streams that passed through a tank and the lack of detailed information showing how waste streams mixed within the tank system before the leak occurred. Also, limited in-tank supernatant data at the estimated time of a leak and limited vadose zone characterization data (gamma radiation and sediment sample results) are available to confirm the composition of past leaks. Consequently, the analytical composition of tank liquids waste is based largely on historical model estimates.

In the 1980's, Francis Jungfleisch developed the Track Radioactive Components (TRAC) model, SD-WM-TI-058 (*Supplemental Information for the Preliminary Estimation of Waste Tank Inventories in the Hanford Tanks through 1980*). This approach modeled the creation of radionuclides in the production reactors starting with output from the Oak Ridge Isotope Generation and Depletion Code (ORIGEN) model, RPP-13489 (*Activity of Fuel Batches Processed Through Hanford Separations Plants, 1944 Through 1989*) and then followed them as they went through various processing steps. In the 1990's, Steve Agnew of the Los Alamos National Laboratory built on Jungfleisch's efforts to produce the Hanford Defined Waste (HDW) model WHC-SD-WM-TI-632 (*Hanford Defined Wastes: Chemical and Radionuclide Compositions*). He had the advantage of better reactor physics codes, better nuclear data, and more Hanford historical documentation. The ORIGEN and HDW models were recently updated and improved with new data and methods, RPP-19822 (*Hanford Defined Waste Model – Rev. 5.0*).

Tank leak composition estimates are based on updated HDW model results for waste streams. The mix of waste streams and waste stream leak compositions at the time of a leak were calculated using the SIM (RPP-26744). Table 6-1 shows the HDW waste streams.

The SIM is an extension and enhancement of previous efforts to quantify contaminant inventories in the Hanford Site vadose zone. In the 1990s, the HDW model was used to predict what was in the single and double-shell tanks at the Hanford Site. The data gathered as part of that modeling effort included fuel processed, chemical process knowledge, and waste transfer information. The HDW model also attempted to define what was disposed to the ground. The SIM effort incorporates HDW model estimates for tank waste, waste composition, and inventory estimates for other unplanned releases (UPRs). Like the HDW model, much of SIM is based on historical records and data from the Hanford Site's various process facilities that extracted plutonium and uranium from spent nuclear fuel. Data from samples collected from selected high-level waste tanks and from process control data contained in historical waste management documents were used to update the HDW model composition estimates used in the SIM.

SIM generates composition uncertainty estimates for 46 radionuclides and 29 chemicals using 196 waste streams applied to 377 liquid-waste disposal sites, unplanned releases, and tank leaks over their operating lifetimes in intervals of one year from 1944 to 2001. The operating times for these sites varied from several weeks to decades in length and could consist of multiple waste streams. These calculated estimates provide uncertainty bounds around the mean inventories as part of a Monte Carlo calculation using uncertainties defined in the input data. Volume uncertainties are not included in SIM for tank farm sites as a more rigorous uncertainty analysis was desired than that provided by Monte Carlo analyses.

6.4 INVENTORY

Inventory leak estimates are a simple calculation of the liquid waste composition at the time of a leak multiplied by waste volume. Inventory uncertainties are a combination of composition and leak volume uncertainties and are discussed in Section 7.0.

Table 6-1. Hanford Defined Waste Streams (3 pages).

Waste Stream	Waste Type and Description	
Bismuth Phosphate Process Waste (1944-1956)	MW1	$BiPO_4$ Metal Waste (1944-1949)
	MW2	$BiPO_4$ Metal Waste (1950-1956)
	1C1	$BiPO_4$ First cycle decontamination waste and coating waste (1944-1949)
	1C2	$BiPO_4$ First cycle decontamination waste and coating waste (1950-1956)
	2C1	$BiPO_4$ Second cycle decontamination waste (1944-1949)
	2C2	$BiPO_4$ Second cycle decontamination waste (1950-1956) and low activity cell 5-6 drainage waste (June 1951-1956)
	224-1	Lanthanum Fluoride process 224 Building waste (1944-1949)

Table 6-1. Hanford Defined Waste Streams (3 pages).

Waste Stream	Waste Type	Description
	224-2	Lanthanum Fluoride process 224 Building waste (1950-1956)
Uranium Recovery And Scavenging Waste (1952-1958)	TBP	Tributyl phosphate process waste (1952-1958), same as UR
	PFeCN1	Ferrocyanide sludge from TBP in-plant scavenged supernatant and co-disposed TBP sludge (1954-1955)
	PFeCN2	Ferrocyanide sludge from TBP in-plant scavenged supernatant and co-disposed TBP sludge (1955-1958)
	TFeCN	Ferrocyanide sludge from supernatant scavenging in 244-CR Vault (1955-1958). These supernatants consisted of TBP supernatant and the commingled supernatants from other wastes stored in the same tanks
	1CFeCN	Ferrocyanide sludge from in-plant scavenging of T-Plant 1C waste (without coating waste). Transferred to TY-Farm (1955-1956)
Reduction And Oxidation (Redox) Process Waste (1952-1966)	R1	REDOX high-level waste (1952-1958)
	R2	REDOX high-level waste (1959-1966)
	CWR1	REDOX cladding waste, aluminum clad fuel (1952-1960)
	CWR2	REDOX cladding waste, aluminum clad fuel (1961-1966)
Plutonium-Uranium Extraction (Purex) Process Waste Types (1956-1990)	P1	PUREX high-level waste (1956-1962)
	P2	PUREX high-level waste (1963-1967)
	P2'	PUREX acid waste to B-Plant (1964-1972)
	P3AZ1	PUREX high-level waste to AZ-101 (1983-March 13, 1986)
	P3AZ2	PUREX high-level waste to AZ-102 (March 13, 1986 to 1990)
	CWP1	PUREX cladding waste, aluminum clad fuel (1956-1960)
	CWP2	PUREX cladding waste, aluminum clad fuel (1961-1972)
	CWZr1	PUREX (and REDOX) zirconium cladding waste, (1968-1972)
	CWZr2	PUREX zirconium cladding waste (1983-1989)
	OWW1	PUREX organic wash waste and non-boiling waste (1956-1962)
	OWW2	PUREX organic wash waste and non-boiling waste (1963-1967)
	OWW3	PUREX organic wash waste (1968-1972)
	PL1	PUREX non-boiling waste (1968-1972)
	PL2	PUREX organic wash waste and non-boiling waste (1983-1988)
	TH1	Thoria process wastes (1966)
	TH2	Thoria process wastes (1970)
	PASF	PUREX Ammonia Scrubber Feed
Cesium And Strontium Recovery Waste Types (1961-1985)	HS	Hot Semiworks strontium purification waste (1961-1968)
	AR	Water washed PUREX sludge entrained in decants of recovered sludge or the water washes of this sludge and the solids remaining after acidification (1967-1976)
	B	B-Plant high-activity waste – Rare earth (RE) fission products, recovered current acid waste (CAW), solvent wash waste, and any solution containing high activity (including cask station receipts, cell drainage containing product spills) (1967-1972)
	BL	B-Plant low-activity waste – 1AW solvent extraction waste stream (includes complexants added for solvent extraction), the 1CP/organic wash waste during PAS processing, and insoluble

Table 6-1. Hanford Defined Waste Streams (3 pages).

Waste Stream		Waste Type and Description
		solids remaining after treatment of solids centrifuged from CAW feed (i.e., acid leached and water washed PUREX high-level waste [HLW] sludge). Cell drainage and Waste Encapsulation Storage Facility (WESF) transfers with low radionuclide content (1967-1976).
	SRR	High-activity waste from B-Plant processing of PUREX acidified sludge (PAS), solids centrifuged from AR vault feed, strontium purification wastes after solvent extraction (SX), RE or ion exchange (IX) rework, and other solutions containing activity (including cask station receipts, cell drainage containing product spills, WESF returns unsuitable for rework and crude RE disposal). (1969-1985)
	CSR	Supernatants from which the cesium has been removed by ion-exchange. 241-C-801 cask station (1962-1967). B-Plant Waste Fractionization (1967-1976).
Other Process Facility Wastes	Z	Plutonium Finishing Plant waste (1974-1988)
	DW	Decontamination wastes, primarily from T Plant operations (1967-1976)
	N	N Reactor decontamination waste (1976-1990)
Miscellaneous Wastes	CEM	Portland cement added to tank 241-BY-105
	DE	Diatomaceous earth added to six tanks (241-BX-102, 241-SX-113, 241-TX-116, 241-TX-117, 241-TY-106, and 241-U-104)
	NIT	Partial neutralization feed for evaporator campaigns (1977-1981)
Saltcakes And Salt Slurries	BT-SltCk	Saltcake from 242-B Evaporator operation (1951-1953) and the 242-T Evaporator operation (1951-1955). Formerly BSltCk and T1SltCk.
	BYSltCk	Saltcake from in-tank solidification (ITS) in BY-Farm (1965-1974)
	RSltCk	Saltcake from self-concentration in S- and SX-Farms (1952-1966)
	T2SltCk	Saltcake from the last 242-T Evaporator campaign (1965-1976)
	A1SltCk	Saltcake from the first 242-A Evaporator campaign using 241-A-102 feed tank (1977-1980)
	A2SltCk	Saltcake form the second 242-Evaporator campaign using 241-AW-102 feed tank (1981-1988)
	S1SltCk	Saltcake from the first 242-S Evaporator campaign using 241-S-102 feed tank (1973-1976)
	S2SltCk	Saltcake from the second 242-S Evaporator campaign using 241-SY-102 feed tank (1977-1980)

7.0 DEALING WITH UNCERTAINTIES

Uncertainties deriving from limitations on the data sources could include, but are not limited to, the following:

1. Tank process reports and assessments:
   - Incomplete records
   - Partial description of the problem
   - Incorrect interpretation of data
   - Historical analysis was sometimes done with incomplete data sets.

2. In-tank liquid level measurements:
   - Precision, accuracy, and frequency varies with instrumentation (manual tape, Food Instrument Corporation gage, or ENRAF™) and waste surface (liquid or solid).
   - Evaporation and barometric pressure effects may not have been considered.
   - Records sometimes incomplete and often were not available for early tank leaks.
   - Liquid level decreases difficult to identify for tanks with frequent transfers.
   - Not usable for self-boiling tanks and waste operated for evaporation (eg. in-tank solidification).

3. Waste transfer records:
   - Gaps in transfer records generally rolled up to month or quarterly summaries.
   - Uncertainty in transfer volumes were not well defined.

4. Gross gamma logging data:
   - Restricted time period 1974-1994.
   - Uncalibrated data does not provide radionuclide specific identification.
   - Multiple probe types with different results were used to obtain data.
   - Restricted to available boreholes (i.e., existing drywells).
   - Gamma logging generally identifies activity only within 12 to 18 inches from well.
   - Data often post dates leak events, sometimes by as much as years.

5. Spectral gamma logging data:
   - Restricted time period (1995-2001) with limited logging from 2002 to present.
   - Restricted to available boreholes (i.e., existing drywells).
   - Gamma logging generally identifies activity only within 12 to 18 inches from well.
   - Data often post dates leak events, sometimes by as much as years.

- Detection of gamma-emitting radionuclides only; unable to detect beta emitters such as Sr-90, Tc-99 or tritium (bremstrahlung associated with high levels of Sr-90 may be detectable).
- Detected radionuclides include Cs-137, Co-60, Eu-154, Eu-152, Sn-126, Sb-125, U-238 (Pa-234m), and U-235; Ru-106 often decayed below detectable levels.
- High-rate detector capable of quantifying Cs-137 up to about 1E9 pCi/g.
- High levels of Cs-137 may mask other radionuclides.

6. Moisture monitoring data:
   - Limited data available
   - No moisture baseline for tank farms

7. Vadose zone program reports:
   - Field investigation reports are limited.
   - Analysis generally focused more on tank integrity.
   - Accuracy limited by data available/reviewed.
   - Some reports do not include supporting data or are unclear.

8. Tank laterals data:
   - Limited data available only for A and SX farm single-shell tanks.
   - Data post-date leak events, sometimes by as much as years.
   - Most data limited to Cs-137 as Ru-106 is largely decayed and not detected.
   - Total gamma only.

9. Vadose zone samples and analysis:
   - Limited data available
   - Sampling and analytical precision and accuracy
   - Depth and special variability of contaminants in vadose zone

10. High Resolution Resistivity:
    - Measures resistivity anomalies in the soil, which may correlate to areas of contamination.
    - Generally does not provide depth information (limited to two dimensions).
    - Tank farm infrastructure limitations.
    - Indirect measurement, not correlated to chemistry or radioactivity.

Considering the sources of uncertainty listed above; the personnel performing the reassessments, as well as the review panels overseeing the assessments, will encounter a wide range of data with various levels of pedigree. Some of the data may be inconsistent or ambiguous. Attempts will be made to assess the quality of the available data and to achieve a consensus on the source, volume, and composition of the material that has leaked to the ground, as well as a justifiable uncertainty range for the values determined.

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APPENDIX A

TANK C-101 ASSESSMENT INFORMATION EXAMPLE

A1.0 TANK C-101 ASSESSMENT INFORMATION EXAMPLE

The information provided in this appendix is an example of the typical information available for conducting the process to estimate tank farm vadose zone inventories. Tank 241-C-101 was selected for this example. However, only Steps 4.1 through 4.7 in the assessment process (see Figure 4-1) are completed in this example. The remaining assessment process steps are interactive with the assessment team.

A2.0 SUMMARY OF INFORMATION TO ASSESS

The following information is excerpted from RPP-20820, *Waste Retrieval Leak Evaluation Report: Single-Shell Tanks*. Additional information such as high resolution resistivity monitoring and newly located historical information obtained after issuance of RPP-20820 have been added to provide a current perspective on potential waste loss from tank 241-C-101. Previous assessments and investigations of releases from tank C-101 include *Review of Classification of Nine Hanford Single-Shell "Questionable integrity" Tanks* (RHO--CD-896) and *Subsurface Conditions Description of the C and A-AX Waste Management Area* (RPP-14430).

A3.0 BACKGROUND

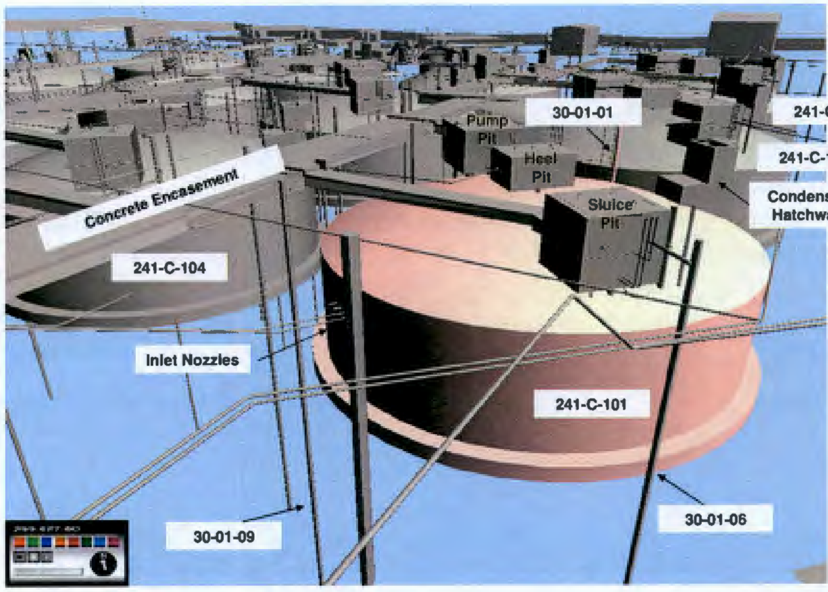
Tank 241-C-101 has a capacity of 2,006,000 liter (530,000 gallon) and a diameter of 22.9 m (75 ft). Tank 241-C-101 is presently passively ventilated and is the first tank in a three-tank cascade that includes tanks 241-C-102 and 241-C-103. Figure A-1 provides the orientation of tanks 241-C-101, 241-C-102 and 241-C-103 along with piping connections to tank 241-C-101. The base of tank 241-C--101 is approximately 38 ft bgs. The inlet nozzles on the tank side wall are approximately 20.5 ft bgs; whereas the cascade overflow pipeline to tank 241-C-102 (not visible in Figure A-1) is approximately 21 ft bgs. Figure A-7 provides details of these piping penetrations into the single-shell tank.

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

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

Tank 241-C-101 received Tri-Butyl Phosphate (TBP) Plant waste intermittently from 221-U Plant[1] beginning on May 15, 1953 (HW-28377, page 4). During August 1953, tank 241-C-101 was filled with TBP Plant waste, and supernatant was cascaded to tank 241-C-102. TBP Plant supernatant waste was pumped from tank 241-C-101 to tank 241-C-103 in September 1953.

Figure A-1. Orientation of Tanks 241-C-101, 241-C-102, and 241-C-103.



The reason why waste was not cascaded from tank 241-C-101 to 241-C-102 and then to 241-C-103 is not provided in the monthly tank farm reports. The cascade overflow line from tank 241-C-101 to tank 241-C-102 may have been plugged. The cascade overflow line to tank 241-C-102 is first noted in the tank farm monthly reports as being partially plugged in June 1954 (HW-32389, page 4). All three tanks were noted as being filled with TBP Plant waste in October 1953.

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

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

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

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

Tank 241-C-101 continued to be used through 1957 as the feed tank to the in farm scavenging process conducted in the 244-CR Vault for in farm scavenging. Tank 241-C-101 received TBP Plant supernatant and 242-B Evaporator bottoms wastes from the tanks listed in Table 1. The scavenged waste was transferred to tanks 241-C-108, 241-C-109, 241-C-111, and 241-C-112 for settling of the FeCN precipitate before discharge to the 216-BC trenches.

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

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

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

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

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

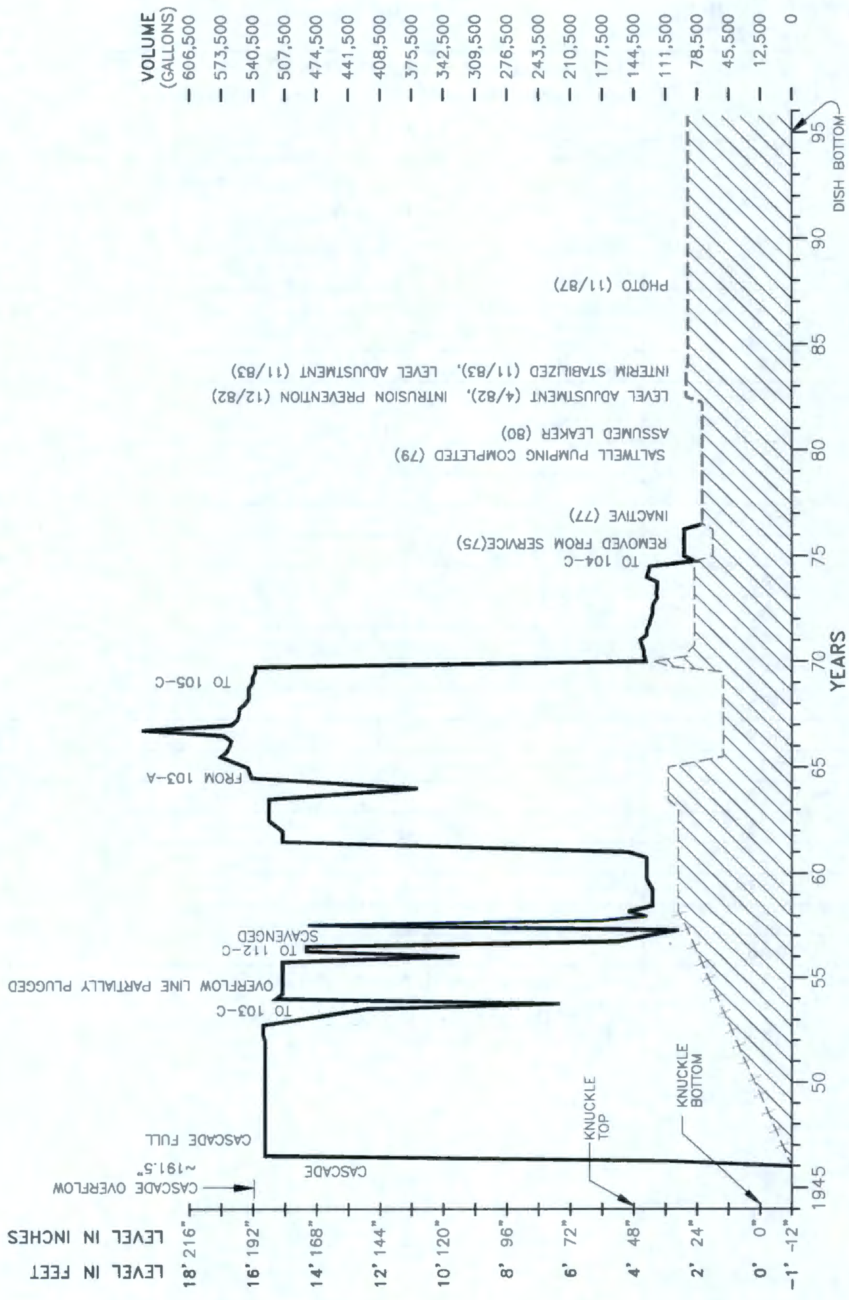
Tank 241-C-101 was removed from service in the first quarter of 1976. It was categorized as a confirmed leaker in 1980 with an approximate leak volume of 76,000 liters (20,000 gallons). Intrusion prevention was completed in December 1982, and the tank was interim-stabilized in November 1983 (HNF-EP-0182, Rev. 219). Table A-2 and Figure A-2 summarize the waste history for tank 241-C-101.

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

Table A-2. Tank 241-C-101 Waste Inventory 1963 – 1970.

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

Figure A-2. Tank C-101 Waste Surface Level History.



A4.0 HISTORICAL BASIS FOR LEAK DECLARATION

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

- Surveillance
- Process Control
- Effluent Control
- Chief Scientist

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

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

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

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

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

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

A5.0 DATA REVIEW AND OBSERVATIONS TO CONSIDER

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

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

These drywells are shown on Figure A-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 A-4 provides the gamma logging for the drywells adjacent to tank 241-C-101, which were obtained in 1997.

Figure A-3. Drywells Located in 241-C Farm.

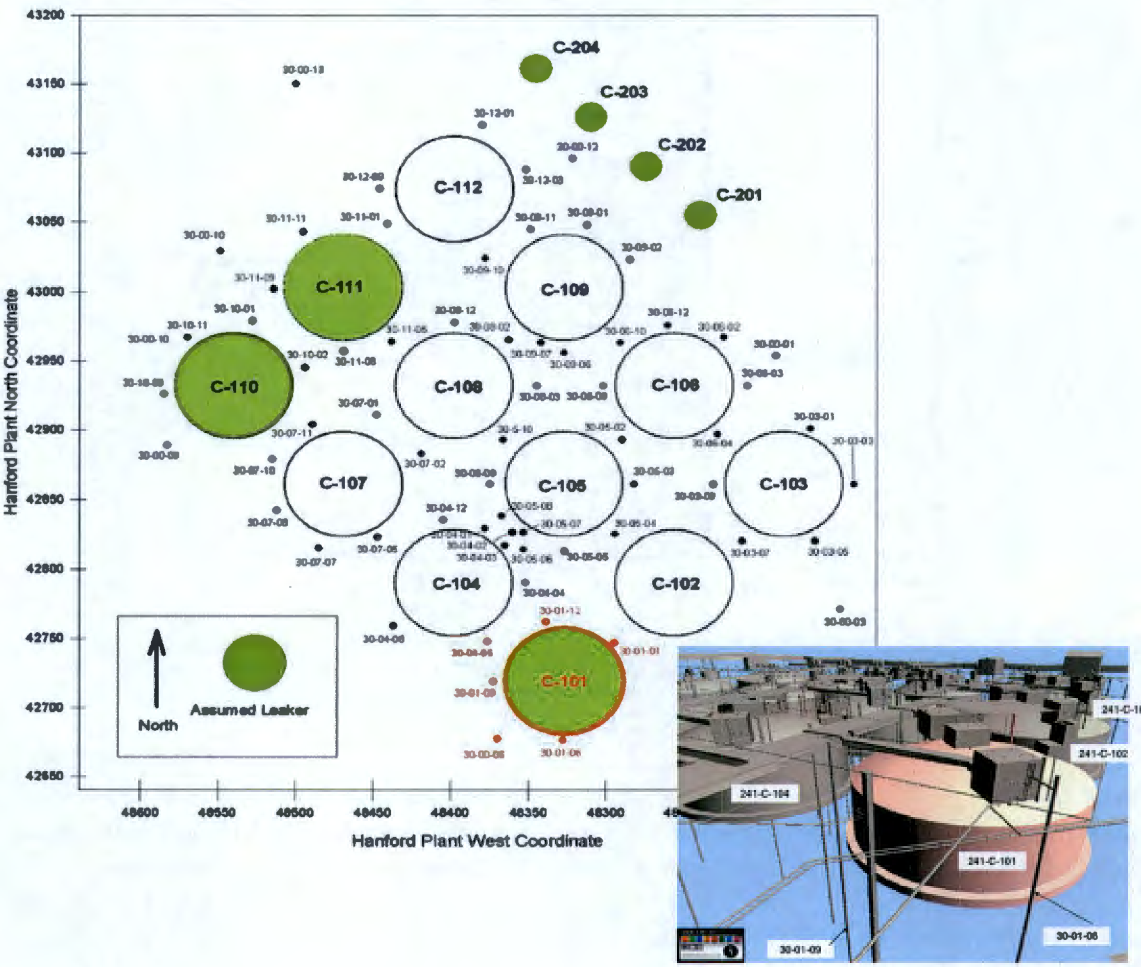
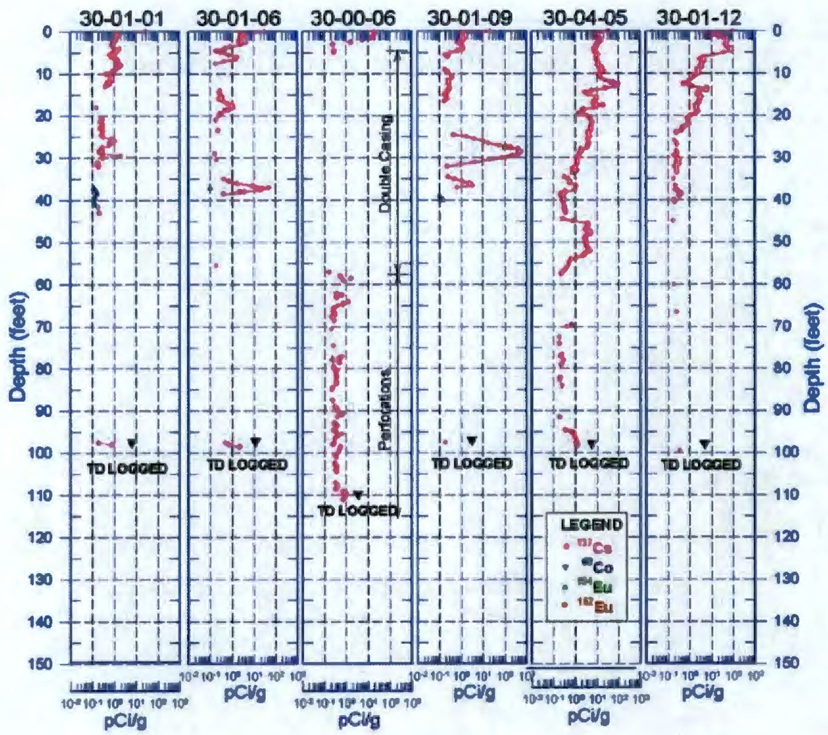


Figure A-4. Tank 241-C-101 Drywell Gamma Activity Monitored in 1997.



During the period between 1965 and 1968, the tank volume exceeded the 546,000-gallon level at which the spare inlet lines would become submerged. At this level, the spare inlet lines would have been covered by about 10 inches 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 241-C-101, near drywells 30-01-09 and 30-01-06. The contamination at 25 to 30 ft below ground surface (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 241-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.

<u>Tank Waste Information</u>: The PSN waste transferred into tank 241-C-101 during 1963 and 1964 originated from tanks 241-A-102 and 241-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 241-A-102 was measured in a range between 94°C and 170°C from January 1963 through May 1963, prior to the transfer to tank 241-C-101. The higher temperature readings in tank 241-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 241-A-102 was increased to 345 inches 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 241-A-103 in January through June 1964 ranged from 76°C to 94°C (RHO-CD-1172, page B-226).

Tanks 241-A-102 and 241-A-103 were equipped with airlift circulators, which aided in cooling the waste temperature. However, tank 241-C-101 was not equipped with an airlift circulator. Clearly the waste stored in tanks 241-A-102 and 241-A-103 were capable of generating sufficient heat to cause liquid evaporation. After transferring 448,000 gallons of PSN waste from tanks 241-A-102 and 241-A-103 to tank 241-C-101, evaporation of this waste would still be expected to occur in tank 241-C-101.

Additional information supporting the potential to evaporate water from the PSN waste stored in tank 241-C-101 was the Cs-137 content of this waste. The Cs-137 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 Cs-137 concentration and a liquid volume of approximately 465,000 gallons, sufficient radiolytic decomposition heat would be generated to account for evaporation of up to 550 gallons/month , or approximately 1,650 gallons/quarter[3], assuming no heat losses to the tank structure or surrounding soil.

Tank 241-C-101 was equipped with atmospheric condensers during the period of 1963 through 1971. The condensers were positioned at the 3 o'clock location on the tanks within 241-C farm. A drawing of the atmospheric condensers is shown in Figure A-5 (W-72927). The condensers were approximately 20-ft (H), 6-ft (W), and 4-ft (L) and consisted of 50, one-inch diameter finned tubes. The bottoms of the condenser tubes were open to the tank atmosphere via the condenser hatchway, as shown on drawing W-72743, reproduces as Figure A-6, Section A-A. The top of the condenser tubes vented to the atmospheres. The condensers are a passive system that did not use cooling water or fans during operation.

The function of these condensers was to condense water evaporated from tank wastes and reflux the condensed water back into the single-shell tank. 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 resulted in the discharge of water vapor to the atmosphere in 1952 to 1954 (ARH-780, page 23). Therefore, it is unlikely that waste evaporation was a significant source for the liquid level declines observed in tank 241-C-101 between 1965 through 1969 given the presence of the condenser on the tank.

[3] Calculation conversion factors are 1.01E-03 W/Ci for Cs-137 decay; 8.60E+5 cal/KWH, and 540 cal/gm heat of evaporation.

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

Areas of low resistivity are shown in Figure A-7 for the 241-C Tank Farm. Areas with low resistivity are most likely associated with increased soil moisture or inorganic salt concentration, which could be due to waste loss events. Specific areas of low-resistivity values within the 241-C tank farm are a region near tanks 241-C-101, 241-C-102, 241-C-104, 241-C-105, and 241-C-107, along with a smaller low-resistivity zone near tank 241-C-108.

FigureA-5. Atmospheric Condenser for Single-Shell Tanks.

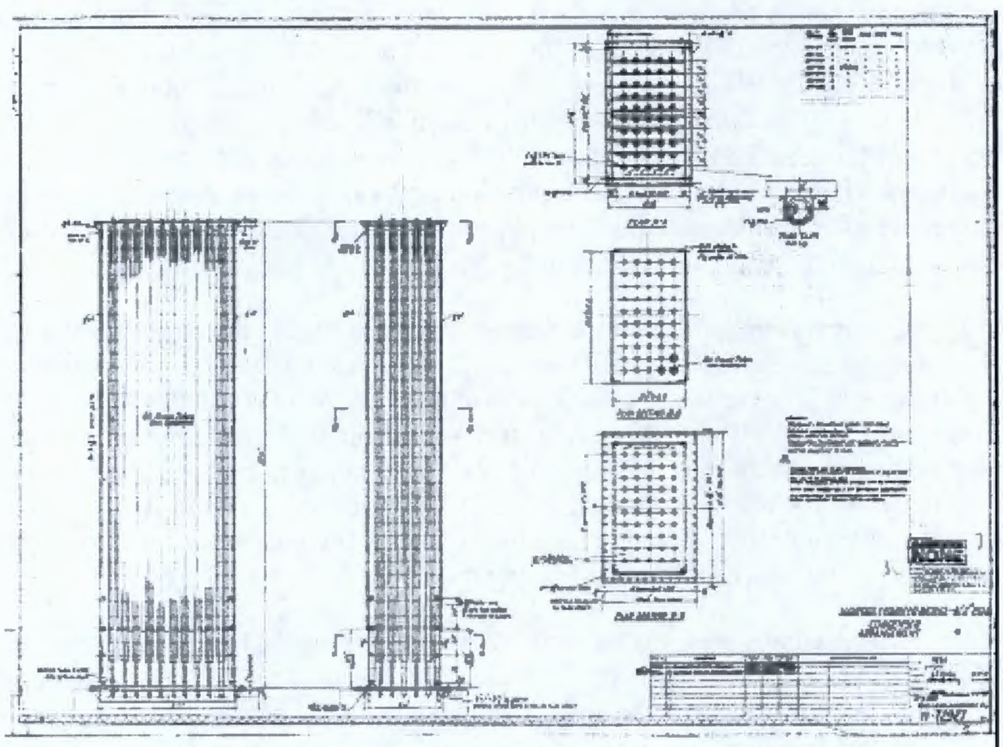


Figure A-6. 75-Ft Diameter Single Shell Tank.

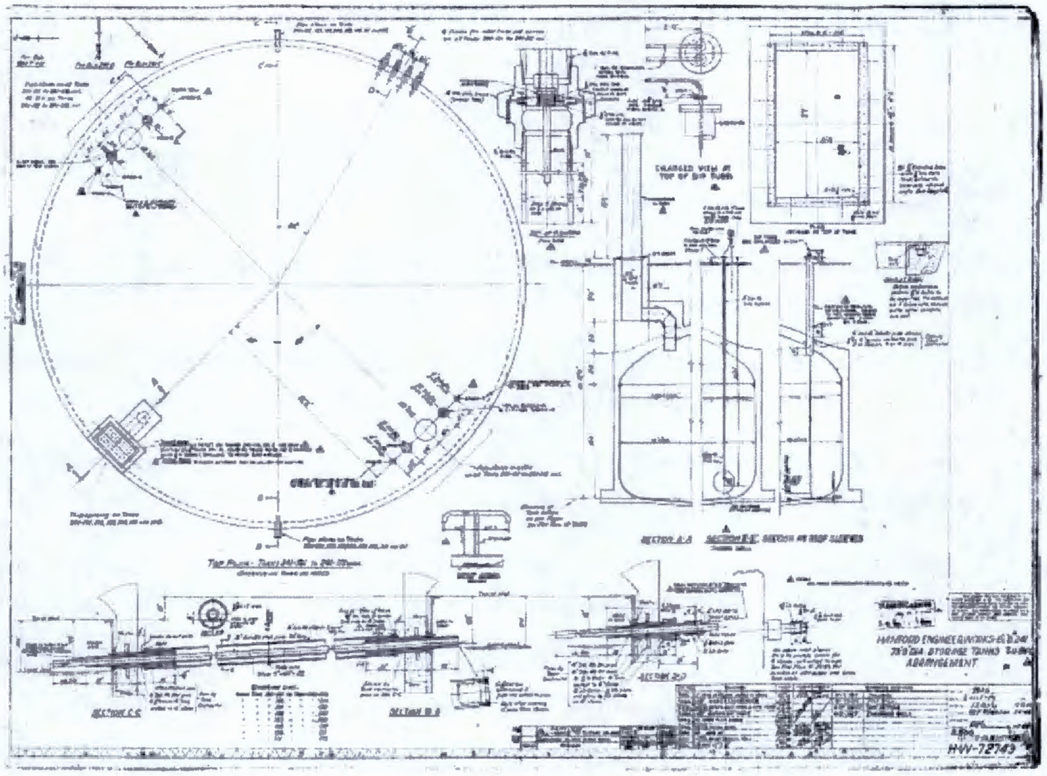
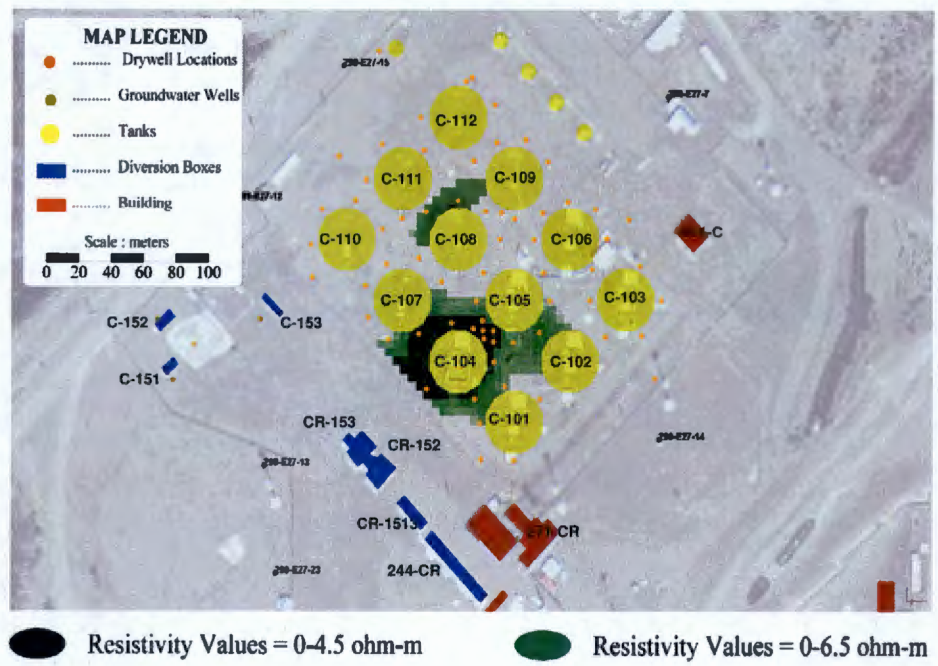


Figure A-7. Areas of Low Resistivity within 241-C Tank Farm (Aug. – Dec. 2006).



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