Tank 241-SX-110 Leak Assessment Report

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EXECUTIVE SUMMARY

Tank SX-110 is a 1,000,000 gallon capacity, 75-ft diameter, mild steel-lined concrete single-shell tank located on the east side of the 241-SX Tank Farm in the middle of a three cascade tank series. The tank was placed in service during the first quarter of 1955, and continued to receive and store waste until July, 1976, when it was removed from service.

A liquid level decrease of 0.75 inches in seven days exceeded the action criterion of 0.50 inches in a seven day period on June 30, 1976. Occurrence Report (OR) 76-91 reported that the tank was considered to be sound as the drywell and lateral radiation readings were stable during the review period.

The Richland Operations Office (RL) responded on July 21, 1976 with the following:

"RL acknowledges ARHCO's [Atlantic Richfield Hanford Company] technical assessment of the surveillance data and technical opinion that the subject tank is sound. However, it is our judgment that the tank should be removed from service due to questionable integrity. This decision is based on the fact that ARHCO's long-range tank use projection does not indicate a continued need for this tank, which obviously does not justify risking continued use with an apparent unexplained liquid level loss over the past two months in excess of one inch," (Letter 7700, F. R. Standerfer to G. T. Stocking, 241-SX-110 Tank).

Tank SX-110 was pumped to minimum heel July 22, 1976, removed from service, and identified as a questionable integrity tank. Photographs taken July 26, 1977 indicated that the waste surface was 99% dry. Based on these photographs the tank was declared interim stabilized August 31, 1979.

An independent panel reviewed the integrity of several tanks including tank SX-110 in 1980, summarized in RHO-CD-896, *Review of Classification of Nine Hanford Single-Shell* "*Questionable Integrity*" *Tanks*. The panel was tasked with reviewing tanks that had been classified as of questionable integrity to determine if the tanks should be reclassified as confirmed leakers. The panel was not authorized to reclassify tanks as being sound integrity. At a 95% confidence level the majority opinion recommended that the tank continue to be classified as questionable integrity. The tank was subsequently reclassified as an assumed leaker in October, 1984, when the confirmed leaker and questionable integrity classifications were combined into a classification designated as assumed leaker, according to Letter 8901832B R1, R. J. Baumhardt to R. E. Gerton, *Single-Shell Tank Leak Volumes*.

In 2007, CH2M HILL Hanford Group Inc., with the U. S. Department of Energy – Office of River Protection and the Washington State Department of Ecology, developed a process to reassess selected single-shell tank leak volume and leak inventory estimates and to update leak and unplanned release volumes and inventory estimates as emergent field data were obtained. The process is described in RPP-32681 Rev. 0, *Process to Assess Tank Farm Leaks in Support of Retrieval and Closure Planning* (RPP-32681).

In February, 2008 a leak integrity review of 241-SX Tank Farm tanks, including tank SX-110, was conducted in accordance with RPP-32681. The review concluded that the tank was unlikely to have leaked and no leak inventory was assigned. The conclusion was based on the lack of leak evidence from drywell and lateral radiation readings, along with no evidence of corrosion of the steel liner.

Based on the 2008 review, a formal leak assessment of tank SX-110 was completed in June 2010. The method of analysis used for the formal leak assessment process was Engineering Procedure TFC-ENG-CHEM-D-42, Rev. B-2, *Tank Leak Assessment Process*. The technical basis for the process and additional details and examples of the methodology for implementing the process can be found in HNF-3747 Rev. 0, *Tank Leak Assessment Technical Background*.

The leak assessment used a panel of experienced Washington River Protection Solutions, LLC engineers, managers, and consultants to review the tank SX-110 historical data and evaluate the tank's leak integrity. The panel consisted of: D. J. Washenfelder, (Assessment Coordinator, Technical Integration Program Manager); D. A. Barnes, (Lead Surveillance System Engineer, In-Tank and Ex-Tank Surveillance); J. W. Ficklin (Mechanical Maintenance Manager, Projects); J. G. Field (Closure and Corrective Measures, Single-Shell Tank Retrieval and Closure Engineer); M. A. Fish (Systems & Area Engineering, West Area Systems Engineer); D. G. Harlow (Senior Technical Advisor, Technical Integration); and E. C. Shallman (Materials Engineer, Technical Integration). The team met between September 21, 2009 and June 16, 2010 to gather and review information, develop the Leak and Non-Leak Hypotheses, and reach a consensus leak integrity recommendation for tank SX-110.

Based on review of the in-tank and ex-tank data as well as an analysis of the tank evaporation rate, the panel developed plausible hypotheses for the observed tank SX-110 behavior:

Leak Hypothesis:

"The surface level decrease occurring between late April and mid-July 1976 was due to the combined effects of evaporation and a tank leak."

Non-Leak Hypothesis:

"The surface level decrease occurring between late April and mid-July 1976 was due to evaporation."

There was consensus among the members of the assessment team that the non-leak hypothesis was more consistent with the data, and that the tank was not likely leaking in the April – July 1976 period. The team concluded that the most likely cause of the liquid level decrease was evaporation.

Evaporation, and stable drywell and lateral readings, reduce the estimated active leak probability to less than one chance in nine that the observed in-tank and ex-tank data would be present if the tank were leaking.

The recommendation of the leak assessment team was that the leak integrity status of tank SX-110 be changed from "Assumed Leaker" to "Sound."

The results of this assessment were presented to the Executive Safety Review Board on October 22, 2010. The Board concurred with the recommendations of the assessment team.

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Abbreviations and Acronyms

ALC Air Lift Circulator

ARHCO Atlantic Richfield Hanford Company

DOE-RL U.S. Department of Energy Richland Operations Office DOE-ORP U.S. Department of Energy Office of River Protection

ERDA Energy Research and Development Administration

FY Fiscal Year

GJ-HAN Grand Junction – Hanford

HLW High Level Waste

ITS In-Tank Solidification

MDA Minimum Detectable Activity

OR Occurrence Report

R² Linear Regression Curve Fit Value

REDOX Reduction Oxidation [Fuels Separation] Plant

RHO Rockwell Hanford Operations

SGLS Spectral Gamma Logging System

SST Single-Shell tank

WRPS Washington River Protection Solutions LLC

WVPCRUST Waste Evaporation Computer Program

Units

cfm cubic feet per minute

gal gallon in inch

lbm pounds mass

pCi/g picocuries per gram

psia pounds per square inch absolute

1.0 INTRODUCTION

This document provides the results of a formal leak assessment performed on tank 241-SX-110 (tank SX-110). The leak assessment process is described in Washington River Protection Solutions LLC (WRPS) engineering procedure TFC-ENG-CHEM-D-42, Rev. B-2, *Tank leak Assessment Process*.

Tank SX-110 is a 1,000,000 gallon capacity, 75-ft diameter, mild steel-lined concrete single-shell tank located on the east side of the 241-SX Tank Farm. The tank was placed in service during the first quarter of 1955, and continued to receive and store waste until July, 1976.

In June, 1976, the tank SX-110 surface level decreased 0.75-in in seven days and an occurrence report (OR), OR-76-91, *Liquid Level Decrease Exceeding Criteria for Tank 110-SX*, was issued. The occurrence report evaluation concluded that the tank as sound. The Energy Research and Development Administration (ERDA) did not disagree with the conclusion. However, they directed that the tank be removed from service due to its questionable integrity, and a long range tank use projection that showed that tank SX-110 space was no longer needed. The supernatant was pumped to tank SX-102 during July 21-22, 1976. Tank SX-110 was removed from service, and reclassified as of questionable integrity.

An independent panel reviewed the integrity of several tanks including tank SX-110, in 1980, documented in RHO-CD-896, *Review of Classification of Nine Hanford Single-Shell* "*Questionable Integrity*" *Tanks*. The panel was tasked with reviewing tanks that had been classified as of questionable integrity to determine whether these tanks should be reclassified as confirmed leakers. At a 95% confidence level three of the four review teams classified tank SX-110 as questionable integrity. Based on majority opinion, the questionable integrity classification was retained. The tank was subsequently reclassified in October, 1984 when the confirmed leaker and questionable integrity classifications were merged into a single classification, "assumed leaker,", according to Letter 8901832B R1, R. J. Baumhardt to R. E. Gerton, *Single-Shell Tank Leak Volumes*.

In 2007, CH2M HILL Hanford Group Inc., with the U. S. Department of Energy – Office of River Protection and the Washington State Department of Ecology, developed a process to reassess selected single-shell tank leak volume and leak inventory estimates and to update leak and unplanned release volumes and inventory estimates as emergent field data were obtained. The process is described in RPP-32681 Rev. 0, *Process to Assess Tank Farm Leaks in Support of Retrieval and Closure Planning* (RPP-32681). In 2008, tank SX-110 was reviewed using this process. The assessment was published in RPP-ENV-39658 Rev. 0, *Hanford SX-Farm Leak Assessments Report*. The assessment concluded that it was reasonably certain tank SX-110 did not leak and no inventory was assigned for a leak from the tank. A formal leak assessment was recommended for tank SX-110.

2.0 METHOD OF ANALYSIS

The method of analysis used for the tank SX-110 leak assessment was Engineering Procedure TFC-ENG-CHEM-D-42, Rev. B-2, *Tank Leak Assessment Process*. The formal leak assessment process is based on probabilistic analysis to assess the mathematical likelihood (probability) that a specific tank is leaking or has leaked. The technical basis for the process and additional details and examples of the methodology for implementing the process can be found in HNF-3747 Rev. 0, *Tank Leak Assessment Technical Background*. For each step a description of the process, products, and responsibilities is provided.

The leak assessment used a panel of experienced Washington River Protection Solutions, LLC engineers, managers, and consultants to review the tank SX-110 historical data and evaluate the tank's leak integrity. The panel consisted of: D. J. Washenfelder, (Assessment Coordinator, Technical Integration Program Manager); D. A. Barnes, (Lead Surveillance System Engineer, In-Tank and Ex-Tank Surveillance); J. W. Ficklin (Mechanical Maintenance Manager, Projects); J. G. Field (Closure and Corrective Measures, Single-Shell Tank Retrieval and Closure Engineer); M. A. Fish (Systems & Area Engineering, West Area Systems Engineer); D. G. Harlow (Senior Technical Advisor, Technical Integration); and E. C. Shallman (Materials Engineer, Technical Integration). The team met between September 21, 2009 and June 16, 2010 to gather and review information, develop the Leak and Non-Leak Hypotheses, and reach a consensus leak integrity recommendation for tank SX-110.

3.0 TANK HISTORY

The 1,000,000 gallon tank SX-110 located in 200-West Area was built between 1953 and 1954 and began operation in 1959. It is the first tank in a cascade series of three tanks that includes tank SX-111 and tank SX-112.

Tank SX-110 has three laterals (horizontal drywells) installed about 10-ft under the tank and eight drywells (41-10-01, 41-10-02, 41-10-03, 41-10-05, 41-10-06, 41-10-08, 41-10-10 and 41-10-11) located around the tank.

Prior to receipt of higher heat waste, Tank SX-110 was pre-heated with a water addition in 1959 followed by Reduction Oxidation (REDOX) facility High Level Waste (HLW) supernatant in 1960, according to RHO-R-39, *Boiling Waste Tank Farm Operational History*.

Tank SX-110 received REDOX facility HLW and then condensate from tank SX-106 from the fourth quarter of 1960 until the first quarter 1964. Self-boiling conditions existed from March, 1961 to December, 1964. Supernatant was transferred to tank SX-103 in the first and second quarter 1965 leaving a heel of 114,000 gallons of waste. After the transfer, the tank was held as a spare. The 241-SX Tank Farm exhaust vapor header condensate slowly drained into tank SX-110 resulting in a waste volume of 192,400 gallons by November, 1965. This volume of waste precluded holding the tank as a spare and it was returned to normal service.

Tank SX-110 received REDOX HLW again in the fourth quarter 1965 and REDOX supernatant periodically through the first quarter of 1969. Self-boiling conditions were experienced during this period from November 1965, to June 1968.

Supernatant was transferred to tank SX-102 in the second and third quarter of 1971. Tank SX-110 then received ion exchange waste from 221-B Plant. Supernatant was then transferred to tank S-110 in the third quarter of 1974. From the fourth quarter of 1975 through the second quarter of 1976 tank SX-110 received 221-B Plant waste, In-Tank Solidification (ITS) waste, miscellaneous waste, and supernatant was transferred to SX-102. In July, 1976 the tank was designated as a questionable integrity tank at the direction of ERDA and pumped to minimum heel.

Four occurrences (OR) were reported for tank SX-110 beginning in 1974 and are addressed in the interest of being complete even though they were all adequately addressed at the time and in subsequent evaluations.

- Occurrence Report 74-132, Decrease of Liquid Level in Tank SX-110
- Occurrence Report 75-04, Increasing Drywell Radiation Levels Between Tanks SX-110 and SX-111
- Occurrence Report 75-118, Liquid Level Increase in Tank 110-SX
- Occurrence Report 75-145, Possible Leakage from an Encased Pipeline

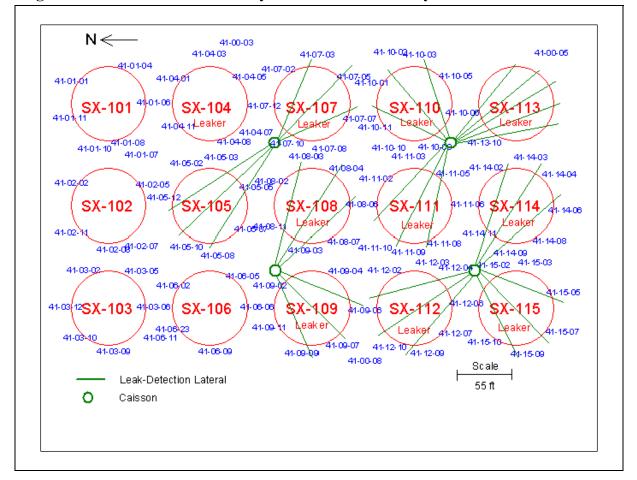


Figure 3-1. 241-SX Tank Farm Drywells and Lateral Arrays

A tank SX-110 occurrence report 76-91 resulted in the tank being declared a questionable integrity tank. The occurrence report documented a liquid level decrease of 0.75-in in seven days. The decrease exceeded the action criteria of 0.50-in in a seven day period on June 30, 1976. The OR reported that the tank was considered to be sound since the drywell and lateral radiation readings were stable during the review period.

The Richland Operations Office (RL) responded on July 21, 1976 with the following:

"RL acknowledges ARHCO's (Atlantic Richfield Hanford Company) technical assessment of the surveillance data and technical opinion that the subject tank is sound. However, it is our judgment that the tank should be removed from service due to questionable integrity. This decision is based on the fact that ARHCO's long-range tank use projection does not indicate a continued need for this tank, which obviously does not justify risking continued use with an apparent unexplained liquid level loss over the past two months in excess of one inch," (Letter 7700, F. R. Standerfer to G. T. Stocking, 241-SX-110 Tank).

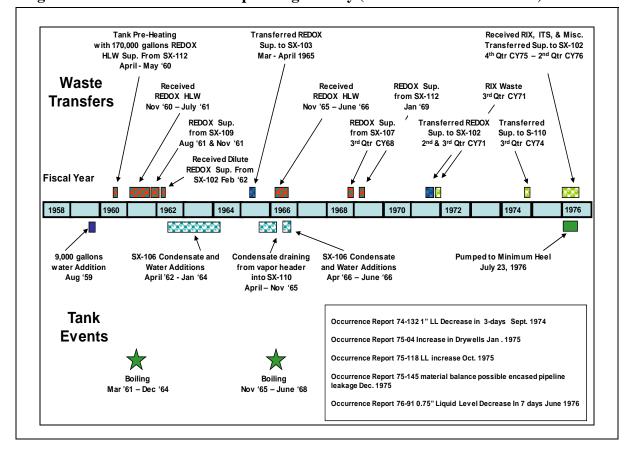
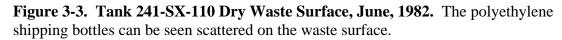


Figure 3-2. Tank 241-SX-110 Operating History (Fiscal Years 1959 to 1976)

Tank SX-110 was pumped to minimum heel July 22, 1976, removed from service, and identified as a questionable integrity tank. Tank SX-110 was then connected to the 241-SX Tank Farm sludge cooler and the remaining supernatant and interstitial liquid were allowed to evaporate. Photographs taken July 26, 1977 indicated that the waste surface was 99% dry. Based on these photographs the tank was declared to be interim stabilized August 31, 1979.

Tank SX-110 is currently estimated to contain 49,000 gallons of sludge and 7,000 gallons of saltcake. Additionally, 16 Argonne National Laboratory 10-liter polyethylene shipping bottles containing a total of 113 grams of natural uranium, 52 grams depleted uranium, 6 grams enriched uranium, and 204 grams of plutonium were added to tank SX-110 sometime before 1977, according to Internal Letter, R. J. Cain to J. C. Womack, Isolation and Stabilization of Special Tanks, 1977. The poly bottles dimensions are 4.6-in i.d. x 51-in length; 0.1-in wall thickness; 712.4 in³ / 11,685 cm³ volume. A June, 1982 photograph of the dry and cracked waste surface in tank SX-110 indicates no supernatant is present in the tank.





4.0 LEAK EVALUATION HISTORY

The tank SX-110 leak evaluations are documented in five ORs and two subsequent reviews.

4.1 Tank SX-110 Occurrence Reports

4.1.1 OR-74-132, Decrease of Liquid Level in Tank SX-110

The tank SX-110 leak detection criterion of 0.5-in/week was exceeded on September 24, 1974, when the liquid level decreased 1-in in three days. The tank contained approximately 400,000 gallons of supernatant and an estimated 32,000 gallons of sludge. The tank was vented to the 241-SX Tank Farm vent system which was reported to have airflow through tank SX-110 of 60-cfm.

A planned switch to the 241-SX Tank Farm sludge cooler vent system, with a reported airflow through the tank of 1000-cfm, occurred on September 26, 1974. The liquid level then decreased an additional 1-in in three days. A psychrometric analysis of the outlet air accounted for a mass transfer rate of 1.4-in of liquid per week. The tank was then reconnected to the 241-SX Tank Farm vent system and the liquid level remained within the leak detection criterion of 0.5-in/week. The fluctuation due to erratic measurements observed between September 21, 1974 and September 24, 1974 was reported to be typical of tanks containing air-lift circulators. The Figure 4-1 photograph shows the tank's choppy liquid surface condition typical of the effects of air lift circulator (ALC) operation.

The tank contains four air lift circulators, two at a height of 102-in and two at 162-in in opposing quadrants (H-2-39951 Sheet 1 Rev. 3, *Arrangement Air-Lift Circulators*). Each air-lift circulator was reported to be operated with an air flow of 5-cfm. Typically two opposing air-lift circulators were operated at one time, according to REDOX weekly reports for 1965, RL SEP 297 *REDOX Weekly Process Reports January through December 1965*.

There were no radiation increases in any of the tank SX-110 vertical drywells during this period. However, a lateral radiation peak of 12 counts per second was detected at the extreme end of the N-25°-0'-E lateral (Lateral 01). The lateral peak was believed to result from an existing, inactive leak from tank SX-107, and was confirmed by radiation detected in two drywells adjacent to tank SX-107, 41-07-05 and 41-07-07.

The liquid level decrease between September 21, 1974 and September 24, 1974 was attributed to fluctuations due to erratic measurements which are typical of tanks containing air-lift circulators. The tank was considered sound and continued in active service.



Figure 4-1. Tank SX-110 Surface Condition Typical of Air-Lift Circulator Effects, June, 1974

4.1.2 OR-75-04, Increasing Drywell Radiation Levels

Drywells 41-10-08 and 41-11-03, located between tanks SX-110 and SX-111, were drilled in 1962. Increasing radiation was detected in the two drywells in January, 1974 with peaks between the 53-ft and 57-ft below ground surface at approximately the level of the tank foundations. Radiation levels had stabilized by late 1974 and were starting to decline in early 1975.

The OR indicated that the tank SX-110 liquid level was decreasing due to evaporation but was within allowable leak detection decrease criteria. The report also reviewed tank SX-111 which contained sludge and interstitial liquid as a possible source of the radiation detected in the drywells. Tank SX-111 had been pumped during the May 4-20, 1974 time period after declaring it a leaker based on increased contamination detected in the central lateral. By January, 1975, tank SX-111 was not believed to contain significant interstitial liquid because the saltwell was unable to pump any liquid, and the high sludge temperatures were tending to evaporate any liquid.

The OR indicated tank SX-110 was considered sound based on the liquid level remaining within the leak detection criteria and stabilization of the drywell radiation levels.

4.1.3 OR-75-118, Liquid Level Increase in Tank 110-SX

A tank SX-110 liquid level increase occurred October 12, 1975 after a transfer of waste to tank SX-102. A preliminary evaluation indicated that the waste material had reached a thickened state which when pumped from the tank created a depression that equalized with time resulting in an increase in liquid level. A visual observation of the receiving tank SX-102 surface showed a relatively slow flowing material. There was also an indicated drop in the receiving tank SX-102 liquid level as the surface level equalized with the manual tape location. A subsequent transfer from tank SX-110 to tank SX-102 on October 22, 1975 also showed a gain in liquid level by the next day in tank SX-102.

4.1.4 OR-75-145, Possible Leakage from an Encased Pipeline

A waste transfer from tank B-103 to tank SX-110 was terminated on December 19, 1975 because of a material imbalance. The material imbalance (-330 to -3,000 gal) was not resolved. A series of swab riser tests indicated possible line leakage into the encasement and further use of the East-West transfer line was postponed pending resolution. The two active pipelines in the East-West encasement were then pressure tested, passed, and returned to service. Tank SX-110 remained in service.

4.1.5 OR-76-91, Liquid Level Decrease Exceeding Criteria for Tank SX-110

The tank SX-110 leak detection criterion of 0.5-in/week was exceeded on June 30, 1976 when the liquid level decreased at a rate of 0.75-in/week. Two psychrometric analyses – one performed two weeks before the decrease, and the second immediately afterwards – calculated evaporative loss rates of 0.30-in/week and 0.15-in/week respectively. The final 76-91 Occurrence Report described erratic surface level readings with the three shift readings for June 30, 1976 of 127.25-in, 127.50-in, and 127.75-in respectively.

The occurrence resulted from using the lowest surface level value, 127.25-in in calculating the surface level drop over the seven day period. Use of either of the other readings, or use of the average of the three readings, would not have resulted in a violation of the 0.75-in/week decrease criterion.

The occurrence report evaluation concluded that the tank was sound. The Energy Research and Development Administration (ERDA) did not disagree with the conclusion. However, ERDA directed that the tank be removed from service due to its questionable integrity, and a long range tank use projection that showed that tank SX-110 space was no longer needed (Letter 7700, F. R. Standerfer to G. T. Stocking, *241-SX-110 Tank*).

The supernatant was pumped to tank SX-102 during July 21-22, 1976. Tank SX-110 was removed from service, and reclassified as of questionable integrity.

4.1.6 Summary - Occurrence Reports

The occurrence reports that relate to a possible tank SX-110 leak seem to be adequately addressed except for OR-76-91. Although the OR's disposition addressed the lack of leak

evidence the tank laterals and drywells, the mismatch between the calculated psychrometric evaporation rates and the 0.75-in/week liquid level decrease were not fully explained.

4.2 Tank SX-110 Previous Leak Reviews

Two leak reviews were conducted on tank SX-110. In 1980 a review looked at potential reclassification of the tank from questionable integrity to confirmed leaker. In 2008 another review reconsidered the 241-SX tank farm leak volumes, and did not directly address the integrity of the tank.

4.2.1 1980 Assessment

An independent panel was convened to review the integrity of several tanks in 1980 including tank SX-110 as documented in RHO-CD-896, *Review of Classification of Nine Hanford Single – Shell "Questionable Integrity" Tanks*. The panel included representatives from Tank Farm Surveillance, Tank Farm Process Control, Effluent Controls, and the Chief Scientist. The panel was tasked with reviewing tanks that had been categorized as questionable integrity to determine whether or not these tanks should be reclassified as confirmed leakers. This panel was not authorized to reclassify questionable integrity tanks as sound tanks. The review focused on three occurrence report: OR-74-132 (Liquid Level Decrease), OR-75-04 (Drywell increases), and OR-76-91 (Liquid Level Decrease).

The Tank Farm Surveillance Group concluded that tank SX-110 should be classified as a confirmed leaker. The Tank Farm Process Control Group, Effluent Controls Group, and the Chief Scientist recommended that tank SX-110 should continue to be classified as questionable integrity. Consistent with the rules established, the tank integrity assessment panel recommended that tank SX-110 continue to be classified as of questionable integrity, since at the 95% confidence level there was insufficient information to warrant reclassification as a confirmed leaker.

The Tank Farm Surveillance Group reviewed OR-74-132 and OR-75-04 and indicated that in tank photographs taken in October, 1975 revealed an apparent tank liner anomaly between the 304-in and 360-in levels. They concluded that the anomaly, and other data, showed that tank SX-110 had leaked during 1974 when the surface level was about 350-in. The waste had been maintained at this level for prolonged periods. The group concluded the tank should be classified as a confirmed leaker.

The Tank Farm Process Control Group also concentrated on OR-74-132 and OR-75-04. Several theories were offered that could explain the tank SX-110 liquid level decrease as well as the drywell peak radiation in 41-10-08 and 41-11-03 below ground surface at the depth of the tank foundation. These included enhanced evaporation because of a pressure difference between tank SX-110 and tank SX-111. The two tanks were ventilated by separate systems – tank SX-110 by the low flow 241-SX Tank Farm vent system, and tank SX-111 by the higher flow 241-SX Tank Farm sludge cooler. The two tanks were interconnected by an open underground cascade line. The lower operating pressure in tank SX-111 was believed to have established an air imbalance that caused a continuous flow of moist air through the cascade line from tank SX-110 to SX-111. This could have increased the rate of evaporation from tank SX-

110. Moist vapor condensing in the line may have resulted in a cascade line leak, which in turn explained the radiation peaks in the two drywells that straddled the cascade line. The mobility and relatively fast rate of radioactive decay in the radiation peaks suggest that the relatively volatile and mobile Ru-106 radioisotope was potentially condensing in the cascade line and leaking into the soil. The group concluded the tank SX-110 classification should not be changed from questionable integrity to confirmed leaker.

Effluent Control Group addressed OR-75-04 and OR-76-91. Adjacent known leakers to tank SX-110 were believed to be related to radiation peaks in the drywells in 1975. The group doubted the 0.75-in/week decrease was accounted for by a tank leak because there was no confirming evidence from the drywells or laterals. It was recommended that tank SX-110 remain classified as questionable integrity.

Chief Scientist reviewed all three occurrence reports and concluded that 95% of the available evidence did not support a tank leak. The conclusion was that tank 110-SX should continue to be classified as a questionable integrity tank..

Based on the recommendations of the participating groups, and consistent with the decision rules in use, the panel recommended that tank SX-110 continue to be classified as questionable integrity, since at the 95% confidence level there was insufficient information to warrant reclassification of this tank as a confirmed leaker.

4.2.2 2008 SX-Farm Leak Assessment

In 2008 an assessment of past leaks in the 241-SX tank farm was completed, and documented in RPP-ENV-39658, *Hanford SX-Farm Leak Assessments Report*. The assessment reviewed tank SX-110 along with other tanks to provide a leak volume and inventory estimate in accordance with RPP-32681, *Process to Assess Tank Farm Leaks in Support of Retrieval and Closure Planning*. The report contains a detailed tank SX-110 operating history. The document reviewed tank temperature, liquid level decreases, evaporation, drywell and lateral information, and the 1980 review of questionable integrity tanks.

Existing photographs were searched for evidence of the apparent tank liner anomaly between the 304-in and 360-in levels that was reported by the Tank Farm Surveillance Group. The 1975 photographs were not located, but 1976 black and white photographs as well as 1987 color photographs were found. The 1976 photographs did not show any evidence of corrosion. The 1987 color photographs show shades of yellow, orange and red along the steel tank liner walls. It was speculated that the color variation could be due to residual red lead paint that had been applied during original construction to protect the steel liner. An example of the color photographs taken on February 20, 1987 is shown in Figure 4-2.



Figure 4-2. Tank SX-110 Interior Wall (February 20, 1987)

The SX Farm leak assessment document summary concluded that, "Tank SX-110 was removed from service and identified as a potential leaker in July 1976 as a result of an apparent unexplained liquid level decline of ~0.75-in/week. Based on the lack of drywell and lateral radiation readings, along with no evidence of corrosion of the steel liner, the assessment team concluded that a tank leak is unlikely and no leak inventory is assigned."

The assessment recommended that a formal leak integrity assessment be conducted in accordance with procedure TFC-ENG-CHEM-D-42, Rev. B-2, *Tank Leak Assessment Process*.

4.2.3 Summary - Previous Leak Reviews

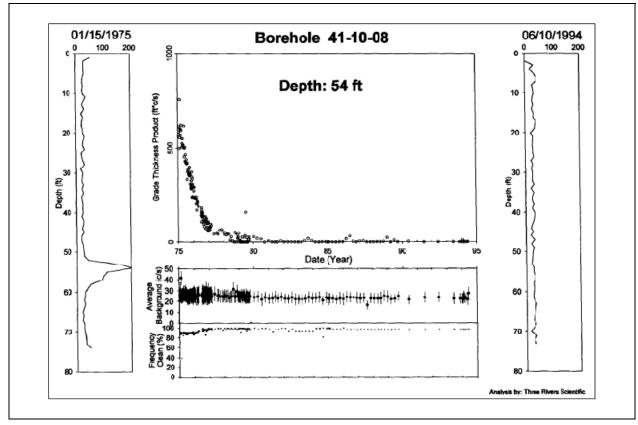
The 1980 leak assessment panel was chartered to review questionable integrity tanks for reclassification as assumed leakers. It had no authority to recommend reclassifying questionable integrity tanks as sound tanks. There is no evidence that the panel considered the possibility that some of the tanks in the review might have been sound. The 2008 assessment concluded that it was possible that tank SX-110 was sound, and recommended that a formal leak assessment be conducted.

4.3 Tank SX-110 Drywells and Laterals

4.3.1 Drywells 41-10-08 and 41-11-03

Radiation peaks in drywells 41-10-08 and 41-11-03 were detected at the depth of the SX-110 and SX-111 tank foundations in December, 1974, and were reported in OR-75-04. In 1975 the gross gamma logs were upgraded to a digital system and reported in HNF-3136, *Analysis Techniques and Monitoring Results*, 241-SX Drywell Surveillance Logs. Logs from the drywells shown in Figures 4-3 and 4-4 from the document. In both drywells the radiation peak had decayed to near-background by 1980, six years later.

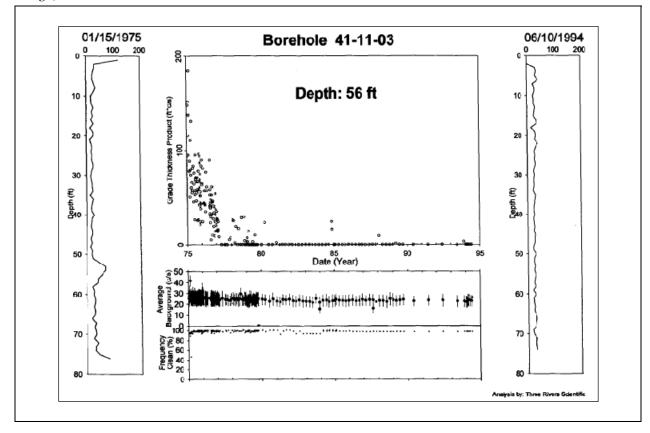
Figure 4-3. Drywell 41-10-08 Historical Radiation Readings
(from HNF-3136, Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs)



When drywell 41-10-08 was logged with the Spectral Gamma Logging System (SGLS) in June, 1995 there was no detectable Cs-137 in the soil interval. The report, GJ-HAN-12, *Vadose Zone Characterization Project at the Hanford Tank Farms - Tank Summary Data Report for Tank SX-110*, discusses the mid-1970's peak, attributing it to short-lived Ru-106, but does not speculate on a possible contamination source. The report concluded, "there is no contamination in the vadose zone that can be positively attributed to leakage from tank SX-

110. All of the contamination detected in the boreholes [drywells] surrounding the tank can be correlated to sources other than the tank itself."

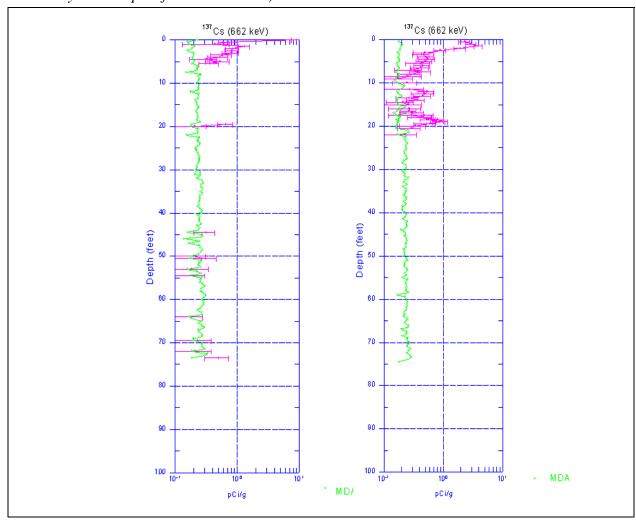
Figure 4-4. Drywell 41-11-03 Historical Radiation Readings (from HNF-3136, Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs)



In 1995 the SGLS logged drywell 41-11-03. The only man-made contaminant detected in this drywell was Cs-137, from the surface to about 22-ft below grade, in concentrations less than 5 pCi/g., and reported in GJ-HAN-13, *Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank SX-111*. The Cs-137 contamination detected in this drywell originated near the surface. The report indicated the increased Cs-137 concentration 19-ft below grade might be due to a leak in a cascade line between tanks SX-110 and SX-111.

The two drywells seem to have responded to the same event: timing, approximate depth, radiation level, and radioactive decay are similar. The 1995 SGLS logs seem to show similar surface contamination, and drywell 41-11-03 indicating increased contamination at the depth of the cascade line.

Figure 4-5. Drywells 41-10-08 and 41-11-03 SGLS Logs (from GJ-HAN-13, Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank SX-111)



4.3.2 Drywells 41-07-05 and 41-07-07 and Lateral 01

The radiation peak in tank SX-110 lateral 01, and the tank SX-107 drywells 41-07-05 and 41-07-07 were evaluated as part of the investigation of OR-74-132, *Decreased Liquid Level*. The lateral indicated an increase in radiation at its extreme far end where it extends beyond the tank's foundation. The radiation peak was interpreted as detecting a soil contamination plume from a previous tank SX-107 leak. Neither of the other two laterals showed any detectable radiation. Figure 4-6 shows the 1989 radiation logs for all three laterals, as reported in RPP-RPT-27605, *Gamma Surveys of the Single-Shell Tank Laterals for A and SX Tank Farms*.

The tank SX-107 drywells were reviewed in OR-74-132. They showed considerable radiation in the area close to the end of the SX-110 lateral 01 as seen in Figures 4-7 and 4-8 from HNF-3136, *Analysis Techniques and Monitoring Results*, 241-SX Drywell Surveillance Logs. This

seems to confirm the belief that the radiation detected at the extreme end of the tank SX-110 lateral 01 was a result of the tank SX-107 leak.

Figure 4-6. Tank SX-110 Laterals 01, 02, and 03 Radiation Logs

(from RPP-RPT-27605, Gamma Surveys of the Single-Shell Tank Laterals for A and SX Tank Farm)

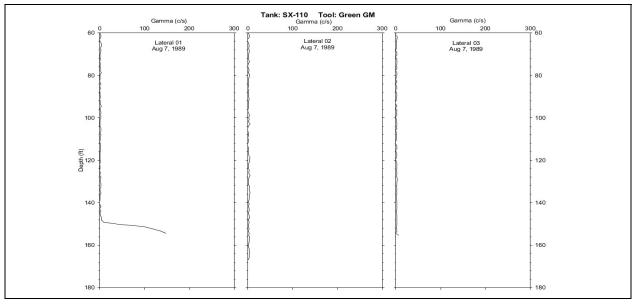


Figure 4-7. Drywell 41-07-05 Historical Radiation Readings

(from HNF-3136, Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs)

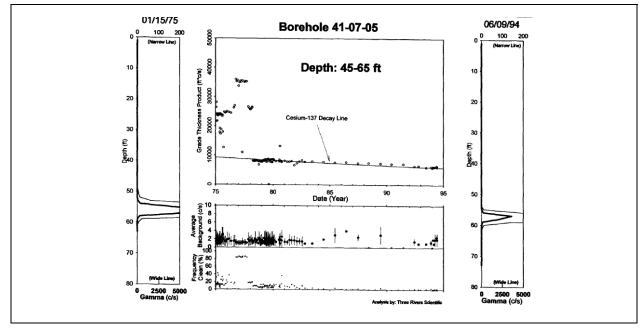
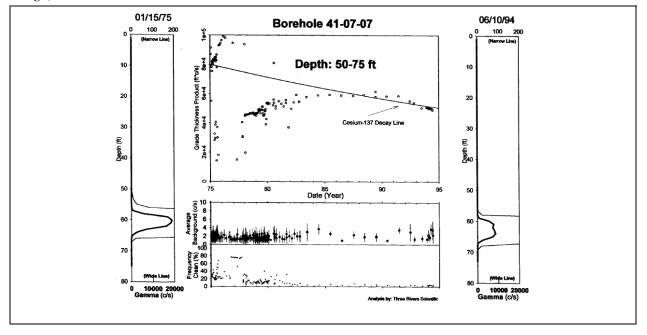


Figure 4-8. Drywell 41-07-07 Historical Radiation Readings

(from HNF-3136, Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs)



4.3.3 Summary - Drywells and Laterals

Tank SX-110 drywells and laterals show no contamination in the vadose zone that can be positively attributed to leakage from the tank. All of the contamination detected in the drywells and laterals surrounding the tank can be reasonably linked to sources other than the tank itself.

4.4 Photographs

The October, 1975 photos referenced in the 1980 assessment were recovered for this formal leak assessment. During the 1980 assessment, the Tank Farm Surveillance Group reported that the photographs were hazy, but that they revealed an apparent tank liner anomaly between the 304-in and 360-in levels. An examination of the 1975 photographs did show some haze but overall the visibility was judged to be good.

A detailed examination of the 1975 photographs could not identify the anomaly identified during the 1980 review. This is the same conclusion that the 2008 assessment reached using the 1975 black and white photographs and 1987 color photographs. The black and white photographs were reported to reveal streaking on the steel liner walls but no evidence of steel liner corrosion. The color photographs show different colorations possibly due to residual red lead paint applied during construction to protect the steel liner during waste storage.

4.5 Summary - Leak Reviews and Ex-Tank Data

There are reasonable explanations for the observed ex-tank data – the drywells and laterals – besides a possible tank leak. Two independent reviews of different sets of in-tank photographs could not identify the reported, but not described, 1980 liner anomaly.

The 0.75-in surface level decrease reported and investigated in OR-76-91 could not be completely explained by the evaporation rates calculated from psychrometric measurements taken before and after the decrease was observed. Surface level fluctuations complicate evaluation of the trended decrease, and are probably the result of surface disturbance caused by air lift circulator operation.

5.0 Analysis of April – July 1976 Liquid Level Decrease

The unexplained liquid level decrease and evaporation rate were investigated in detail using additional methods for analyzing both existing and newly acquired data. None of the previous reviews resulted in an explanation of the tank SX-110 liquid level decrease. These included a psychrometric determination the day after the 0.75-in/week liquid level decrease that accounted for about a 0.15-in/week liquid level decrease.

Two approaches were used to examine the role of evaporation in the liquid level decrease for the period beginning with the transfer of waste to tank SX-110 from tank B-103 on April 27, 1976 and ending with the transfer of supernatant from the tank on July 21, 1976 after the declaration of questionable integrity. During this period the liquid level decreased from 129.5-in to 126.5-in.

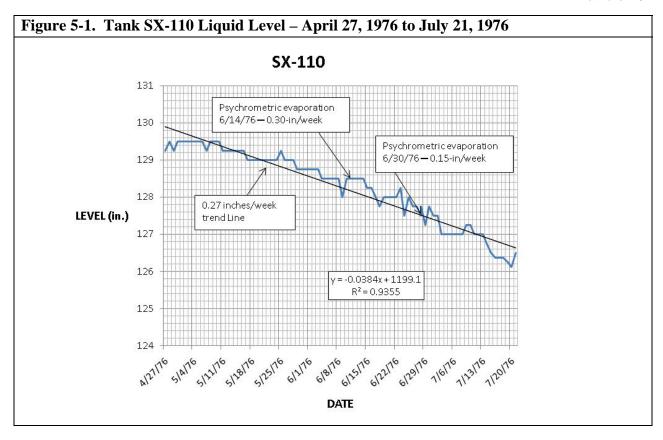
No intervening waste transfers into or out of the tank occurred during this period. After the July, 1976 transfer, the remaining supernatant and interstitial liquid was allowed to evaporate resulting in a waste surface estimated to be 99% dry solids based on in-tank photographs taken July 26, 1977.

The first approach was a detailed review of the liquid level decrease over the entire period. The second involved an evaporation analysis using two independent methods.

5.1 Liquid Level Decrease - Curve Fit

5.1.1 Entire Time Period

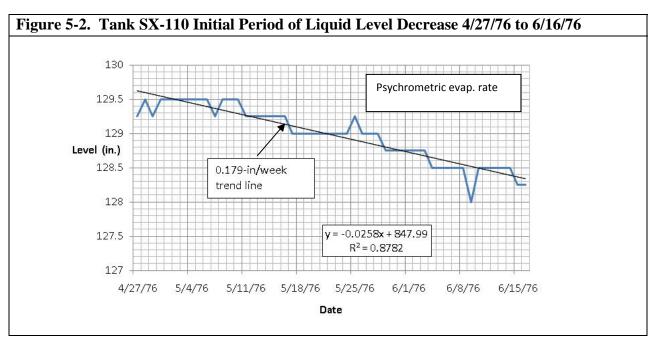
Figure 5-1 illustrates the liquid level behavior for the period between April 27, 1976 and July 21, 1976. A linear regression curve fit trend line yields a liquid level decrease of 0.27-in/week for the entire period. Using just the beginning and ending liquid levels of 129.5-in and 126.5-in results in a calculated liquid level decrease of 0.25-in/week. Both of these rates are less than the leak detection criterion of 0.5-in/week.

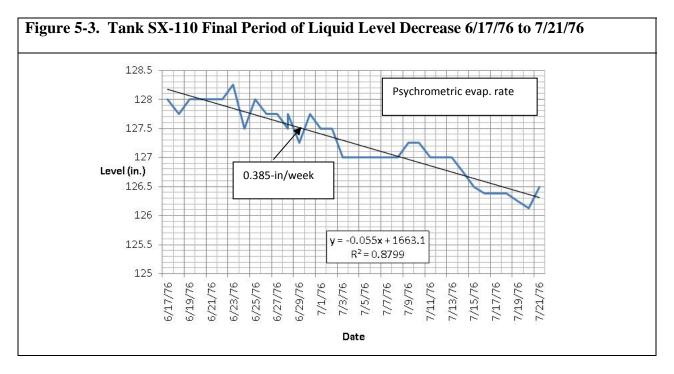


5.1.2 Different Curve Slopes

A detailed review of the curve shown in Figure 5-1 indicates there are two different slopes with a breakpoint at June 16/17, 1976. Graphs of the initial period, Figure 5-2, from April 27, 1976 and the final period, Figure 5-3, to July 21, 1976 result in similar linear regression curve fit values (R²) indicating approximately the same level of curve fit. Either side of the breakpoint date results in divergent R² values. The rate of decrease for the first period is 0.179-in/week and for the second period 0.385-in/week, with corresponding psychrometric evaporation rates of 0.30-in/week and 0.15-in/week, respectively.

The differences between the trend line rates and the corresponding psychrometric rates is probably from the trend line rate being an average over time and the two psychrometric rates being single point determinations. Also, the psychrometric rates are dependent on dynamic measurements including hourly atmospheric conditions that can be highly variable, as well as tank operating configuration at the time the measurements are made, including air lift circulator operation, and the tank vent system configuration/flow.





The worst case of 0.385-in/week trend line rate for the final period from the above plots is within the allowable liquid level decrease of 0.50-in/week rate.

5.2 Evaporation Analysis

5.2.1 Water Evaporation Calculation

A water evaporation calculation was performed. This required estimating several parameters including ambient air water vapor concentration, ventilation rate, tank head space water vapor concentration, and using head space volume, temperature, and single-point psychometric determinations.

Water evaporation is basically a difference between the tank inlet and outlet conditions. Inlet water concentration was based on the Hanford Meteorological Station hourly data. A nominal flow rate of 960-cfm was used from actual measurements taken in July, 1976, April, 1977, and August,1977, per letter, C. M. Walker to J. C. Womack, *Status of Tanks Connected to the 241-SX Sludge Cooler*, September 15, 1977. The rate is essentially the same as the 1000-cfm rate reported in OR-74-132 for an earlier period. Outlet water vapor concentration was derived by fitting two available psychrometric determinations with relative humidity measurements. The calculation resulted in a rounded 0.26-in/week which closely matched the liquid level decrease curve fit trend line of 0.27-in/week. The calculation was issued as RPP-CALC-46420, Rev 0, *Estimated Water Evaporated from Tank 241-SX-110 Between April 27, 1976 And July 21, 1976.*

The psychrometric measurements that resulted in the 0.15-in/week decrease reported on June 30, 1976, may have been biased by weather conditions that day. A review of the hourly weather data indicates a cool humid front moved into the region in the late afternoon. This probably depressed the individual psychrometric reading due to the lowered difference in water content of the inlet and outlet airstreams from the tank. The 0.30-in./week psychrometric measurement made on June 14, 1976 was probably closer to average evaporation rate, but would have been influenced by the tank conditions, especially the operation of the air lift circulators, that could not be determined.

5.2.2 WVPCRUST Evaporation Calculation

The WVPCRUST program is a crust diffusion model computer code which was verified and validated as part of the tank SX-102 evaporation analysis, WHC-SD-WM-ER-213, Rev. 0, *Evaporation Rate Prediction for Waste Tank SX-102*, in 1993. The document details the derivation and the source code listing of the WVPCRUST calculation procedure used in earlier tank evaluations, including WHC-SD-WM-ER-182, *An Evaporation Analysis of Tanks 241-SX-103*, 241-SX-105, and 241-SX-106, WHC-SD-WM-ER-202, *Evaporation Analysis for Tank SX-105*, and WHC-SD-WM-ER-332, *Evaporation Analysis for Tank SX-104*. The program can be used to perform a calculation of the water evaporation from either a partial or full crusted surface as well as a complete liquid surface.

The WVPCRUST program was used to estimate the overall evaporation rate between April 27, 1976 and July 21, 1976 using the assumptions, atmospheric data, and incorporation of select information from WHC-SD-WM-ER-332, *Evaporation Analysis for Tank SX-104*. A list of the parameters and reference sources is contained in Appendix A. Photographs are not available during the report period, therefore a 100% liquid surface was first assumed in order to determine the maximum evaporation rate. Using 960-cfm tank outlet flow, 100 % liquid surface, with no air lift circulator operation resulted in a calculated water evaporation rate of 0.11-in/week.

Increasing the surface velocity assuming operation of two air lift circulators at 5-cfm each, the WVPCRUST program resulted in an evaporation rate of 0.15-in/week.

Further evaluation of the WVPCRUST variables identified that the allowable ranges for some modeling parameters probably cannot account for some tankconditions, such as air lift circulator operation. In addition the liquid/vapor space absolute and differential temperatures for some cases from heat content standpoint did not match the values used in the water evaporation calculation that had been taken from standard reference documents. Force fitting select parameters to come closer to the base line was not productive.

The 0.15-in/weed evaporation rate calculated from the WVPCRUST program was therefore dismissed from further consideration. And it was not reasonably close to the actual 0.30-in/week evaporation rate measured on June 14, 1976, or to the 0.26-in/week evaporation calculation using historical data.

5.3 Summary

The 0.75-in/week surface level decrease measured in tank SX-110 exceeded the allowable leak detection criteria of 0.50-in/week for the seven day period ending June 29, 1976, using the lowest of three surface level measurements made that day.

Two methods were used to determine the evaporation rate as a possible explanation for the observed decrease.

- The water evaporation calculation resulted in an evaporation rate of 0.26-in/week under conservative conditions which closely matched the overall liquid level curve fit trend line of 0.27-in/week. The results indicate that evaporation could account for all of the tank liquid level decrease.
- The WVPCRUST program calculation resulted an evaporation rate of 0.15-in/week under optimum conditions, which was considerable less than the overall liquid level curve fit trend line of 0.27-in/week. The calculated rate was suspect because of unexplained differences between the parameter values in the model and established reference values, and concerns about the program's ability to account for variations in tank operating conditions. The WVPCRUST rate was not reasonably close to the 0.30-in/week evaporation rate from calculated from psychrometric measurements made on June 14, 1976, nor the 0.27-in/week rate from the evaporation calculation. The WVPCRUST was not considered in the final evaluation.

A summary of the SX-110 liquid level decrease data is contained in Table 5-1.

Table 5-1. Tank SX-110 Evaporation Rate Comparison

Data Source	Evap. Rate in/week	Evaluation Time Period
Liquid Level Decrease Criteria	0.50	4/27/1976 – 7/21/1976
Psychrometric Determination	0.30	6/14/1976
Reported In OR-76-91	0.15	6/30/1976
	0.27	4/27/1976 – 7/21/1976*
Liquid Loyal Dagranga Curvo Fit	0.25	4/27/1976 – 7/21/1976**
Liquid Level Decrease – Curve Fit	0.18	4/27/1976 – 6/16/1976*
	0.39	6/17/1976 – 7/21/1976*
Water Evaporation Calculation	0.26	4/27/1976 – 7/21/1976
WVPCRUST Calculation	0.15	4/27/1976 – 7/21/1976

^{*} Trend line

^{**} Beginning to ending liquid levels

6.0 HYPOTHESES

Based on review of the tank SX-110 data, the team developed plausible hypotheses for the observed tank behavior:

Leak Hypothesis:

"The surface level decrease occurring between late April and mid July 1976 was due to the combined effects of evaporation and a tank leak."

Non-Leak Hypothesis:

"The surface level decrease occurring between late April and mid July 1976 was due to evaporation."

7.0 CONCLUSIONS

The process for assessing the leak status of a tank is designed to estimate a leak probability. Probability is defined as a measure of the state of knowledge or belief about the likelihood that a specific state of nature (e.g., a tank has leaked or is leaking) is true. Probability must be between 0 (absolute certainty that the state of nature is not true) and 1 (absolute certainty that the state of nature is true). The process starts with a prior probability independent of the available data. This establishes any pre-evaluation bias and is typically established at 0.5 that the tank is leaking or has leaked without consideration of the specific data initiating this process (i.e., no pre-evaluation bias, either for or against a leak). Then reviews of in-tank data and ex-tank data are used to establish conditional probabilities for whether the leak hypothesis or the non-leak hypothesis is supported by the data. The conditional probabilities are used to adjust the leak probability toward a leak hypothesis (probability > 0.5) or a non-leak hypothesis (probability < 0.5).

There was consensus among the members of the leak assessment team that the available in-tank and ex-tank data indicated that the no-leak hypothesis was more consistent with the data, and that there was a low probability that the tank was leaking during the late April through mid July time frame. The water evaporation calculation coupled with the stable baseline readings in the drywells and laterals reduced the estimated active leak probability to less than one chance in nine that the observed in-tank and ex-tank data would be present if the tank were leaking.

The recommendation of the assessment team was that the integrity status of tank SX-104 be changed from "Assumed Leaker" to "Sound."

The results of leak assessment were presented to the Executive Safety Review Board on October 22, 2010. The Board concurred with the recommendation of the assessment team.

8.0 REFERENCES

- Letter 7700, 1976, Energy Research and Development Administration to Atlantic Richfield Hanford Company, 241-SX-110, Energy Research Development Administration, Richland Washington.
- Letter 8901832B R1, 1989, R. J. Baumhardt to R. E. Gerton, *Single-Shell Tank Leak Volumes*, Westinghouse Hanford Company, Richland Washington.
- GJ-HAN-12, 1995, Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank SX-110, U.S. Department of Energy, Grand Junction Office, Grand Junction, Colorado.
- GJ-HAN-13, 1995, Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank SX-110, U.S. Department of Energy, Grand Junction Office, Grand Junction, Colorado.
- H-2-39951, Sheet 1 Rev. 2, 1956, *Arrangement Air-Lift Circulators*, General Electric, Richland Washington.
- HNF-EP-0182, 2009, *Waste Tank Summary Report for Month Ending December 31*, Rev. 238, CH2M Hill, Richland Washington.
- HNF-3136, 1999, *Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs*, Rev. 0, Lockheed Martin Hanford Corp., Richland, Washington.
- HNF-3747, 1998, *Tank Leak Assessment Process: Technical Background*, Rev. 0, Lockheed Martin Hanford Corp., Richland, Washington.
- Internal Letter, 60412-78-014, page 50, 1997, *Heat Tracing for 200 Series Tanks*, Rockwell Hanford Operations, Richland, Washington.
- Internal Letter, 1977, *Status of Tanks Connected to the 241-SX Sludge Cooler*, Rockwell Hanford Operations, Richland, Washington.
- Occurrence Report 74-132, 1974, *Decrease of Liquid Level in Tank SX-110*, Atlantic Richfield Hanford Company, Richland, Washington.
- Occurrence Report 75-04, 1975, *Increasing Drywell Radiation Levels Between SX-110 and SX-111*, Atlantic Richfield Hanford Company, Richland, Washington.
- Occurrence Report 75-118, 1975, *Liquid Level Increase in Tank 110-SX*, Atlantic Richfield Hanford Company, Richland, Washington.

- Occurrence Report OR-75-145, 1975, *Possible Leakage from an Encased Pipeline*, Atlantic Richfield Hanford Company, Richland, Washington.
- Occurrence Report 76-91, 1976, *Liquid Level Decrease Exceeding Criteria for Tank 110-SX*, Atlantic Richfield Hanford Company, Richland, Washington.
- RHO-CD-213, 1977, *Waste Storage Tank Status and Leak Detection Criteria*, Rev. 0, Atlantic Richfield Hanford Company, Richland, Washington.
- RHO-CD-896, 1980, Review of Classification of Nine Hanford Single-Shell "Questionable Integrity" Tanks, Rev. 0, Rockwell Hanford Operations, Richland, Washington.
- RHO-R-39, 1969, *Boiling Waste Tank Farm Operational History*, Rockwell Hanford Operations, Richland, Washington.
- RL-SEP-297, 1965, *REDOX Weekly Process Reports January through December 1965*, General Electric Corporation, Richland, Washington.
- RPP-32681, 2007, *Process to Estimate Tank Farm Vadose Zone Inventories*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.
- RPP-CALC-46420, 2010, Estimated Water Evaporated from Tank 241-SX-110 Between April 27, 1976 And July 21, 1976, Rev 0, Washington River Protection Solutions, Richland Washington.
- RPP-ENV-39658, 2010, *Hanford SX-Farm Leak Assessments Report*, Rev. 0, Washington River Protection Solutions, Inc., Richland, Washington.
- RPP-RPT-27605, 2006, *Gamma Surveys of the Single Shell Tank Laterals for A and SX Tank Farms*, Rev. 0, CH2M Hill, Richland Washington.
- TFC-ENG-CHEM-D-42, 2009, *Tank Leak Assessment Process*, Rev. B-2, Washington River Protection Solutions, Inc., Richland, Washington.
- WHC-SD-WM-ER-182, 1993, An Evaporation Analysis of Tanks 241-SX-103, 241-SX-105, and 241-SX-106, Rev. 0, Westinghouse Hanford Co., Richland, Washington.
- WHC-SD-WM-ER-202, 1993, *Evaporation Analysis for Tank SX-105*, Rev. 0, Westinghouse Hanford Co., Richland, Washington.
- WHC-SD-WM-ER-213, 1993, Rev. 0, *Evaporation Rate Prediction for Waste Tank SX-102*, Rev. 0, Westinghouse Hanford Co., Richland, Washington.
- WHC-SD-WM-ER-332, 1994, *Evaporation Analysis for Tank SX-104*, Rev. 0, Westinghouse Hanford Co., Richland, Washington.

APPENDIX A

Evaporation Parameters

The WVPCRUST program is a computer code used to perform a calculation of the water evaporation from either a partial or full crusted surface as well as a complete liquid surface by setting the appropriate parameters. The program was used to estimate the overall evaporation rate between April 27, 1976 and July 21, 1976 using assumptions, atmospheric data, and incorporation of select information from WHC-SD-WM-ER-332, *Evaporation Analysis for Tank SX-104* as follows:

- Time period, 2016-hours
- Tank outlet flow, 960-cfm, Internal Letter, 1977, Status of Tanks Connected to the 241-SX Sludge Cooler
- Tank vapor space temperature, 79.9°F, weighted average from Table A-1
- Tank vapor space volume, 133,531-ft³, volume above the average liquid level of 127-in
- Surface velocity, 0.2-ft/sec w/o ALC, WHC-SD-WM-ER-332, Evaporation Analysis for Tank SX-104
 - o 0.34-ft/sec w/ALC (0.2-ft/sec + total of 10-cfm over entire surface area)
- Surface area, 4418-ft², area of tank
- Length, 37.5-ft, radius of tank
- Diffusion coefficient, 1,000,000-ft²/hr, assuming no crust
- Crust thickness, 0.000,000,1-ft assuming no crust
- Pool temperature, 81.3°F, weighted average from Table A-1
- Average ambient temperature, 65.6°F, Hanford Metrological Data
- Average ambient pressure, 14.28 psia, Hanford Metrological Data
- Average ambient relative humidity, 39.8%, Hanford Metrological Data
- Vapor Pressure multiplier, 0.72, WHC-SD-WM-ER-332, *Evaporation Analysis for Tank SX-104*
- Conversion factor, density of water, 62-lbm/ft³

Table A-1 shows the available waste and headspace temperatures for the time frame of interest and is a summary of the temperature data sheets. Average waste height for the time period was 127 inches. A double underline is drawn in the table to distinguish between thermocouples in the headspace and thermocouples in the waste.

Table A-1 Tank 241-SX-110 Temperatures

Thermocouple Distance	4/03/76	5/02/76	6/02/76	7/01/76	7/17/76	7/17/76	7/21/76
from Tank Bottom	Temp						
(inches)	(° F)						
4	85	63	94	82	81	96	87
28	85	64	92	82	81	96	87
52	86	64	92	83	81	96	87
76	86	64	87	81	79	96	85
100	87	64	87	81	80	96	85
124	NA	64	87	81	79	96	85
148	NA	64	87	81	79	96	85
172	NA	64	87	81	79	96	85
196	NA	64	87	82	79	96	85
220	NA	64	87	81	79	96	85
244	NA	64	87	80	79	96	85
268	NA	65	87	72	79	96	85
292	NA	NA	87	NA	79	96	85
316	NA	NA	87	NA	79	96	84

Notes: NA = not available

APPENDIX B

Tank SX-110 Leak Assessment Team Meetings #1 - #5 Meeting Minutes

B.1 MEETING #1

MEETING MINUTES

SUBJECT: Tank SX-110 Leak Assessment Meeting #1 Minutes					
TO:	BUILDING	3 :			
Distribution	2750E/A-2	229			
FROM:	CHAIRMA	N:			
D. J. Washenfelder	Same				
DEPARTMENT-OPERATION-COMPONENT	AREA	SHIFT	DATE OF MEETING	NUMBER ATTENDING	
Engineering - Technical Integration	200-E		09/21/2009	9	

Distribution:
D. A. Barnes+*
D. G. Baide
M. V. Berriochoa
J. W. Ficklin+*
J. G. Field+*
M. A. Fish+*
D. G. Harlow+*
K. J. Hull
J. M. Johnson* (ORP)
R. W. Lober* (ORP)
E. C. Shallman+*
Attendees*

Background:

Team Members+

The 1,000,000 gallon tank 241-SX-110 (tank SX-110) located in 200 West area was built between 1953 and 1954 and is the first tank in a cascade series of three tanks including tank 241-SX-111 and tank 241-SX-112. Tank SX-110 has three laterals installed about 10 ft under the tank and eight drywells located around the tank.

Tank SX-110 received Reduction Oxidation (REDOX) waste and then condensate from 241-SX-106 from the second quarter of 1960 until the first quarter 1964. Boiling conditions existed from March, 1961 to December, 1964. Supernatant was transferred to 241-SX-103 in the first and second quarter 1965 leaving a heel of 114,000 gallons of waste and the tank was held as a spare. The vapor header condensate slowly drained into tank SX-110 resulting in a waste volume of 192,400 gallons by November, 1965. This volume of waste precluded holding the tank as a spare and it was returned to normal service November, 1965.

Tank SX-110 received REDOX waste again in the fourth quarter 1965 and periodically through the first

quarter of 1969 including REDOX supernatant from other 241-SX Farm tanks and reached 932,000 gallons of waste. Boiling conditions were experienced during this period from November, 1965 to June, 1968.

Supernatant was transferred to tank SX-102 in the second and third quarter of 1971. Tank SX-110 then received ion exchange waste from 221-B Plant. Supernatant was then transferred to tank S-110 in the third quarter of 1974. From the fourth quarter of 1975 through the second quarter of 1976 tank SX-110 received 221-B Plant, ITS waste, and miscellaneous supernatant waste.

The tank SX-110 liquid level decreased 0.75 inches in seven days which exceeded the action criteria of 0.50 inches in a seven day period and Occurrence Report (OR) 76-91 was issued on June 29, 1976. The OR reported that the tank was considered to be sound. Stating that dry well and lateral radiation readings were stable during the review period. The OR further stated the following:

"A June 14, 1976, psychrometric analysis indicating a 0.30 inch per week evaporation rate. The evaporation rate analyzed June 30 indicates a loss of 0.15 inches per week. Using only the lower evaporation rate, the cumulative liquid level decrease would still be accounted for."

There is an obvious error in the above statement contained in the OR. If the evaporation rates are actually weekly rates neither would cover the liquid level loss of 0.75 inches in seven days. The word cumulative offers a clue that the weekly evaporation rates may actually be daily. The weekly evaporation rates were stated twice in different sections of the OR. Further review of the OR evaporation rates for this period is required.

The Richland Operations Office (RL) responded on July 21, 1976 with the following:

"RL acknowledges ARHCO's technical assessment of the surveillance data and technical opinion that the subject tank is sound. However, it is our judgment that the tank should be removed from service due to questionable integrity. This decision is based on the fact that ARHCO's long-range tank use projection does not indicate a continued need for this tank, which obviously does not justify risking continued use with an apparent unexplained liquid level loss over the past two months in excess of one inch."

Tank SX-110 was pumped to minimum heel July 23, 1976, removed from service, and identified as a questionable integrity tank. Tank SX-110 was connected to the 241-SX Farm sludge cooler and the supernatant and interstitial liquid was allowed to evaporate. Photographs taken July 26, 1977 indicated that the waste surface was 99% dry. Based on these photographs the tank was declared interim stabilized August 31, 1979.

Tank SX-110 is currently estimated to contain 49,000 gallons of sludge and 7,000 gallons of saltcake (HNF-EP-0182 Rev 238). Additionally, 16 plastic tubes which hold a total of 113 grams of natural uranium, 52 grams depleted uranium, 6 grams enriched uranium, and 204 grams of plutonium were added to tank SX-110 sometime before 1977 (RHO-CD-756 page 5). The plastic tubes are reported to be 3-inch diameter by 54 inches long (IDMS Accession #D194042886 page 50).

1980 Assessment

An independent panel was convened to review the integrity of tank SX-110 in 1980 (RHO-CD-896). This panel was comprised of representatives from Tank Farm Surveillance Group, Tank Farm Process Control

Group, Effluent Controls Group, and the Chief Scientist. The panel was tasked with reviewing tanks that had been classified as of questionable integrity to determine whether these tanks should be reclassified as confirmed leakers. This panel was not chartered to reclassify tanks as being sound integrity.

Consistent with the rules established, the RHO tank integrity assessment panel recommended that tank SX-110 continue to be classified as of questionable integrity, since at the 95% confidence level there was insufficient information to warrant reclassification of this tank as a confirmed leaker.

2009 SX Farm Leak Assessments

Tank SX-110 was one of several 241-SX tank farm tanks that were selected for review using RPP-32681, 2007, *Process to Estimate Tank Farm Vadose Zone Inventories*. This process provides for re-assessment of tank leak estimates and update of single-shell tank leak and unplanned releases volumes and inventory estimates as emergent field data is obtained. The resulting re-assessment for Tank SX-104 in RPP-ENV-39658 Rev 0, Draft, 2008, *Hanford SX-Farm Leak Assessments Report*, generated the following conclusion:

"Tank SX-110 was removed from service and identified as a potential leaker in July 1976 as a result of an apparent unexplained liquid level decline of ~0.75-inches. Based on the lack of drywell and lateral radiation readings, along with no evidence of corrosion of the steel liner, the assessment team concluded that a tank leak is unlikely and no leak inventory is assigned."

Next Meeting: The next SX-110 leak assessment team meeting is scheduled for 9-25-09 at 2:00PM in 2750/B-225

Discussion:

The conclusion for tank SX-110 stated above in RPP-ENV-39658 provided the basis for evaluation of a potential change in the tank SX-110 leak status from an "assumed leaker" to "sound" as provided in TFC-ENG-CHEM-D-42, Rev. B-2, *Tank Leak Assessment Process*. A tank SX-110 Leak Assessment Team was assembled and is proceeding with the evaluation of the tank using the Tank Leak Assessment Process.

The information on the presentation slides (attached) was discussed in the meeting. The following actions came out of the discussions and further review of existing documentation.

Team Member Actions Status:

Leak assessment actions from the tank SX-110 September 21st Leak Assessment Team meeting are listed below:

	Member	Action
1.	E. C. Shallman	Understand and provide LL pumping and OR history for 1974-1976. (Check Welty, Brevick, Anderson for surface level references). Track down anomalous transfer data and timing (e.g. OR 75-118 states depression formation but tank would have had to have been pumped dry for this to form.) Post 1-1-1980 data. Status:
2.	D. A. Barnes	Provide available waste temperature data post-1968 (possible source: Nancy Scott-Proctor). Status:
3.	D.A. Barnes	Compare SX-107 and SX-110 laterals. Jennie Reynolds can prepare plots from the raw data. <i>Status:</i>
4.	J. G. Field	Review how many drywells show up contaminated on nearby SX Farm Leakers. Look at pattern for drywells around SX-110 (possible interpretive source - Stoller/GJO reports). Status:
5.	D. J. Washenfelder	Verify air lift circulator air flow. Status:
6.	M.A. Fish	Check air supply configuration for SX-110 on the sludge cooler. <i>Status:</i>
7.	J. G. Field	Review pipeline leak implications OR 75-145. Status:
8.	D. G. Harlow	Review OR 76-91 evaporation rates. <i>Status:</i>

References:

Briefings:

Date	Title

Correspondence - Emails:

Date	Title

Number	Title
TVIIIIOCI	Titte
Do a monta	
Documents:	
Number	Title
RPP-ENV-39658, Rev. 0	Hanford SX-Farm Leak Assessment Report (DRAFT)
OR 74-132	Decrease of Liquid Level in Tank 110-SX
OR 75-04	Increasing Dry Well Radiation Levels Between Waste Tanks 110-SX and 111-SX
OR 75-118	Liquid Level Increase in Tank 110-SX
OR 75-145	Possible Leakage from an Encased Pipeline
OR 76-91	Liquid Level Decrease Exceeding Criteria for Tank 110-SX
RHO-CD-896	Review of Classification of Nine Single-Shell "Questionable Integrity" Tanks
RPP-RPT-27605	Gamma Surveys of the Single-Shell Tank Laterals for A and SX Tank Farms
RHO-CD-756	Evaluation of Special Tanks 101-BX, 111-S, 107-SX, and 110-SX
D	
Drawings:	
Number	Title



241-SX-110 Leak **Assessment**

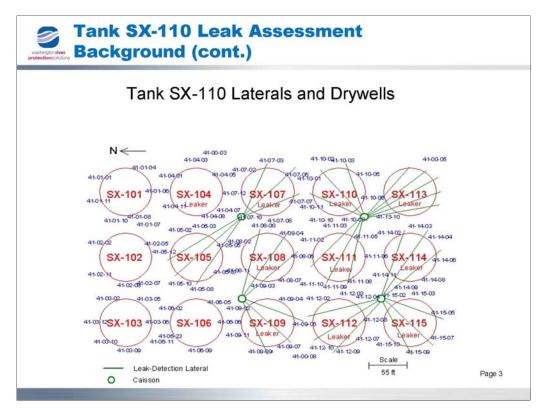
D. J. Washenfelder **Technical Integration** Program September 21, 2009





Tank SX-110 Leak Assessment Background

- One million gallon single-shell tank active from 1959-1976
- · Four air lift circulators five cfm each
- · In 1976 ERDA acknowledged ARHCO's assessment that tank is sound but decides that the tank should be removed from service due to questionable integrity from an unexplained liquid level decrease and the need for the tank in the long-range tank use projection
- · Pumped to minimum heel July, 1976
- Interim Stabilized in 1979
- · Contains approximately 49,000 gal. of Sludge and 7,000 gal. of
- Also has 16 bottles (3" OD by 54" long) containing 204g ²³⁹Pu and 6g enriched Uranium





Tank SX-110 Leak Assessment Team

- Purpose: Review Leak Evidence and determine tank leak integrity status using TFC-ENG-CHEM-D-42 "Leak Assessment Process"
- Leak Assessment Team
 - Dennis Washenfelder
 - David Barnes
 - James Ficklin
 - Jim Field
 - Michael Fish
 - Don Harlow
 - Erik Shallman



Tank SX-110 Leak Detection History

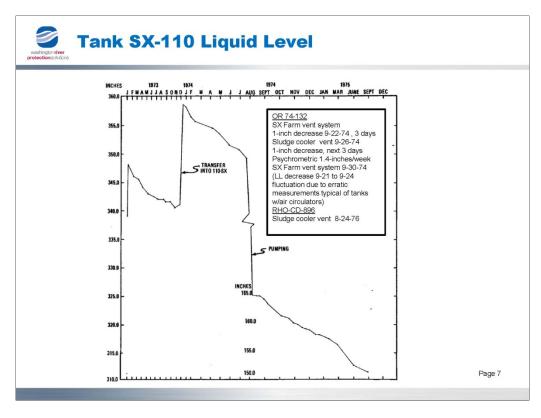
- Declared questionable integrity in 1976 based on liquid level decrease of 0.75-inches which exceeded the action criteria of 0.5-inches, tank was considered sound (OR 76-91) but changed classification at the direction of **ERDA**
- Review of questionable integrity tanks January, 1980 (RHO-CD-896), continue as questionable integrity
- 8 drywells are located around the tank
 - Activity in 41-10-08 and 41-11-03 assumed to be associated with tank SX-111
- · 3 Laterals retrofitted under the tank with survey data from 1974-1989
 - Activity at extreme end of 44-10-01 is thought to be associated with tank SX-107 leak

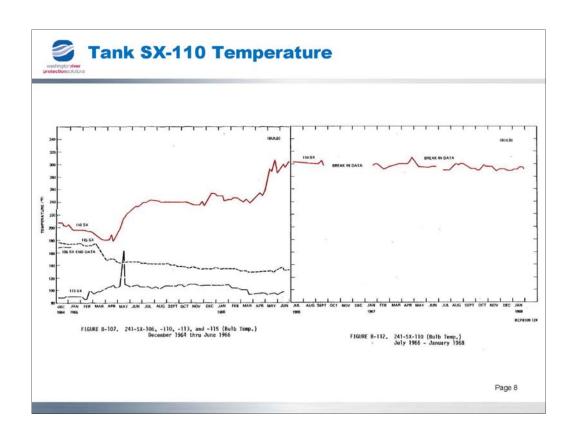
Page 5

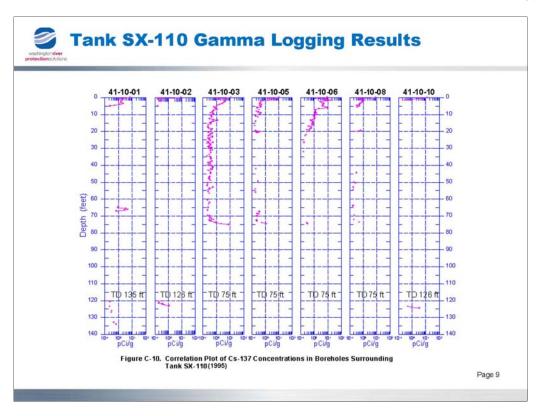


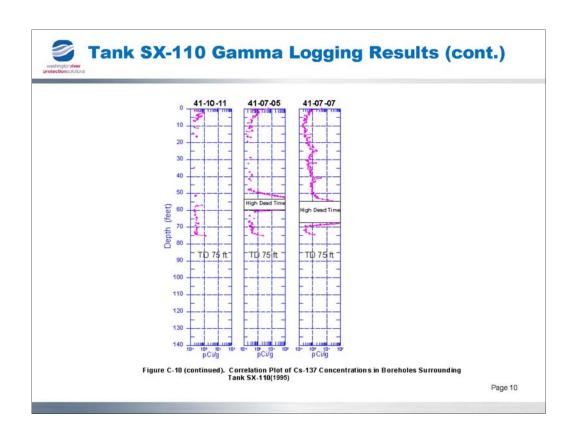
Tank SX-110 Leak Assessment Data

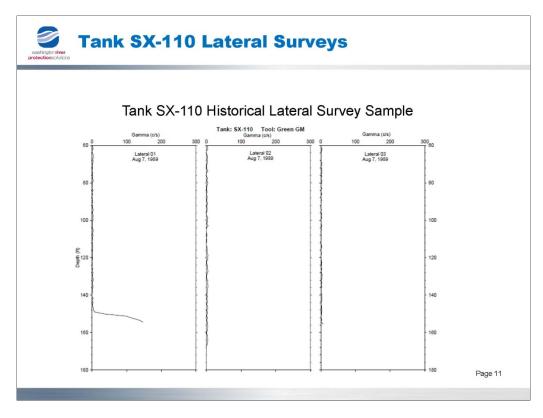
- · Liquid level
- Temperature
- Drywells
- Laterals

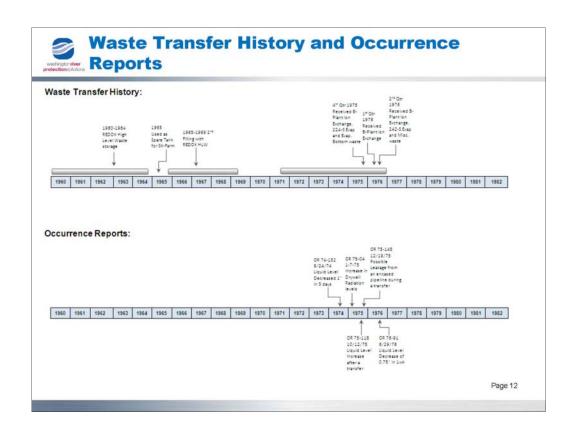


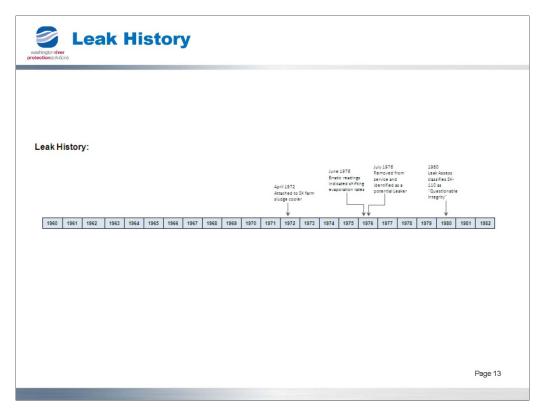














1960-1964 REDOX High-Level Waste Storage (HW-83906-E-RD)

1965 used as a spare tank in case of tank failures (RL-SEP-297)

Dec. 1965-Jan. 1969 2nd Filling of REDOX HLW (RL-SEP-297)

2nd Quarter 1971-2nd Quarter 1976 B Plant Ion Exchange Waste and Miscellaneous Waste (ARH-871)

April 1972 SX-110 was attached to the SX farm sludge cooler system. (RHO-CD-213 Vol. 4 Section 7 of 7)

Sept. 1974 Liquid Level Decreased 1" in 3 days (74-132 Occurrence Report)

Jan. 1975 Drywells 41-10-08 and 41-11-03 showed a rise in radiation levels at the 53-57foot depth, approx. the bottom of SX-110 and 111, (OR 75-04) ,Tank SX-111 was a declared leaker based on a previous center lateral increase

Oct. 1975 Liquid Level Increase in SX-110 after a transfer to SX-102 (OR 75-118)

Dec. 1975 Possible Leakage from an encased pipeline during a transfer of B-103 and SX-110 (OR 75-145)

June 1976 Liquid Level Decrease of 0.75" in 7 days(OR 76-91) declared questionable integrity at the direction of ERDA

1980 Leak Assessment Team has no authority to classify the tank as a Non-Leaker. They keep the tank as Questionable Integrity, with only the surveillance team wanting a Confirmed Leaker classification. (RHO-CD-896)

B.2 MEETING #2

MEETING MINUTES

SUBJECT: Tank SX-110 Leak Assessment Meeting #2 Minutes				
TO:	BUILDING	3:		
Distribution	2750E/A-2	229		
FROM:	CHAIRMA	AN:		
D. J. Washenfelder	Same			
DEPARTMENT-OPERATION-COMPONENT	AREA	SHIFT	DATE OF MEETING	NUMBER ATTENDING
Engineering - Technical Integration	200-E		09/28/2009	9

Distribution:

D. A. Barnes+*

D. G. Baide

M. V. Berriochoa

J. W. Ficklin+*

J. G. Field+*

M. A. Fish+*

D. G. Harlow+*

K. J. Hull

J. M. Johnson* (ORP)

R. W. Lober* (ORP)

E. C. Shallman+*

Attendees*

Team Members+

Background:

The 1,000,000 gallon tank 241-SX-110 (tank SX-110) located in 200 West area was built between 1953 and 1954 and is the first tank in a cascade series of three tanks including tank 241-SX-111 and tank 241-SX-112. Tank SX-110 has three laterals installed about 10 ft under the tank and eight drywells located around the tank.

Tank SX-110 received Reduction Oxidation (REDOX) waste and then condensate from 241-SX-106 from the second quarter of 1960 until the first quarter 1964. Boiling conditions existed from March, 1961 to December, 1964. Supernatant was transferred to 241-SX-103 in the first and second quarter 1965 leaving a heel of 114,000 gallons of waste and the tank was held as a spare. The vapor header condensate slowly drained into tank SX-110 resulting in a waste volume of 192,400 gallons by November, 1965. This volume of waste precluded holding the tank as a spare and it was returned to normal service November, 1965.

Tank SX-110 received REDOX waste again in the fourth quarter 1965 and periodically through the first quarter of 1969 including REDOX supernatant from other 241-SX Farm tanks and reached 932,000 gallons of waste. Boiling conditions were experienced during this period from November, 1965 to June, 1968.

Supernatant was transferred to tank SX-102 in the second and third quarter of 1971. Tank SX-110 then received ion exchange waste from 221-B Plant. Supernatant was then transferred to tank S-110 in the third quarter of 1974. From the fourth quarter of 1975 through the second quarter of 1976 tank SX-110 received 221-B Plant, ITS waste, and miscellaneous supernatant waste.

The tank SX-110 liquid level decreased 0.75 inches in seven days which exceeded the action criteria of 0.50 inches in a seven day period and Occurrence Report (OR) 76-91was issued on June 29, 1976. The OR reported that the tank was considered to be sound. Stating that dry well and lateral radiation readings were stable during the review period. The OR further stated the following:

"A June 14, 1976, psychrometric analysis indicating a 0.30 inch per week evaporation rate. The evaporation rate analyzed June 30 indicates a loss of 0.15 inches per week. Using only the lower evaporation rate, the cumulative liquid level decrease would still be accounted for."

There is an obvious error in the above statement contained in the OR. If the evaporation rates are actually weekly rates neither would cover the liquid level loss of 0.75 inches in seven days. The word cumulative offers a clue that the weekly evaporation rates may actually be daily. The weekly evaporation rates were stated twice in different sections of the OR. Further review of the OR evaporation rates for this period is required.

The Richland Operations Office (RL) responded on July 21, 1976 with the following:

"RL acknowledges ARHCO's technical assessment of the surveillance data and technical opinion that the subject tank is sound. However, it is our judgment that the tank should be removed from service due to questionable integrity. This decision is based on the fact that ARHCO's long-range tank use projection does not indicate a continued need for this tank, which obviously does not justify risking continued use with an apparent unexplained liquid level loss over the past two months in excess of one inch."

Tank SX-110 was pumped to minimum heel July 23, 1976, removed from service, and identified as a questionable integrity tank. Tank SX-110 was connected to the 241-SX Farm sludge cooler and the supernatant and interstitial liquid was allowed to evaporate. Photographs taken July 26, 1977 indicated that the waste surface was 99% dry. Based on these photographs the tank was declared interim stabilized August 31, 1979.

Tank SX-110 is currently estimated to contain 49,000 gallons of sludge and 7,000 gallons of saltcake (HNF-EP-0182 Rev 238). Additionally, 16 plastic tubes which hold a total of 113 grams of natural uranium, 52 grams depleted uranium, 6 grams enriched uranium, and 204 grams of plutonium were added to tank SX-110 sometime before 1977 (RHO-CD-756 page 5). The plastic tubes are reported to be 3-inch diameter by 54 inches long (IDMS Accession #D194042886 page 50).

1980 Assessment

An independent panel was convened to review the integrity of tank SX-110 in 1980 (RHO-CD-896). This panel was comprised of representatives from Tank Farm Surveillance Group, Tank Farm Process Control Group, Effluent Controls Group, and the Chief Scientist. The panel was tasked with reviewing tanks that had

been classified as of questionable integrity to determine whether these tanks should be reclassified as confirmed leakers. This panel was <u>not</u> chartered to reclassify tanks as being sound integrity.

Consistent with the rules established, the RHO tank integrity assessment panel recommended that tank SX-110 continue to be classified as of questionable integrity, since at the 95% confidence level there was insufficient information to warrant reclassification of this tank as a confirmed leaker.

2009 SX Farm RPP-32681 Evaluation

Tank SX-110 was one of several 241-SX tank farm tanks that were selected for review using RPP-32681, 2007, *Process to Estimate Tank Farm Vadose Zone Inventories*. This process provides for re-assessment of tank leak estimates and update of single-shell tank leak and unplanned releases volumes and inventory estimates as emergent field data is obtained. The resulting re-assessment for Tank SX-104 in RPP-ENV-39658 Rev 0, Draft, 2008, *Hanford SX-Farm Leak Assessments Report*, generated the following conclusion:

"Tank SX-110 was removed from service and identified as a potential leaker in July 1976 as a result of an apparent unexplained liquid level decline of ~0.75-inches. Based on the lack of drywell and lateral radiation readings, along with no evidence of corrosion of the steel liner, the assessment team concluded that a tank leak is unlikely and no leak inventory is assigned."

Discussion:

The conclusion for tank SX-110 stated RPP-ENV-39658 provided the basis for evaluation of a potential change in the tank SX-110 leak status from an "assumed leaker" to "sound" as provided in TFC-ENG-CHEM-D-42, Rev. B-2, *Tank Leak Assessment Process*. A tank SX-110 Leak Assessment Team was assembled and is proceeding with the evaluation of the tank using the Tank Leak Assessment Process.

The information on the presentation slides (attached) was discussed in the meeting. The following actions came out of the discussions and further review of existing documentation.

Team Member Actions Status:

Leak assessment actions from the tank SX-110 September 28th Leak Assessment Team meeting are listed below:

	Member	Action		
1.	E. C. Shallman	Understand and provide LL pumping and OR history for 1974-1976. (Check Welty, Brevick, Anderson for surface level references). Track down anomalous transfer data and timing (e.g. OR 75-118 states depression formation but tank would have had to have been pumped dry for this to form.) Post 1-1-1980 data. Status:		
2.	D. A. Barnes	Provide available waste temperature data post-1968 (possible source: Nancy Scott-Proctor). Status: Three cartons of archived liquid level and temperature records have been identified. These are located at the Seattle Federal Repository and will be requested for use.		

3.	D.A. Barnes	Compare SX-107 and SX-110 laterals. Jennie Reynolds can prepare plots from the raw data. Status:
4.	J. G. Field	Review how many drywells show up contaminated on nearby SX Farm Leakers. Look at pattern for drywells around SX-110 (possible interpretive source - Stoller/GJO reports). Status: Complete
5.	D. J. Washenfelder	Verify air lift circulator air flow. Status: Complete Verify air lift circulator air flow per Tank SX-110 Leak Assessment Meeting #1 Minutes During the tank 241-SX-110 formal leak assessment kick-off meeting on September 21, 2009, the introductory briefing described that tank as containing four air lift circulators rated at an air flow of five cubic feet per minute (cfm). If all four air lift circulators were operating the maximum volume of air discharged, and the maximum volume of liquid waste that could be displaced would have been about 30 gallons per minute. In a one million gallon tank, it is difficult to conclude that 30 gallons per minute mixing would prevent steam bumps, the intended function of the air lift circulators. Although this parameter is unlikely to have any material effect on the leak assessment outcome, an action was taken to review the historical documentation to verify the air lift circulator air flow. A note on drawing H-2-39951 Sheet 1 Rev. 3 Arrangement Air-Lift Circulators (IDMS # D9082557) shows that tanks 241-SX-107 through 241-SX-115 were each retrofitted with four air lift circulators. Installation was completed in 1956 per the as-built date. Drawing H-2-39952 Sheet 1 Rev. 3 (IDMS # D9082563) Air Lift Circulators Plot Plan & Outside Lines shows that tank 241-SX-105 was retrofitted with air lift circulators in 1966. Tank 241-SX-101 was equipped with a waste-self concentrator that included a ½-inch sparge line according to H-2-39599 Sheet 1 Rev. 1 (IDMS # D9080408) 241-SX Waste Self-Concentrator Test Facility. Drawing H-2-73218 (IDMS # DA07218723) Piping Waste Tank Isolation 241-SX-101 indicates that an air lift circulator was installed in Riser 5, near the waste self-concentrator. It is believed that tank SX-104 also was equipped with air lift circulators, but no record could be recovered from IDMS. Isolation drawing H-2-73221 Sheet 1 Rev. 4 Piping Waste Tank Isolation 241-SX-104 does not identify any air lift circulator installations. The airflow rate through the air lift c

		1965 and August 28, 1965, 3, 4, 3, 4, 4, and 4 air lift circulators were operating at 10 cfm in tanks 241-SX-107, -SX-108, -SX-109, -SX-111, -SX-112, and – SX-114, respectively. The construction specification that equipped tanks SX-107 – SX-115 with the air lift circulators, HWS-5853, Construction Specifications for Circulator Facilities Additional Waste Storage Facilities 241-SX Phase II Project CA-539 Project Revision 7 (IDMS #D197217721) required that the air lift circulator system be equipped with two single-stage, positive displacement, water-cooled rotary compressors, each rated at 220 cfm at 14.4 psia (p. 28). Thus a total airflow of 440 cfm was available to the air lift circulators. The maximum number of air lift circulators operating in the farm was somewhere between 40 (four each in tanks SX-105 and tanks SX-107 – SX-115) and 46, assuming the previous 40 plus the equivalent of two air lift circulators deployed in tank SX-101 (the self-concentrator air sparge on drawing H-2-39599 and the air lift circulator referenced on isolation drawing H-2-73218) and four air lift circulators were deployed in tank SX-104. The two rotary air compressors together supplied 440 cfm of air, so the maximum airflow per air lift circulator would have been in the range of 9.8 cfm (46 equivalent air lift circulators operating) to 11 cfm (40 air lift circulators operated simultaneously. For example in the weekly report cited above, only 22 of the 40 air lift circulators in tanks sx-107 – SX-115 were begin operated during the August 22 – August 28, 1965 period. And they were reported as all operating at 10 cfm. Thus the 5 cfm airflow rate reported for the tank SX-110 in the leak assessment kickoff briefing is entirely plausible.
6.	M.A. Fish	Check air supply configuration for SX-110 on the sludge cooler. Status:
7.	J. G. Field	Review pipeline leak implications OR 75-145.
<u> </u>		Status: Poving OP 76 01 eveneration rates
8.	D. G. Harlow	Review OR 76-91 evaporation rates. Status:

References:

Briefings:

Date	Title

Correspondence - Emails:				
Date	Title			
Correspondence - Letters:				
Number	Title			
_				
Documents:	m 1			
Number	Title Carrier			
· · · · · · · · · · · · · · · · · · ·	se Zone Characterization Project at the Hanford Tank Farms SX Tank Farm			
1	tment of Energy, Grand Junction Office, Grand Junction, Colorado.			
	ta\HLANPlan\Geophysical_Logs\index.html			
	se Zone Characterization Project at the Hanford Tank Farms Addendum to the			
	t," U. S. Department of Energy, Grand Junction Office, Grand Junction,			
	data\Sitedata\HLANPlan\Geophysical_Logs\index.html			
	one Characterization Project at the Hanford Tank Farms Tank Summary Data			
-	110," U. S. Department of Energy, Grand Junction Office, Grand Junction,			
	data\Sitedata\HLANPlan\Geophysical_Logs\index.html			
Richland, Washington.	974, "Decrease of Liquid Level in Tank 110-SX, Atlantic Richfield Hanford Company, (IDMS Accession # D194052942)			
Occurrence Report 75-04, 1975, "Increasing Dry Well Radiation Levels Between Waste Tanks 110-SX and 111-				
SX," Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # D194052957)				
Richland, Washington.	975, "Liquid Level Increase in Tank 110-SX," Atlantic Richfield Hanford Company, (IDMS Accession # N/A)			
	975, "Possible Leakage from an Encased Pipeline," Atlantic Richfield Hanford ashington. (IDMS Accession # D1940053029)			
Occurrence Report 76-91, 19	Occurrence Report 76-91, 1976, "Liquid Level Decrease Exceeding Criteria for Tank 110-SX," Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # N/A)			
RHO-CD-756, 1979, "Evaluation of Special Tanks 101-BX, 111-S, 107-SX, and 110-SX," Rockwell Hanford Operations, Richland, Washington. (IDMS Accession # D194023422)				
RHO-CD-896, 1980. "Review of Classification of Nine Single-Shell "Questionable Integrity" Tanks." Rockwell Hanford Operations, Richland, Washington. (IDMS Accession # D8434517)				
RPP-ENV-39658 Rev. 0 (Draft), "Hanford SX-Farm Leak Assessment Report," Washington River Protection Solutions, LLC, Richland, Washington. (IDMS Accession # N/A)				
RPP-RPT-27605 Rev. 0, 2006, "Gamma Surveys of the Single-Shell Tank Laterals for A and SX Tank Farms,"				
CH2M HILL Hanford Group, Inc., Richland, Washington. (IDMS Accession # NA01745043)				
Drawings:				
Number	Title			
i e				

B3. MEETING #3

MEETING MINUTES

SUBJECT: Tank SX-110 Leak Assessment Meeting #3 Minutes				
TO:	BUILDING	3:		
Distribution	2750E/A-2	229		
FROM:	CHAIRMAN:			
D. J. Washenfelder	Same			
DEPARTMENT-OPERATION-COMPONENT	AREA	SHIFT	DATE OF MEETING	NUMBER ATTENDING
Engineering - Technical Integration	200-E		11/02/2009	6

Distribution:

D. A. Barnes+*

D. G. Baide

M. V. Berriochoa

J. W. Ficklin+

J. G. Field+*

M. A. Fish+*

K. J. Hull

J. M. Johnson* (ORP)

R. W. Lober (ORP)

E. C. Shallman+*

Attendees*

Team Members+

Occurrence Reports:

Two of the five tank SX-110 occurrence reports – 74-132 and 76-91 – document manual tape surface level decreases that exceeded the decrease criterion of -0.5-in/week. In September, 1974, the surface level decreased 1-in over three days, and an additional 1-in in three days after the tank ventilation was moved from the low flow 241-SX ventilation system to the high flow 241-SX sludge cooler. Psychrometric measurements accounted for a portion of the decrease – up to 1.4-in per week

In June, 1976, the surface level decreased 0.75-in in seven days. Two psychrometric analyses – one performed two weeks before the drop, and the second immediately afterwards – calculated evaporative loss rates of 0.30-in/week and 0.15-in/week respectively. The final 76-91 Occurrence Report described erratic surface level readings during on June 30, 1976, that ranged from 125.25-in to 127.75-in, a range of 0.75-in. The occurrence resulted from using the lowest value, 125.25-in in calculating the surface level drop. The report did not note that the range of the three readings itself would have resulted in a decrease criterion violation.

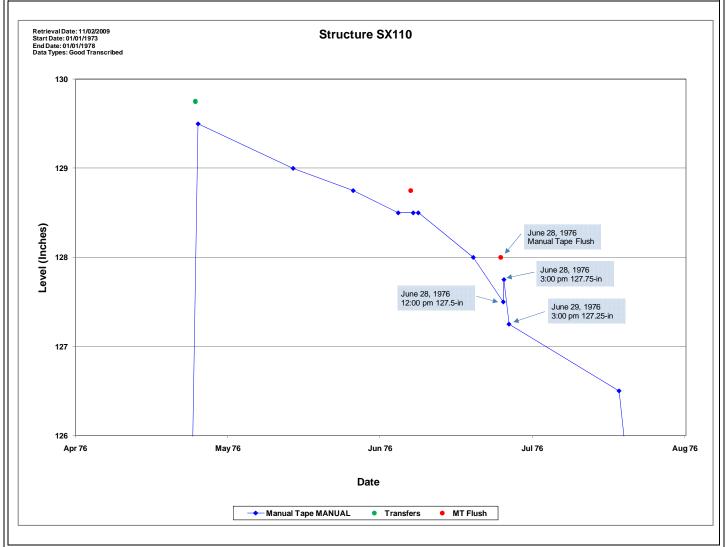
It is probable that characteristics of the waste and the waste surface were affecting the surface level measurements. We know this because of a third occurrence report, 75-145, reporting an irreconcilable material balance discrepancy in December, 1975 following a transfer into tank SX-110 from tank B-103. The material balance discrepancy was reported to range between 300 and 3,000 gallons, in itself puzzling, because the material balance discrepancy is usually stated as a single value. Pressure testing of the transfer route, and swab readings of the route encasement confirmed that the lines were sound. It is likely that erratic surface level readings had compromised the material balance calculation.

Erratic manual tape surface level readings may have been a chronic problem in tank SX-110. Examination of manual tape record during the April – July, 1976 covering the period when Occurrence Report 76-91 was filed shows that the manual tape was flushed on June 10, 1976, and again on June 28, 1976. A short interval between flushes suggests that either the surface beneath the manual tape was not conductive, or that it was highly irregular. Either condition would result in erratic surface level readings, for example, the 0.75-in spread among the three surface level readings recorded on June 30, 1976.

Figure XX-XX illustrates that the June 28, 1976 flush somehow changed the waste surface characteristics. On June 28 the surface level was recorded as 127.5-in at 12:00 pm before the manual tape was flushed. After the manual tape was flushed, the surface level was recorded at 3:00 pm, and had increased 0.25-in to 127.75-in. This increase suggests that a small elevated pool had been formed and filled during the flush, corroborating the speculation of an irregular surface. The following afternoon, June 29, 1976 at 3:00 pm when the surface level was read again, 127.25-in was recorded, a decrease of 0.50-in. The manual tape flush water had dispersed through the waste by this time, probably dissolving saltcake as it moved downward. The water and material loss created a depression in the surface underneath the manual tape that was about 0.25-in deep. The depression had not been there the day before.

Figure XX-XX also illustrates that the rate of surface level decrease in the tank was high variable suggesting the waste characteristics rather than a steady tank leak were affecting the surface level readings.

Figure XX-XX. Tank SX-110 Surface Level April – July, 1976. The manual tape was flushed on June 10, 1976, and again on June 28, 1976. The June 28, 1976 flush caused the surface level reading to increase by 0.25-in suggesting that a small elevated pool had been formed and filled during the flush. The following day, a decrease of 0.50-in was recorded. By this time the flush water had dispersed, probably dissolving saltcake as it moved downward. The water and material loss created a depression in the surface underneath the manual tape. The rate of surface level decrease during the period shown was 1.08-in/month (0.27-in/week).



Team Member Actions Status:

Leak assessment actions from the tank SX-110 November 2, 2009 Leak Assessment Team meeting are listed below:

	Member	Action
1.	D. A. Barnes	Send out tank SX-110 1970's surface level data that are now available on PCSACS, including the manual tape flush information for the period covered by Occurrence Report 76-91. Status: Complete. A portion of the data covering the April – August, 1976 time frame, and illustrating the effect of the manual tape flushes is provided in the text above.
2.	D. A. Barnes	Review logs for drywells 41-10-08 and 41-11-03 discussed in OR 75-04 and the tank SX-111 laterals. If the plume that affected the drywells was from tank SX-111 as the OR concluded, the laterals beneath the tank SX-111 should show evidence of soil contamination <i>Status</i> :

Leak assessment actions from the tank SX-110 September 28th Leak Assessment Team meeting are listed below:

	Member	Action
1.	E. C. Shallman	Understand and provide LL pumping and OR history for 1974-1976. (Check Welty, Brevick, Anderson for surface level references). Track down anomalous transfer data and timing (e.g. OR 75-118 states depression formation but tank would have had to have been pumped dry for this to form.) Post 1-1-1980 data. Status:
2.	D. A. Barnes	Provide available waste temperature data post-1968 (possible source: Nancy Scott-Proctor). Status: Three cartons of archived liquid level and temperature records have been identified. These are located at the Seattle Federal Repository and will be requested for use.
3.	D.A. Barnes	Compare SX-107 and SX-110 laterals. Jennie Reynolds can prepare plots from the raw data. Status: Complete. Available in document RPP-RPT-27605 Gamma Surveys of the Single-Shell Tank Laterals for A and SX Tank Farms.
4.	J. G. Field	Review how many drywells show up contaminated on nearby SX Farm Leakers. Look at pattern for drywells around SX-110 (possible interpretive source - Stoller/GJO reports). Status: Complete
5.	D. J. Washenfelder	Verify air lift circulator air flow. Status: Complete During the tank 241-SX-110 formal leak assessment kick-off meeting on September 21, 2009, the introductory briefing described that tank as containing four air lift circulators rated at an air flow of five cubic feet per minute (cfm). If all four air lift circulators were operating the maximum volume of air discharged, and the maximum volume of liquid waste that could be displaced

would have been about 30 gallons per minute. In a one million gallon tank, it is difficult to conclude that 30 gallons per minute mixing would prevent steam bumps, the intended function of the air lift circulators. Although this parameter is unlikely to have any material effect on the leak assessment outcome, an action was taken to review the historical documentation to verify the air lift circulator air flow.

A note on drawing H-2-39951 Sheet 1 Rev. 3 Arrangement Air-Lift Circulators (IDMS # D9082557) shows that tanks 241-SX-107 through 241-SX-115 were each retrofitted with four air lift circulators. Installation was completed in 1956 per the as-built date. Drawing H-2-39952 Sheet 1 Rev. 3 (IDMS # D9082563) Air Lift Circulators Plot Plan & Outside Lines shows that tank 241-SX-105 was retrofitted with air lift circulators in 1966.

Tank 241-SX-101 was equipped with a waste-self concentrator that included a ½-inch sparge line according to H-2-39599 Sheet 1 Rev. 1 (IDMS # D9080408) 241-SX Waste Self-Concentrator Test Facility. Drawing H-2-73218 (IDMS # DA07218723) Piping Waste Tank Isolation 241-SX-101 indicates that an air lift circulator was installed in Riser 5, near the waste self-concentrator.

It is believed that tank SX-104 also was equipped with air lift circulators, but no record could be recovered from IDMS. Isolation drawing H-2-73221 Sheet 1 Rev. 4 Piping Waste Tank Isolation 241-SX-104 does not identify any air lift circulator installations.

The airflow rate through the air lift circulators was report as 10 cfm per circulator in RL-SEP-297 (IDMS # D2707918) REDOX Weekly Process Reports January through December, 1965. For example, between August 22, 1965 and August 28, 1965, 3, 4, 3, 4, 4, and 4 air lift circulators were operating at 10 cfm in tanks 241-SX-107, -SX-108, -SX-109, -SX-111, -SX-112, and -SX-114, respectively.

The construction specification that equipped tanks SX-107 – SX-115 with the air lift circulators, HWS-5853, Construction Specifications for Circulator Facilities Additional Waste Storage Facilities 241-SX Phase II Project CA-539 Project Revision 7 (IDMS #D197217721) required that the air lift circulator system be equipped with two single-stage, positive displacement, water-cooled rotary compressors, each rated at 220 cfm at 14.4 psia (p. 28). Thus a total airflow of 440 cfm was available to the air lift circulators.

The maximum number of air lift circulators operating in the farm was somewhere between 40 (four each in tanks SX-105 and tanks SX-107 – SX-115) and 46, assuming the previous 40 plus the equivalent of two air lift circulators deployed in tank SX-101 (the self-concentrator air sparge on drawing H-2-39599 and the air lift circulator referenced on isolation drawing H-2-73218) and four air lift circulators were deployed in tank SX-104. The two rotary air

		compressors together supplied 440 cfm of air, so the maximum airflow per air		
		lift circulator would have been in the range of 9.8 cfm (46 equivalent air lift		
		circulators operating) to 11 cfm (40 air lift circulators operating).		
	MA Ell	Based on the REDOX Weekly Reports, not all of the air lift circulators operated simultaneously. For example in the weekly report cited above, only 22 of the 40 air lift circulators in tanks sx-107 – SX-115 were begin operated during the August 22 – August 28, 1965 period. And they were reported as all operating at 10 cfm. Thus the 5 cfm airflow rate reported for the tank SX-110 in the leak assessment kickoff briefing is entirely plausible. Check air supply configuration for SX-110 on the sludge cooler.		
6.	M.A. Fish	Status:		
7.	Review pipeline leak implications OR 75-145. Status: The material balance discrepancy of 300 – 3,000 gallons for the 103 to tank SX-110 transfer was never reconciled. Pressure testing of transfer route, and swab riser samples failed to turn up an indication This substantiates the opinion that surface level measurements in tank were erratic, and affected by waste surface irregularities and/or waste conductivity.			
	• D. G.	Review OR 76-91 evaporation rates.		
	Harlow	• Status:		
Brief	rences: ings:			
	Date	Title		
Corr	espondence - Emails			
	Date	Title		
Corr	espondence - Letters	:		
	Number	Title		

Documents:				
Number	Title			
GJPO-HAN-4, 1996, "Vadose Zone Characterization Project at the Hanford Tank Farms SX Tank Farm				
Report," U. S. Depart	Report," U. S. Department of Energy, Grand Junction Office, Grand Junction, Colorado.			
\\hanford\data\Sitedat	\\hanford\data\Sitedata\HLANPlan\Geophysical_Logs\index.html			
GJPO-HAN-4, 2000, "Vados	se Zone Characterization Project at the Hanford Tank Farms Addendum to the			
SX Tank Farm Repor	t," U. S. Department of Energy, Grand Junction Office, Grand Junction,			
Colorado. \\hanford\\	data\Sitedata\HLANPlan\Geophysical_Logs\index.html			
GJPO-HAN-12,, "Vadose Z	one Characterization Project at the Hanford Tank Farms Tank Summary Data			
Report for Tank SX-1	10," U. S. Department of Energy, Grand Junction Office, Grand Junction,			
Colorado. \\hanford\\	data\Sitedata\HLANPlan\Geophysical_Logs\index.html			
Occurrence Report 74-132, 19	974, "Decrease of Liquid Level in Tank 110-SX, Atlantic Richfield Hanford Company,			
	(IDMS Accession # D194052942)			
	75, "Increasing Dry Well Radiation Levels Between Waste Tanks 110-SX and 111-			
	Hanford Company, Richland, Washington. (IDMS Accession # D194052957)			
	975, "Liquid Level Increase in Tank 110-SX," Atlantic Richfield Hanford Company,			
<u> </u>	(IDMS Accession # N/A)			
Occurrence Report 75-145, 1975, "Possible Leakage from an Encased Pipeline," Atlantic Richfield Hanford				
Company, Richland, Washington. (IDMS Accession # D1940053029)				
Occurrence Report 76-91, 1976, "Liquid Level Decrease Exceeding Criteria for Tank 110-SX," Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # N/A)				
RHO-CD-756, 1979, "Evalua	tion of Special Tanks 101-BX, 111-S, 107-SX, and 110-SX," Rockwell Hanford			
Operations, Richland, Washington. (IDMS Accession # D194023422)				
RHO-CD-896, 1980. "Review of Classification of Nine Single-Shell "Questionable Integrity" Tanks." Rockwell				
Hanford Operations, Richland, Washington. (IDMS Accession # D8434517)				
RPP-ENV-39658 Rev. 0 (Draft), "Hanford SX-Farm Leak Assessment Report," Washington River Protection				
Solutions, LLC, Richland, Washington. (IDMS Accession # N/A)				
RPP-RPT-27605 Rev. 0, 2006, "Gamma Surveys of the Single-Shell Tank Laterals for A and SX Tank Farms,"				
CH2M HILL Hanford Group, Inc., Richland, Washington. (IDMS Accession # NA01745043)				
Drawings:				
Number	Title			

B4. MEETING #4

MEETING MINUTES

SUBJECT: Tank SX-110 Leak Assessment Meeting #4 Minutes				
TO:	BUILDING	3:		
Distribution	2750E/A-2	229		
FROM:	CHAIRMAN:			
D. J. Washenfelder	Same			
DEPARTMENT-OPERATION-COMPONENT	AREA	SHIFT	DATE OF MEETING	NUMBER ATTENDING
Engineering - Technical Integration	200-E		11/02/2009	5

Distribution:

D. A. Barnes+*

D. G. Baide

M. V. Berriochoa

J. W. Ficklin+*

J. G. Field+*

M. A. Fish+

K. J. Hull

J. M. Johnson* (ORP)

R. W. Lober (ORP)

E. C. Shallman+

Attendees*

Team Members+

Further Interpretation of June 28 – 29, 1976 Surface Level Behavior:

As a follow-up to Meeting #3's interpretation of the surface level measurement fluctuation that occurred before and after a flush of the manual tape June 28 – 29, 1976, in-tank photographs and waste transfers made during the period were reviewed. The interpretation was based on the assumption that the manual tape was contacting a solid waste surface at the time of the flush. In-tank photographs show that that scenario was assumption was not correct:

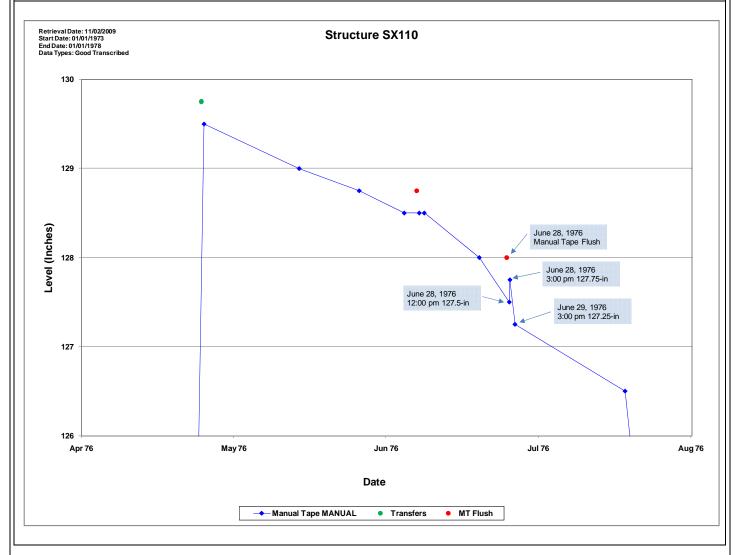
On April 2, 1976, a photo mission reported the surface level as 3-ft – 4-in; the manual tape is seen over a shallow pool. Beginning about April 11, 1976, about a week after the photo mission, waste was again transferred into tank SX-110 from tanks B-103 and BX-103, filling the tank to 10-ft – 9-in. Tank SX-110 was again pumped to a reported minimum heel of 3-ft – 3-in on July 23, 1976; additional pumping during August, 1976 further reduced the heel to ~ 2-ft – 5-in (*RHO-CD-896 p. 55 [D8434517]; WHC-MR-0132 p. 110-SX-5 [D196015712]*).

So during the June 28-29, 1976 flush and surface level measurement fluctuation, the manual tape plummet would have been in contact with a liquid, rather than a solid surface. Last meeting's interpretation of the manual tape's behavior assumed the plummet was contacting a solid surface, and needs to be reconsidered (see

accompanying Figure 4-1, and photographs).

Figure 4-1 illustrates that the June 28, 1976 flush somehow changed the waste surface measurement. On June 28, the surface level was recorded as 127.5-in at 12:00 pm before the manual tape was flushed. After the manual tape was flushed, the surface level was recorded at 3:00 pm, and had increased 0.25-in to 127.75-in. Since the manual tape was contacting a liquid surface, a post-flush level surface level measurement increase would not be expected. Discussion during the meeting did not identify a reason for the increase based on the team's understanding of the waste condition at the time of the flush.

Figure 4-1. Tank SX-110 Surface Level April – July, 1976. The manual tape was flushed on June 10, 1976, and again on June 28, 1976. The June 28, 1976 flush caused the surface level reading to increase by 0.25-in which would not be expected since the manual tape was contacting a liquid surface. The following day, a decrease of 0.50-in was recorded. The decrease could represent the dissolution of a small salt 'icicle' adhering to the bottom of the manual tape plummet. In-tank photos from the period lack sufficient detail to confirm this explanation. The rate of surface level decrease during the period shown was 1.08-in/month (0.27-in/week).



The afternoon following the flush, June 29, 1976 at 3:00 pm, the surface level was read again, and 127.25-in was recorded, a decrease of 0.50-in. The decrease could have resulted from dissolution of an conductive salt icicle hanging on the manual tape plummet; elimination of the icicle would have caused the manual tape to be lowered further into the tank until contact between the plummet and the liquid was obtained. In-tank photos from the period lack sufficient detail to confirm this explanation.

Figure 4-1 also illustrates that the rate of surface level decrease in the tank was high variable suggesting the waste characteristics rather than a steady tank leak were affecting the surface level readings. It is possible that operation of one or more of the four air lift circulators in the tank was affecting the surface level readings (Drawing H-2-39951 *Arrangement Air-Lift Circulators*).

Figure 4-2 shows the waste surface condition on June 12, 1974, about two years before the manual tape flush. The waste surface seems to be covered with small islands of semi-submerged solids; in the background wave depressions caused by the air lift circulators are observable.

Figure 4-2. Tank SX-110 Surface Level June 12, 1974. This photo, taken with \sim 312-in of liquid over the solids, shows what appear to be small islands of semi-submerged solids. Surface chop from air lift circulator operation is apparent in the upper portion of the photograph (743876-21cn June 12, 1974 Surface Level = 29-ft – 4.125-in).



Figure 4-3 from the same photo mission shows considerable surface chop created by one of the air lift circulators.

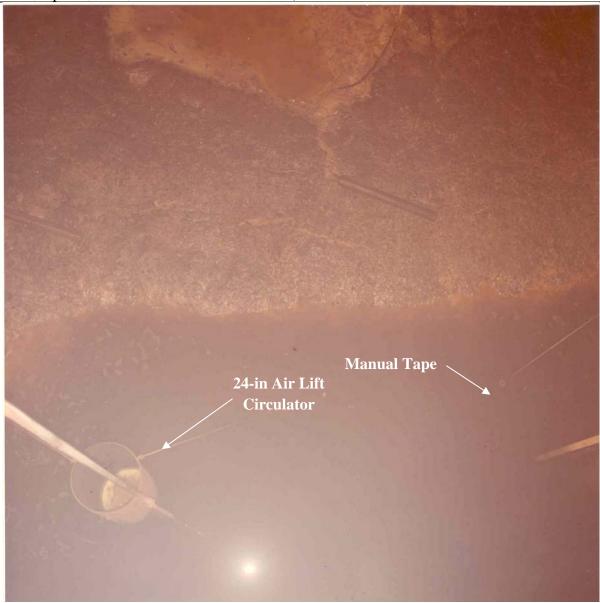
Figure 4-3. Surface Turbulence from Air Lift Circulator Operation. Surface level chop created by air lift circulator operation would have affected the measurement precision of the manual tape (743876-13cn, June 12, 1974, Surface Level 29-ft - 4.125-in).



The third photograph taken April 2, 1976 shows when the surface level was at 3-ft – 4-in shows that one of the air lift circulators was located close to the manual tape. The air lift circulator barrel was 24-in Schedule 20 carbon steel pipe (Drawing H-2-39950 *Details Air-Lift Circulator*). Scaling the photograph indicates that the air lift circulator was located within about 10 - 11-ft of the manual tape. When the tank was filled with waste

and the air lift circulator was operating it is easy to imagine that continually displaced liquid could have affected surface level measurements.

Figure 4-4. Relative Positions of Air Lift Circulator and Manual Tape. This photograph illustrates the position of one of the four tank SX-110 air lift circulators with respect to the manual tape. The separation distance is $\sim 10 - 11$ -ft. When the tank was filled with waste and the air lift circulator was operating it is easy to imagine how the continually displaced liquid could have affected surface level measurements (763161-5cn, April 2, 1976, Surface Level 3-ft - 4-in).



Impact of Air Lift Circulator Operation on Surface Level Measurement

The influence of air lift circulator operation on surface level measurements was evaluated by comparing the standard deviation of ENRAF measurements made in tank AW-102 with and without the 16-in and 24-in air lift circulators operating. Impact on surface level measurement reproducibility is illustrated in the following

table.

Table 4-1. Influence of Air Lift Circulator Operation on Surface Level Measurement				
Reproducibility – Tank AW-102				
Configuration	Standard	Measurement Precision Decrease		
Configuration	Deviation	from Air Lift Circulator Operating		
No Air Lift Circulator Operating	<u>+</u> 0.005-in			
16-in Air Lift Circulator	+ 0.200-in	40X		
Operating	<u>+</u> 0.200-III			
16-in and 24-in Air Lift	<u>+</u> 0.038-in	7.6X		
Circulators Operating				

With both air lift circulators operating in tank AW-102 the standard deviation of the ENRAF measurement is 7.6 times greater than if the air lift circulators are shut off. Operating the 16-in circulator alone results in a greater standard deviation suggesting that the placement geometry of the air lift circulators with respect to the surface level measurement device plays a significant role in measurement precision, as well as the possibility that measurements are affected by the liquid volume held in the tank. The manual tape in tank SX-110 would have been similarly affected depending on the separation distance between the air lift circulator and the manual tape. Trended data should not be affected to the extent of individual data by air lift circulator operation however.

Were Air Lift Circulators Operating During June, 1976?

There are no recoverable tank SX-110 air lift circulator operating data available for the 1976 time period. However, records of 241-SX tank air lift circulator operating data exist in the REDOX Weekly Process Reports for the years 1965 and 1966. These reports indicate that air lift circulators were operated as standard practice whenever the tank sludge temperature $\geq \sim 200^{\circ} \text{F}$, the supernatant temperature $\geq \sim 195^{\circ} \text{F}$, or if the supernatant temperature gradient between the thermocouple located 2-ft above the tank bottom and the highest immersed thermocouple in the tank was $> 0^{\circ} \text{F}$ (HW-80202 *REDOX Weekly Process Reports January through December 1964*; RL SEP 297 *REDOX Weekly Process Reports January through December 1965*).

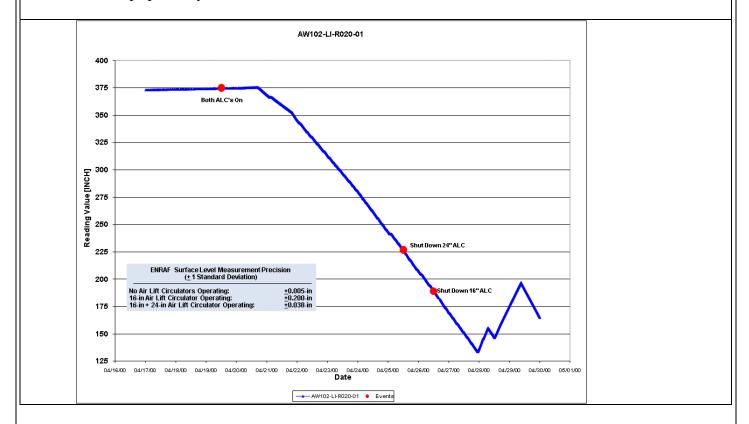
Tanks SX-107 – SX-115 (and probably SX-105) were equipped with an eight-thermocouple cluster; the thermocouples terminated 2-ft – 0-in, 5-ft – 0-in, 8-ft – 0-in, 12-ft – 0-in, 16-ft – 0-in, 22-ft – 0-in, and 30-ft – 0-in above the tank bottom (H-2-39951 *Arrangement Air-Lift Circulators*).

The document RHO-CD-896, *Review of Classification of Nine Single-Shell "Questionable Integrity Tanks"*, reports that tank SX-110 had an estimated sludge heat generation rate of ~ 56,000 BTU/hour in 1974, with recorded sludge temperatures in the range of 180 – 210°F (RHO-CD-896, p. 64). These sludge temperatures would have been borderline for air lift circulator operation based on review of the 1964 – 1965 REDOX process reports even without considering the supernatant temperature. During the 1964 – 1965 period, the supernatant temperature in tanks SX-105, and SX-107 – SX-115 averaged about 57°F lower than the sludge temperature. So the tank SX-110 supernatant temperature was probably in the range of 123 – 153°F, well below the minimum supernatant temperature threshold for air lift circulator operation. Liquid surface turbulence captured in the 1974 in-tank photographs (e.g., Figure 4-3) show that the air lift circulators were operating at that time, so it is possible that they were still being operated in 1976 whenever the tank was filled with enough supernatant to submerge them. This would require a waste level of at least 120-in to operate the two low air lift circulators, and 180-in to operate both the two low and two high air lift circulators (H-2-29950 *Details Air-Lift Circulator*;

H-2-39951 Arrangement Air-Lift Circulators).

Figure 4-5. Effect of Air Lift Circulator Operation on Surface Level Measurement Precision.

Photographs of the tank SX-110 surface level during air lift circulator operation shows the air lift circulators created surface chop. At least one air lift circulator was within $\sim 10-11$ -ft of the manual tape. A review of the surface level measurement effects of air lift circulator operation in tank AW-102, the 242-A Evaporator feed tank, shows that the positional relationship of the air lift circulator and surface level measurement device, as well as the depth of liquid being circulated, seem to affect the measurement precision. The same inter-relationships probably affected tank SX-110 surface level measurements too.



Drywells Surrounding Tanks SX-107 and SX-110

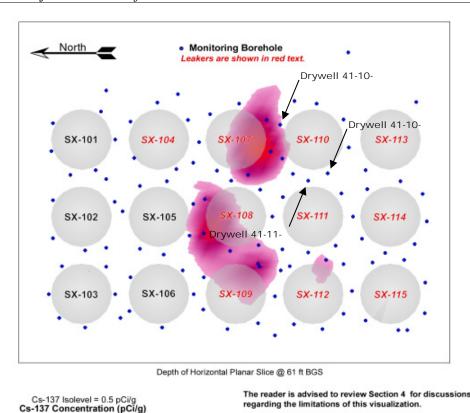
Two tank SX-110 drywells, 41-10-01 and 41-10-08, showed soil contamination during their logging history. Drywell 41-10-01 had peak count readings of ~ 300 – 400 counts/second at about 65-ft during the period between September, 1973 and July 10, 1974 (Occurrence Report 76-91 *Liquid Level Decrease Exceeding Criteria for Tank 110-SX*). The peak had decayed to near background by July 12, 1974. Low level Cs-137 was detected from 65-ft – 76-ft when the drywell was logged with the Spectral Gamma Logging System (SGLS) in June, 1995. The contamination was attributed to the drywell intercepting the edge of the plume from leaking tank SX-107 (GJ-HAN-12 *Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank SX-110*).

Soil contamination was detected around drywell 41-10-08 between September, 1975 – June, 1976 at ~ 55-ft. The contamination increased from background in July, 1974 to 328 counts/sec in November, 1974; by June, 1976, the peak had decreased to near background (Occurrence Report 76-91 *Liquid Level Decrease Exceeding Criteria for Tank 110-SX*). When the drywell was logged with the SGLS in June, 1995 there was no detectable

Cs-137 in the same soil interval. The SGLS report notes the mid-1970's peak, attributing it to short-lived Ru-106, but does not speculate on a possible contamination source (GJ-HAN-12 *Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank SX-110*).

Soil contamination was detected around drywell 41-11-03 located between tanks SX-110 and SX-111 between September, 1974 and February, 1975 at ~ 54-ft. The contamination increased from background to a peak of 144 counts/second in December, 1974, and then began to decrease to near background. The contamination was attributed to a leak from tank SX-111. Tank SX-111 had been pumped May 4 - 20, 1974 (~ four months before the contamination was detected in the drywell), after declaring it a leaker based on increased contamination detected in one of the tank's laterals; in September, 1975 it contained ~ 125 kgal of sludge and interstitial liquid (Occurrence Report 74-38, Symptoms of Leakage from an Underground Waste Tank – 111-SX; Occurrence Report 75-04, Increasing Dry Well Radiation Levels Between Waste Tanks 110-SX and 111-SX). The June, 1996 SGLS logs did not detect any contamination at the 54-ft depth; the SGLS report concluded that the radionuclide had either decayed to background or had been further dispersed (GJ-HAN-13 Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank SX-111).

Figure 4-5. 241-SX Tank Farm Contamination Plumes at 61-ft. Dry well 41-10-01 is located at the edge of the contamination plume emanating from tank SX-107 (*from GJPO-HAN-4 Vadose Zone Characterization Project at the Hanford Tank Farms Addendum to the SX Tank Farm Report Appendix E*)



10-1 100 101 102 103 104 105 106 107 108

Future Evaporation Rate Calculation

The document RHO-CD-896, *Review of Classification of Nine Single-Shell "Questionable Integrity Tanks"*, reports that tank SX-110 had an estimated sludge heat generation rate of ~ 56,000 BTU/hour in 1974, with recorded sludge temperatures in the range of 180 – 210°F (RHO-CD-896, p. 64); and speculates that increases in tank SX-110's rate of evaporation starting in April, 1974 resulted from connecting tank SX-111 to the 241-SX sludge cooler. Tanks SX-110 and SX-111 are interconnected by a four-inch cascade line (RHO-CD-896, p. 64).

Another part of the report – prepared by a different group evaluating the leak integrity of the tank – states that tank SX-110 was connected to the 241-SX sludge cooler sometime after September 24, 1974, and that a psychrometric analysis conducted shortly thereafter accounted for an evaporative loss of 1.5-in per week.

There are no temperature records available for the 1974 – 1976 period to independently calculate the evaporation rate from the tank. However, four boxes of archived 241-SX Tank Farm liquid level and temperature records from this period have been identified and ordered from the Seattle, WA National Archives Regional Repository. If the records contain relevant temperature data, it should be possible to back-calculate the HVAC airflow necessary to cause the observed evaporation rate during the period, and compare it to the known air handling capacity of the 241-SX sludge cooler.

It was decided to delay further tank SX-110 leak assessment meetings until the records are reviewed and the calculation performed.

Team Member Actions Status:

Leak assessment actions from the tank SX-110 November 6, 2009 Leak Assessment Team meeting are listed below:

	Member	Action
1.	D. A. Barnes	If surface level and temperature data for the April – July, 1976 period are received from the Seattle National Archives Regional Repository perform an evaporation analysis to determine the airflow needed for account for the observed evaporation rate. <i>Status:</i>
2.	D. J. Washenfelder	Determine if air lift circulators were operating during the April – July, 1976 period. Status: Complete. In 1974 the tank SX-110 180°F – 210°F sludge temperature reported in RHO-CD-896 was high enough to justify continuous operation of the air lift circulators based temperature thresholds determined from review of the 1964 – 1965 REDOX weekly process reports. The 1974 in-tank photographs show waste surface turbulence indicative of air lift circulator operation. It is likely that the air lift circulators were still in use in 1976, whenever the supernatant level was \geq 120-in (high enough to cover the low air lift circulators).

Leak assessment actions from the tank SX-110 November 2, 2009 Leak Assessment Team meeting are listed below:

	Member	Action
1.	D. A. Barnes	Send out tank SX-110 1970's surface level data that are now available on PCSACS, including the manual tape flush information for the period covered by Occurrence Report 76-91. Status: Complete. A portion of the data covering the April – August, 1976 time frame, and illustrating the effect of the manual tape flushes is provided in the text above.
2.	D. A. Barnes	Review logs for drywells 41-10-08 and 41-11-03 discussed in OR 75-04 and the tank SX-111 laterals. If the plume that affected the drywells was from tank SX-111 as the OR concluded, the laterals beneath the tank SX-111 should show evidence of soil contamination Status: Complete. Discussed in drywell section above.

Leak assessment actions from the tank SX-110 September 28th Leak Assessment Team meeting are listed below:

	Member	Action
	THOMBOT	Understand and provide LL pumping and OR history for 1974-1976. (Check Welty, Brevick, Anderson for surface level references).
1.	E. C. Shallman	Track down anomalous transfer data and timing (e.g. OR 75-118 states depression formation but tank would have had to have been pumped dry for this to form.) Post 1-1-1980 data.
		Status: Archived surface level and temperature records for the 1974 – 1976 period have been ordered from the Seattle National Archives Regional Repository.
2.	D. A. Barnes	Provide available waste temperature data post-1968 (possible source: Nancy Scott-Proctor).
2.		Status: Archived surface level and temperature records for the 1974 – 1976 period have been ordered from the Seattle National Archives Regional Repository.
		Compare SX-107 and SX-110 laterals. Jennie Reynolds can prepare plots from the raw
3.	D.A. Barnes	data. Status: Complete. Available in document RPP-RPT-27605 Gamma Surveys of the Single-Shell Tank Laterals for A and SX Tank Farms.
		Review how many drywells show up contaminated on nearby SX Farm Leakers.
4.	J. G. Field	Look at pattern for drywells around SX-110 (possible interpretive source - Stoller/GJO reports).
		Status: Complete. Discussed in drywell section above.
		Verify air lift circulator air flow.
5.	D. J. Washenfelder	Status: Complete. During the tank 241-SX-110 formal leak assessment kick-off meeting on September 21, 2009, the introductory briefing described that tank as containing four air lift circulators rated at an air flow of five cubic feet per minute (cfm). If all four air lift circulators were operating the maximum volume of air discharged, and the maximum volume of liquid waste that could be
		displaced would have been about 30 gallons per minute. In a one million gallon tank, it is difficult to conclude that 30 gallons per minute mixing would prevent steam bumps, the intended function of the air lift circulators. Although this parameter is unlikely to have any material effect on the leak assessment outcome, an action was taken to review the historical documentation to verify

the air lift circulator air flow.

A note on drawing H-2-39951 Sheet 1 Rev. 3 Arrangement Air-Lift Circulators (IDMS # D9082557) shows that tanks 241-SX-107 through 241-SX-115 were each retrofitted with four air lift circulators. Installation was completed in 1956 per the as-built date. Drawing H-2-39952 Sheet 1 Rev. 3 (IDMS # D9082563) Air Lift Circulators Plot Plan & Outside Lines shows that tank 241-SX-105 was retrofitted with air lift circulators in 1966.

Tank 241-SX-101 was equipped with a waste-self concentrator that included a ½-inch sparge line according to H-2-39599 Sheet 1 Rev. 1 (IDMS # D9080408) 241-SX Waste Self-Concentrator Test Facility. Drawing H-2-73218 (IDMS # DA07218723) Piping Waste Tank Isolation 241-SX-101 indicates that an air lift circulator was installed in Riser 5, near the waste self-concentrator.

It is believed that tank SX-104 also was equipped with air lift circulators, but no record could be recovered from IDMS. Isolation drawing H-2-73221 Sheet 1 Rev. 4 Piping Waste Tank Isolation 241-SX-104 does not identify any air lift circulator installations.

The airflow rate through the air lift circulators was report as 10 cfm per circulator in RL-SEP-297 (IDMS # D2707918) REDOX Weekly Process Reports January through December, 1965. For example, between August 22, 1965 and August 28, 1965, 3, 4, 3, 4, 4, and 4 air lift circulators were operating at 10 cfm in tanks 241-SX-107, -SX-108, -SX-109, -SX-111, -SX-112, and -SX-114, respectively.

The construction specification that equipped tanks SX-107 – SX-115 with the air lift circulators, HWS-5853, Construction Specifications for Circulator Facilities Additional Waste Storage Facilities 241-SX Phase II Project CA-539 Project Revision 7 (IDMS #D197217721) required that the air lift circulator system be equipped with two single-stage, positive displacement, water-cooled rotary compressors, each rated at 220 cfm at 14.4 psia (p. 28). Thus a total airflow of 440 cfm was available to the air lift circulators.

The maximum number of air lift circulators operating in the farm was somewhere between 40 (four each in tanks SX-105 and tanks SX-107 – SX-115) and 46, assuming the previous 40 plus the equivalent of two air lift circulators deployed in tank SX-101 (the self-concentrator air sparge on drawing H-2-39599 and the air lift circulator referenced on isolation drawing H-2-73218) and four air lift circulators were deployed in tank SX-104. The two rotary air compressors together supplied 440 cfm of air, so the maximum airflow per air lift circulator would have been in the range of 9.8 cfm (46 equivalent air lift circulators operating) to 11 cfm (40 air lift circulators operating).

Based on the REDOX Weekly Reports, not all of the air lift circulators operated

		simultaneously. For example in the weekly report cited above, only 22 of the 40 air lift circulators in tanks sx-107 – SX-115 were begin operated during the
		August 22 – August 28, 1965 period. And they were reported as all operating at 10 cfm. Thus the 5 cfm airflow rate reported for the tank SX-110 in the leak assessment kickoff briefing is entirely plausible.
6.	M.A. Fish	Check air supply configuration for SX-110 on the sludge cooler. Status: Complete. During the 1974 – 1976 period being reviewed tank SX-110 was ventilated via tank SX-111 to the 241-SX sludge cooler system. The two tanks were connected by an open 4-in diameter cascade line.
7.	J. G. Field	Review pipeline leak implications OR 75-145. Status: The material balance discrepancy of 300 – 3,000 gallons for the tank B-103 to tank SX-110 transfer was never reconciled. Pressure testing of the transfer route, and swab riser samples failed to turn up an indication of a leak. This substantiates the opinion that surface level measurements in tank SX-110 were erratic, and affected by waste surface irregularities and/or waste surface conductivity.
8.	D. G. Harlow	Review OR 76-91 evaporation rates. Status: Superseded by planned evaporation analysis.
Corr	respondence - Emai Date	Title
Corr	Number	Title
Docu	iments:	Title
GJF	O-HAN-4, 1996, "V Report," U. S. D	Vadose Zone Characterization Project at the Hanford Tank Farms SX Tank Farm Department of Energy, Grand Junction Office, Grand Junction, Colorado. itedata\HLANPlan\Geophysical_Logs\index.html

- GJPO-HAN-4, 2000, "Vadose Zone Characterization Project at the Hanford Tank Farms Addendum to the SX Tank Farm Report," U. S. Department of Energy, Grand Junction Office, Grand Junction, Colorado. \\hanford\data\Sitedata\HLANPlan\Geophysical_Logs\index.html
- GJPO-HAN-12, 1996, "Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank SX-110," U. S. Department of Energy, Grand Junction Office, Grand Junction, Colorado. \hanford\data\Sitedata\HLANPlan\Geophysical_Logs\index.html
- GJ-HAN-13, 1995, "Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank SX-111," U. S. Department of Energy, Grand Junction Office, Grand Junction, Colorado. \hanford\data\Sitedata\HLANPlan\Geophysical_Logs\index.html
- H-2-29950 Sh 1. Rev. 21, 1956, "Details Air-Lift Circulator," General Electric Corporation, Richland, Washington. (IDMS Accession # D9082552)
- H-2-39951 Sh. 1 Rev. 2, 1956, "Arrangement Air-Lift Circulators," General Electric Corporation, Richland, Washington. (IDMS Accession # D9082557)
- HNF-3136 Rev. 0, 1999, "Analysis and Techniques and Monitoring Results, 241-SX Dry Well Surveillance Logs," Lockheed Martin Hanford Corporation, Richland, Washington. (IDMS Accession # D8109566)
- HW-80202, 1964 [sic], "REDOX Weekly Process Reports January through December 1964," General Electric Corporation, Richland, Washington. (IDMS Accession # D8558047)
- Occurrence Report 74-38, 1974, "Symptoms of Leakage from an Underground Waste Tank 111-SX," Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # D194052926)
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- Occurrence Report 75-04, 1975, "Increasing Dry Well Radiation Levels Between Waste Tanks 110-SX and 111-SX," Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # D194052957)
- Occurrence Report 75-118, 1975, "Liquid Level Increase in Tank 110-SX," Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # N/A)
- Occurrence Report 75-145, 1975, "Possible Leakage from an Encased Pipeline," Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # D1940053029)
- Occurrence Report 76-91, 1976, "Liquid Level Decrease Exceeding Criteria for Tank 110-SX," Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # N/A)
- RHO-CD-756, 1979, "Evaluation of Special Tanks 101-BX, 111-S, 107-SX, and 110-SX," Rockwell Hanford Operations, Richland, Washington. (IDMS Accession # D194023422)
- RHO-CD-896, 1980. "Review of Classification of Nine Single-Shell "Questionable Integrity" Tanks." Rockwell Hanford Operations, Richland, Washington. (IDMS Accession # D8434517)
- RL SEP 297, 1965 [sic], "REDOX Weekly Process Reports January through December 1965," General Electric Corporation, Richland, Washington. (IDMS Accession # D2707918)
- RPP-ENV-39658 Rev. 0 (Draft), "Hanford SX-Farm Leak Assessment Report," Washington River Protection Solutions, LLC, Richland, Washington. (IDMS Accession # N/A)
- RPP-RPT-27605 Rev. 0, 2006, "Gamma Surveys of the Single-Shell Tank Laterals for A and SX Tank Farms," CH2M HILL Hanford Group, Inc., Richland, Washington. (IDMS Accession # NA01745043)

B5. MEETING #5

MEETING MINUTES

SUBJECT: Tank SX-110 Leak Assessment Meeting #5 Mi	nutes			
TO:	BUILDING	3 :		
Distribution	2750E/A-	229		
FROM:	CHAIRMA	AN:		
D. J. Washenfelder	Same			
DEPARTMENT-OPERATION-COMPONENT	AREA	SHIFT	DATE OF MEETING	NUMBER ATTENDING
Engineering - Technical Integration	200-E		6/16/2010	9

Distribution:

D. A. Barnes+*

D. G. Baide

M. V. Berriochoa

J. W. Ficklin+*

J. G. Field+*

M. A. Fish+*

Harlow+*

K. J. Hull

J. M. Johnson (ORP)

R. W. Lober (ORP)

J. E. Meacham*

G. E. Reeploeg*

E. C. Shallman+*

Attendees*

Team Members+

Meeting #5, June 16, 2010

The tank SX-110 leak assessment was resumed with the attached presentation material on June 16, 2010. The leak assessment had been postponed until the SX-110 evaporation analysis and higher priority tank C-105 leak assessment had been completed. During the meeting previous results were discussed, new information was presented, leak – non-leak hypothesis was created and expert elicitations were developed.

Information Acquired/Developed After Meeting #4

Air Lift Circulator (ALC) operating information was found in the July 12, 1976 Weekly Tank Farm Surveillance Report which indicated the tank SX-110 ALCs were found running. A notation on the July 17, 1976 temperature data sheet indicated the ALCs were turned off. ALC operation would affect the evaporation rate.

The 1975 photographs mentioned in RHO-CD-896 as revealing an apparent tank liner anomaly between the 304 and 360-in levels were examined and did not reveal any anomalies that might be attributed to a tank liner failure. This confirmed the 2008 leak assessment of the examination of 1975 black and white photographs and

1987 color photographs which did not indicate a tank liner leak.

The November 6, 2009 meeting #4 of the SX-110 Leak Assessment Team outlined actions to determine if a back calculation could determine a reasonable outlet flowrate that could account for the tank SX-110 decreasing liquid level rate. Tank temperatures were needed to perform the calculation which were received from the Seattle National Archive Regional Repository for the time period as follows:

Table 1 Tank SX-110 Temperatures

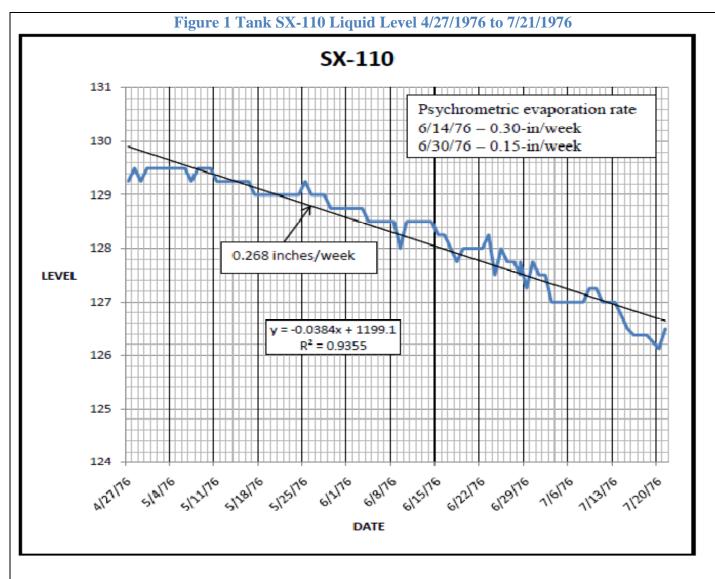
			1111 1521 1				
Thermocouple Distance	4/03/76	5/02/76	6/02/76	7/01/76	7/17/76	7/17/76	7/21/76
from Tank Bottom		Temp	Temp	Temp	Temp	Temp	Temp
(inches)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)
4	85	63	94	82	81	96	87
28	85	64	92	82	81	96	87
52	86	64	92	83	81	96	87
76	86	64	87	81	79	96	85
100	87	64	87	81	80	96	85
124	NA	64	87	81	79	96	85
148	NA	64	87	81	79	96	85
172	NA	64	87	81	79	96	85
196	NA	64	87	82	79	96	85
220	NA	64	87	81	79	96	85
244	NA	64	87	80	79	96	85
268	NA	65	87	72	79	96	85
292	NA	NA	87	NA	79	96	85
316	NA	NA	87	NA	79	96	84

Notes: NA = not available

Waste height 128-in depicted by double underline

EVAPORATION ANALYSIS

The period of waste storage between the transfer of tank B-103 into tank SX-110 on April 27, 1976 and ending with the transfer of waste out of the tank on July 21, 1976 was examined. This period encompassed the 0.75-in/week decrease exceeding allowable liquid level decrease during late June. No transfers occurred during this period. An expanded tank SX-110 liquid level graph was plotted which resulted in a liquid level decrease trend line rounded to a rate of 0.27-in/week for the entire 12 weeks, Figure 1. Two psychrometric evaporation rates were determined during the period as indicated.



WVPCRUST

The WVPCRUST tank evaporation computer code was used to calculate an evaporation rate. A nominal air outlet flow rate of 960 cfm was used for tank SX-110 on the 241-SX Sludge Cooler vent system which was found referenced in Internal Letter, Walker to Womack, September 15, 1977, Status of Tanks Connected to the 241-SX Sludge Cooler. This is near the 1000 cfm reported in OR-74-132 for the tank SX-110 ventilation rate on the 241-SX Sludge Cooler in an earlier period. The tank surface was set with no crust with ALCs operating in the normal two configuration mode, and atmospheric conditions. Unknown conditions such as air velocity across the surface and vapor pressure multiplier were derived from information in WHC-SD-WM-ER-332, Evaporation Analysis for Tank SX-104 which may not adequately describe actual tank conditions. The temperatures were weight averaged from the above table even though the liquid/vapor space absolute and differential temperatures in some cases do not seem reasonable from heat content standpoint. In any case the WVPCRUST results indicated an evaporation rate of 0.15 in/week using the list of variables in Table 2. This rate does not match the liquid level decrease in the study period and leaves open to question the variables involved and/or the possibility of another liquid level decrease mechanism such as a tank leak. The results were checked using different method.

Table 2 WVPCRUST Program Input Parameters

- Tank outlet flow, 960 cfm
- Tank vapor space temperature, 79.9°F, weighted average, Table 1
- Tank vapor space volume, 133,531 ft³, above average liquid level of 127-inches
- Surface velocity, 0.2 ft/sec w/o ALC, 0.34 ft/sec w/ALC, WHC-SD-WM-ER-332
- Surface area, 4418 ft², area of tank
- Length, 37.5-ft, radius of tank
- Diffusion coefficient, 1,000,000 ft², assuming no crust
- Crust thickness, 0.000,000,1 ft² assuming no crust
- Pool temperature, 81.3°F, weighted average
- Average ambient temperature, 65.6°F, Hanford Metrological Data
- Average ambient pressure, 14.28 psia, Hanford Metrological Data
- Average ambient relative humidity, 39.8%, Hanford Metrological Data
- Vapor Pressure multiplier, 0.72, WHC-SD-WM-ER-332
- 2016 hours

Conversion factor, density of water 62 lbm/ft³

EVAPORATION CALCULATION

A second independent water evaporation calculation was performed to estimate the mass balance between the tank inlet and outlet conditions, RPP-CALC-46420, Draft, *Estimated Water Evaporated from Tank* 241-SX-110 Between April 27, 1976 And July 21, 1976. Inlet water concentration was based on the Hanford Meteorological Station hourly data. The same nominal air outlet flow rate of 960 cfm was used as indicated above in the WVPCRUST results. Nominal outlet water vapor concentration was derived by fitting two available psychrometric determinations. The calculation resulted in a rate of 0.26-in/week which was a very close match with the trend line liquid level decrease over the entire time period.

SUMMARY

Table 3 is a summary of the evaporation data compared with the liquid level trend line and the liquid level decrease criteria.

Table 3 Summary of SX-110 Liquid Level Decrease Data

Data Source	Rate	Time Period
Data Source	in/week	
Liquid Level Decrease Criteria	0.50	4/27/1976 – 7/21/1976
Liquid Level Plot Trend Line	0.27	4/27/1976 – 7/21/1976
WVPCRUST	0.15	4/27/1976 – 7/21/1976
Water Evaporation Calculation	0.26	4/27/1976 – 7/21/1976

The Water Evaporation Calculation closely matched the Liquid Level Plot Trend Line indicating that evaporation was causing the liquid level decrease. Previous meeting minutes indicated the ALC affect on the manual tape readings were probably the cause of the individual 0.75-in/week liquid level decrease late in June 1976. The WVPCRUST results were disregarded due to the lack of specificity with some of the variables.

LEAK HYPOTHESIS

Based on review of the tank SX-110 data, the team developed plausible hypotheses for the observed tank behavior:

Leak Hypothesis:

"The surface level decrease occurring between late April and mid July 1976 was due to the combined effects of evaporation and a tank leak."

Non-Leak Hypothesis:

"The surface level decrease occurring between late April and mid July 1976 was due to evaporation."

EXPERT ELICITATIONS

Following a discussion of the above results and the development of the leak hypothesis there was unanimous opinion that evaporation accounted for the tank SX-110 liquid level decrease between late April and mid July 1976 coupled with the stable baseline readings in the drywells and laterals. The leak assessment the team expert elicitation leak assessment probabilities resulted in a combined team score of 0.05 resulting in a >99% probability that the tank did not leak.

Team Member Actions Status:

Leak assessment actions from the tank SX-110 November 6, 2009 Leak Assessment Team meeting are listed below:

	Member	Action
1.	D. A. Barnes	If surface level and temperature data for the April – July, 1976 period are received from the Seattle National Archives Regional Repository perform an evaporation analysis to determine the airflow needed for account for the observed evaporation rate. Status: Complete, see discussion above.
2.	D. J. Washenfelder	Determine if air lift circulators were operating during the April – July, 1976 period. <i>Status: Complete.</i> See Meeting Minutes #4. <i>Follow-up</i> : ALC's were reported to have been found running as indicated in the 7/12/76 Weekly Tank Farm Surveillance Report. A note was found on the 7/17/76 temperature data sheet that said the ALC's had been turned off. No other ALC operating information was found.

Leak assessment actions from the tank SX-110 November 2, 2009 Leak Assessment Team meeting are listed below:

	Member	Action
1.	D. A. Barnes	Send out tank SX-110 1970's surface level data that are now available on PCSACS, including the manual tape flush information for the period covered by Occurrence Report 76-91. Status: Complete. A portion of the data covering the April – August, 1976 time frame, and illustrating the effect of the manual tape flushes is provided in the text above.
2.	D. A. Barnes	Review logs for drywells 41-10-08 and 41-11-03 discussed in OR 75-04 and the tank SX-111 laterals. If the plume that affected the drywells was from tank SX-111 as the OR concluded, the laterals beneath the tank SX-111 should show evidence of soil contamination Status: Complete. Discussed Meeting Minutes #4.

Leak assessment actions from the tank SX-110 September 28th Leak Assessment Team meeting are listed below:

	Member	Action
		Understand and provide LL pumping and OR history for 1974-1976. (Check Welty, Brevick, Anderson for surface level references).
1.	E. C. Shallman	Track down anomalous transfer data and timing (e.g. OR 75-118 states depression formation but tank would have had to have been pumped dry for this to form.) Post 1-1-1980 data.
		Status: Archived surface level and temperature records for the 1974 – 1976 period have been ordered from the Seattle National Archives Regional Repository.
		Provide available waste temperature data post-1968 (possible source: Nancy
2.	D. A. Barnes	Scott-Proctor).
		Status: Archived surface level and temperature records for the 1974 – 1976 period
		have been ordered from the Seattle National Archives Regional Repository.
		Compare SX-107 and SX-110 laterals. Jennie Reynolds can prepare plots from the raw data.
3.	D.A. Barnes	Status: Complete. Available in document RPP-RPT-27605 Gamma Surveys of the
		Single-Shell Tank Laterals for A and SX Tank Farms.
		Review how many drywells show up contaminated on nearby SX Farm
		Leakers.
4.	J. G. Field	Look at pattern for drywells around SX-110 (possible interpretive source - Stoller/GJO reports).
		Status: Complete. Discussed in drywell section above.
		Verify air lift circulator air flow.
		Status: Complete. During the tank 241-SX-110 formal leak assessment kick-off
		meeting on September 21, 2009, the introductory briefing described that tank as
5.	D. J. Washenfelder	containing four air lift circulators rated at an air flow of five cubic feet per
٥.	D. J. Washellielder	minute (cfm). If all four air lift circulators were operating the maximum volume
		of air discharged, and the maximum volume of liquid waste that could be
		displaced would have been about 30 gallons per minute. In a one million
		gallon tank, it is difficult to conclude that 30 gallons per minute mixing would

prevent steam bumps, the intended function of the air lift circulators. Although this parameter is unlikely to have any material effect on the leak assessment outcome, an action was taken to review the historical documentation to verify the air lift circulator air flow.

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		circulators operating) to 11 cfm (40 air lift circulators operating).
		Based on the REDOX Weekly Reports, not all of the air lift circulators operated simultaneously. For example in the weekly report cited above, only 22 of the 40 air lift circulators in tanks sx-107 – SX-115 were begin operated during the August 22 – August 28, 1965 period. And they were reported as all operating at 10 cfm. Thus the 5 cfm airflow rate reported for the tank SX-110 in the leak assessment kickoff briefing is entirely plausible.
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8.	D. G. Harlow	Review OR 76-91 evaporation rates. Status: Superseded by planned evaporation analysis.
	rences:	
	Date	Title
Cori	respondence - Emai	
	Date	Title
Cori	respondence - Lette	rs:
	Number	Title

Documents:

Number Title

- GJPO-HAN-4, 1996, "Vadose Zone Characterization Project at the Hanford Tank Farms SX Tank Farm Report," U. S. Department of Energy, Grand Junction Office, Grand Junction, Colorado. \hanford\data\Sitedata\HLANPlan\Geophysical_Logs\index.html
- GJPO-HAN-4, 2000, "Vadose Zone Characterization Project at the Hanford Tank Farms Addendum to the SX Tank Farm Report," U. S. Department of Energy, Grand Junction Office, Grand Junction, Colorado. \hanford\data\Sitedata\HLANPlan\Geophysical_Logs\index.html
- GJPO-HAN-12, 1996, "Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank SX-110," U. S. Department of Energy, Grand Junction Office, Grand Junction, Colorado. \hanford\data\Sitedata\HLANPlan\Geophysical_Logs\index.html
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- Occurrence Report 75-04, 1975, "Increasing Dry Well Radiation Levels Between Waste Tanks 110-SX and 111-SX," Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # D194052957)
- Occurrence Report 75-118, 1975, "Liquid Level Increase in Tank 110-SX," Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # N/A)
- Occurrence Report 75-145, 1975, "Possible Leakage from an Encased Pipeline," Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # D1940053029)
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- RL SEP 297, 1965 [sic], "REDOX Weekly Process Reports January through December 1965," General Electric Corporation, Richland, Washington. (IDMS Accession # D2707918)
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- RPP-ENV-39658 Rev. 0 (Draft), "Hanford SX-Farm Leak Assessment Report," Washington River Protection Solutions, LLC, Richland, Washington. (IDMS Accession # N/A)

RPP-RPT-27605 Rev. 0, 2006, "Gamma Surveys of the Single-Shell Tank Laterals for A and SX Tank Farms," CH2M HILL Hanford Group, Inc., Richland, Washington. (IDMS Accession # NA01745043)

WHC-SD-WM-ER-332, 1994, *Evaporation Analysis for Tank SX-104*, Rev. 0, Westinghouse Hanford Co., Richland, Washington.



241-SX-110 Leak **Assessment**

D. J. Washenfelder **Technical Integration** Program June 16, 2010





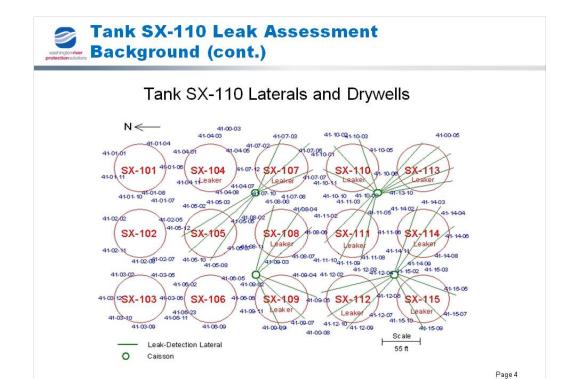
Purpose of this meeting

- · Summarize 2009 meetings
- · Review evaporation analyses
- Decide on Leak No-Leak Hypotheses
- · Decide path forward



Background Tank SX-110 Leak Assessment

- One million gallon single-shell tank active from 1959-1976
- · Four air lift circulators, five cfm each
- Boiling waste tank
- In 1976 ERDA removed from service due to questionable integrity from unexplained liquid level decrease and no need for the tank in the long-range tank use projection
- Pumped to minimum heel in July, 1976
- Interim Stabilized in 1979
- Contains approximately 49,000 gal. of Sludge and 7,000 gal. of salt cake
 - Also, 16 bottles (3" OD by 54" long) containing 204g ²³⁹Pu and 6g enriched Uranium





Tank SX-110 Leak Assessment Team

- Purpose: Review Leak Evidence and determine tank leak integrity status using TFC-ENG-CHEM-D-42 "Leak Assessment Process"
- Leak Assessment Team
 - Dennis Washenfelder
 - David Barnes
 - James Ficklin
 - Jim Field
 - Michael Fish
 - Don Harlow
 - Erik Shallman

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Tank SX-110 Occurrence Reports (cont.)

- Four occurrence reports 1974 -1975
 - No change in leak integrity status
 - Tank continued to be used for liquid storage
- OR-76-91, Liquid Level Decrease Exceeding Criteria for Tank SX-110
 - 0.75" LL decrease in 7 days June 22-28 1976 (allowable decrease 0.5-in/week
 - Two psychrometric determinations, 0.30-in/week two weeks before and 0.15-in/week immediately after
 - Erratic LL readings
 - Dry wells and laterals stable
 - Tank was considered sound, ERDA acknowledged assessment but directed reclassification to Questionable Integrity based on lack of need and apparent unexplained liquid level decrease of >1-in in 2-mo,



Tank SX-104 1980 Tank Review

- Review of QI tanks January, 1980 (RHO-CD-896)
 - Determine if QI tanks should be reclassified as confirmed leakers, not to reclassify tanks as being sound integrity.
 - Reviewed OR-74-132 (LL decrease), OR-75-04 (dry well increases), and OR-76-91 (LL decrease).
 - Continue to classify as of Questionable Integrity at 95% confidence level

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Tank SX-104 SX-Farm Leak Assessment 2010

- SX-Farm leak assessment RPP-ENV 39658 included SX-110
 - Due to lack of drywell and lateral radiation readings and no evidence of liner corrosion, team concluded that a tank leak is unlikely and no leak inventory was assigned.
 - Formal integrity assessment should be conducted for tank SX-110 per procedure TFC-ENG-CHEM-D-42, Tank Leak Assessment Process.



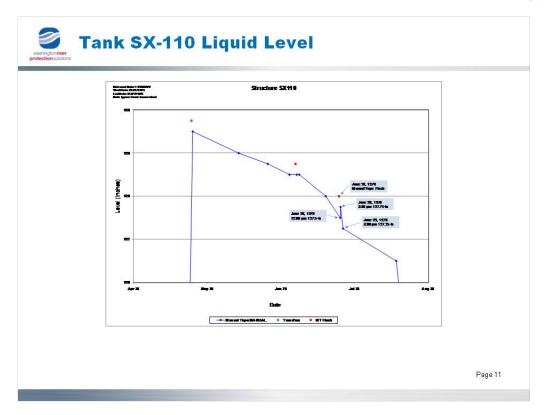
Tank SX-110 Leak Assessment Meetings

- Four SX-110 leak assessment meetings
 - 1. September 21, 2009
 - o Background and action assignments, five OR's two reviews
 - 2. September 28, 2009
 - o Meeting Summary:
 - Dry wells/laterals GJO-HAN-4
 - · SX-Farm surface contamination in general
 - · No SX-110 contamination 12-ft bgs and below
 - SX-107 leak toward SX-110 between 12-ft & 53-ft bgs close to end of Lateral SX-110-01
 - Dry wells 41-11-03 and 41-10-08 surface contamination and 41-11-03 points to cascade line
 - o Air lift circulator, 5 cfm each typically two at a time.

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- 3. November 2, 2009
 - Lateral gamma surveys, only Lateral 01 had a hit at extreme end - from SX-107
 - LL available between last fill from tank B-103 (4/27/1976) and pumping (7/21-22/1976) - next slide
 - Erratic level readings, flushing anomalies indicating possible erratic surface
 - · LL decrease highly variable waste characteristics?
 - o Confirmed 5 cfm/ALC reasonable
 - OR 75-145 transfer material imbalance 300 3,000 gallons never reconciled
 - Remaining items include; tank SX-111 influence on tanks SX-110 drywells and laterals, temperature data, and evaporation rate determination





- 4. November 9, 2009
 - Summary of meeting Can evaporation account for the surface level decrease or not?
 - SX-111 lateral 02 increased radiation but drywell 41-11-03 and 41-10-08 between the tanks decayed away at the level of the base of the tanks, 41-11-03 indicated a possible cascade line leak which was not indicated in 41-10-08
 - Photographs
 - Plummet contacting liquid rather than solids based on photographs before B-103 transfer and after pumping also ALC close to manual tape
 - 1974 photographs showing surface turbulence (ALCs) and possible small islands of semi-submerged solids
 - Solids around edge of tank on 4/2/76 and 7/23/76 both at 3-ft 4-in, no photos during storage after the B-103 transfer (waste surface?)
 - No ALC operating data found for the period but 1965-6 weekly reports, but temperature and low gradient indicate ALCs may have been operating
 - Future action: Collect temperature data and perform evaporation analysis



Information After Fourth Meeting

- Temperature
- · ALC operation (limited)
- 1975 Photographs
- · Evaporation analysis
- · Further meetings postponed until evaporation analysis and higher priority tank C-105 leak assessment completed

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Tank SX-110 Temperatures From Archives

TANK SX-110 TEMPERATURE

Distance from	Temp (°F)	Temp (°F)	Temp (°F)	Temp (°F)	Temp (°F)	Temp (°F)
Tank Bottom	4/3/1976	5/2/1976	6/2/1976	7/1/1976	7/17/1976	7/21/1976
0' 4"	85	63	94	82	81	87
2' 4"	85	64	92	82	81	87
4' 4"	86	64	92	83	81	87
6' 4"	86	64	87	81	79	85
8' 4"	87	64	87	81	80	85
10' 4"	NA	64	87	81	79	85
12' 4"	NA	64	87	81	79	85
14' 4"	NA	64	87	81	79	85
16' 4"	NA	64	87	82	79	85
18' 4"	NA	64	87	81	79	85
20' 4"	NA	64	87	80	79	85
22' 4"	NA	65	87	72	79	85
24' 4"	NA	NA	87	NA	79	85
26' 4"	NA	NA	87	NA	79	84

Waste level 129.5" (10' 9.5") April 27, 1976 to 126.25" (10' 6.25") July 21, 1976. Indicated

Received waste from tank B-103 April 27, 1976. B-103 temperature was in the mid 50's up to 224" (8 readings) except for one reading at 56" of 74 °F

Air lift circulator noted as being turned off on the 7/17/1976 temperature data sheet.

Weighted average temperatures: liquid 81.3°F and vapor space 79.9°F.

Second set of 7/17/76 footnoted as "not used in program" is not included.



Tank SX-110 Air Lift Circulators

- ALC's found running 7/12/76 (Weekly TFSR) turned off 7/17/76 (temperature data sheet)
 - No other ALC operating time entries found
 - Irregular, wavy, choppy surface



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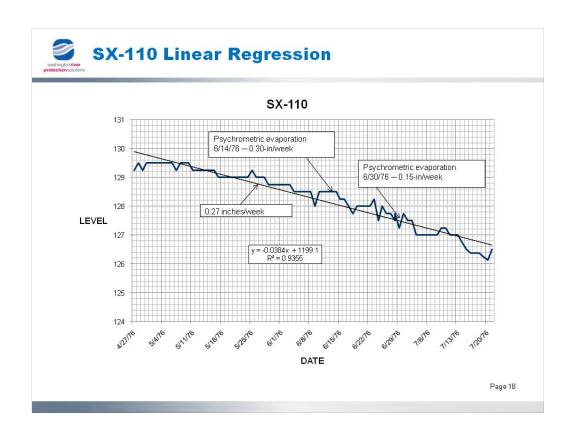
- 1975 photos found
 - Fairly clear- away from liquid surface
 - No anomalies evident
 - Supports observation in 2008 assessment
 - No obvious evidence of corrosion

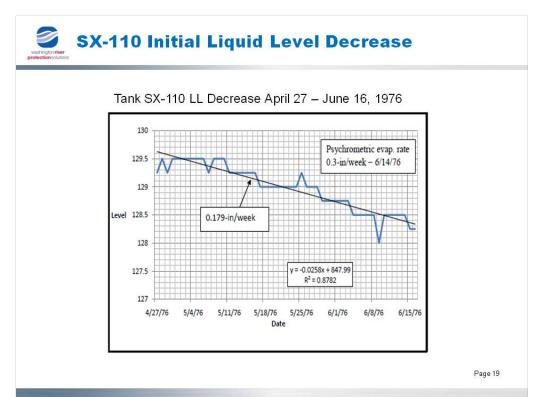


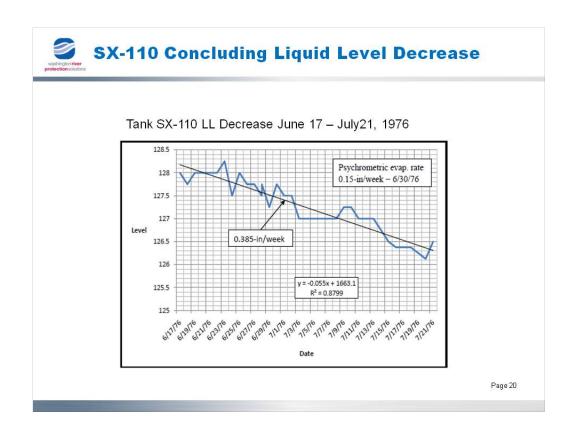
757564-14CN 1975-10-15 SL=11ft-9in .tif



- SX-110 Liquid Level Decrease April 27-July 21 1976
 - LL Plot
 - · Linear regression rate
 - · Actual decrease start to finish rate
 - Potentially two different slope periods









SX-110 Calculated Evaporation Rate

Estimated Water Evaporation Rate Calculation

- Water concentration mass balance inlet vs. outlet
- Hanford Meteorological Station hourly data
- Flowrate nominal 960cfm; Letter, Walker to Womack, September 15, 1977
- Inlet water concentration based on hourly ambient air data
- Nominal outlet water vapor concentration derived by fitting two available psychrometric determinations
- Evaporation Rate = (Outlet Inlet)(Flowrate)

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SX-110 WVPCRUST Evaporation Rate

WPCRUST Program Evaporation Rate

- · Assume 100% liquid surface to begin
- 960 cfm vent outlet flow; Letter, Walker to Womack, September 15, 1977
- Temperature °F weighted averages; solution 81.3, vapor 79.9
- · Two ALC at 5 cfm each, total air velocity across surface 0.34-ft/sec, no ALC 0.20-ft/sec
- Vapor pressure multiplier 0.72, WHC-SD-WM-ER-332



SX-110 WVPCRUST Evaporation Rate

- WPCRUST Program Evaporation Rate
 - Assume 100% liquid surface to begin
 - 960 cfm vent outlet flow; Letter, Walker to Womack, September 15, 1977
 - Temperature °F weighted averages; solution 81.3, vapor 79.9
 - Two ALC at 5 cfm each, total air velocity across surface 0.34-ft/sec. no ALC 0.20-ft/sec
 - Vapor pressure multiplier 0.72, WHC-SD-WM-ER-332

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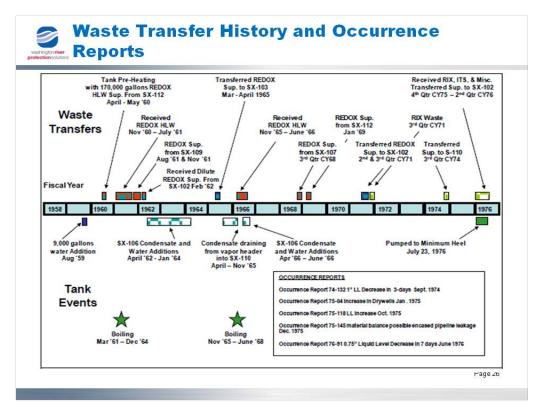
SX-110 Evaporation Information

- April 27 July 21 1976 B-103 Storage period
 - 0.50-in/week, allowable leak detection decrease criteria
 - 0.27-in/week, linear regression
 - 0.25-in/week, actual LL decrease
 - 0.26-in/week, estimated water evaporation calculation (draft)
 - · 960 cfm, atmospheric conditions, calculated water vapor pressure, other parameters
 - 0.15-in/week, WVPCRUST
 - Two ALC's at 5 cfm each, 100% liquid surface, 960 cfm vent, atmospheric conditions (vapor/liquid temperature differential only 1.4°F)



- Develop Leak Non-Leak Hypothesis
- Expert Elicitation Forms







1960-1964 REDOX High-Level Waste Storage (HW-83906-E-RD)

1965 used as a spare tank in case of tank failures (RL-SEP-297)

Dec. 1965-Jan. 1969 2nd Filling of REDOX HLW (RL-SEP-297)

2nd Quarter 1971-2nd Quarter 1976 B Plant Ion Exchange Waste and Miscellaneous Waste (ARH-871)

April 1972 SX-110 was attached to the SX farm sludge cooler system. (RHO-CD-213 Vol. 4 Section 7 of 7)

Sept. 1974 Liquid Level Decreased 1" in 3 days (74-132 Occurrence Report)

Jan. 1975 Drywells 41-10-08 and 41-11-03 showed a rise in radiation levels at the 53-57foot depth, approx. the bottom of SX-110 and 111, (OR 75-04), Tank SX-111 was a declared leaker based on a previous center lateral increase

Oct. 1975 Liquid Level Increase in SX-110 after a transfer to SX-102 (OR 75-118)

Dec. 1975 Possible Leakage from an encased pipeline during a transfer of B-103 and SX-110 (OR 75-145)

June 1976 Liquid Level Decrease of 0.75" in 7 days (OR 76-91) declared questionable integrity at the direction of ERDA

1980 Leak Assessment Team has no authority to classify the tank as a Non-Leaker. They keep the tank as Questionable Integrity, with only the surveillance team wanting a Confirmed Leaker classification. (RHO-CD-896)

APPENDIX C

Tank SX-110 In-Tank and Ex-Tank Data

TABLE C-1. IN-TANK DATA

	Tank 241-SX-110 Leak Assessment (from HNF-3747, Rev. 0			
URI	FACE LEVEL MEASUREMENTS (SLM)	Observation		
NR	AF			
	Unexplained, repeatable drop>tolerance	Yes	No	NA
	Significant drop	Yes	No	NA
	Significant trend change	Yes	No	NA
IC				
		.,		
	Unexplained, repeatable drop>tolerance	Yes	No	NA NA
	Significant drop Tank SX-110 contained approximately 336 kgal (129.5-in) of waste on April 28, 1976 feed staging transfers to the 242-S Evaporator/Crystallizer. The tank liquid level was decreasing at a rate of approximately -0.25 inches per week as a result of evaporation from April 28 through June 22, 1976. The evaporation rate for tank SX-110 was within normal limits for this tank. From June 22 through June 29, 1976, the liquid level in tank SX-110 decreased 0.75-inches (~2,000 gallons), which exceeded normal expected evaporation rates for this tank. The manual tape used to measure liquid level in tank SX-110 had been flushed on June 28, 1976 and the liquid level increased from 127.5 to 127.75-in. However, the measured liquid level in tank SX-110 decreased to 127.25-in on June 29, 1976. The liquid level was measured on June 30, 1976 as was reported as 127.25, 127.5, and 127.75-in, indicating erratic readings. An occurrence report was issued June 29, 1976 (ARHCO Occurrence Report 76-91). The evaporation rate for the waste in tank SX-110 was measured as -0.3 inches per week in early June, 1976 and -0.15 inches per week on June 30, 1976 (ARHCO Occurrence Report 76-91). Significant trend change	Yes	No No	NA NA
IAN	UAL GAUGE			
	Unexplained, repeatable drop>tolerance	Yes	No	NA
	Significant drop	Yes	No	NA
	Significant trend change	Yes	No	NA
IQU	IID OBSERVATION WELL (LOW) MEASUREMENTS		Observation	
	Unexplained, repeatable drop>tolerance	Yes	No	NA
	Significant drop	Yes	No	NA
	Significant trend change	Yes	No	NA NA

OBORATING EVIDENCE	Corroborates SLM or LOW Data Given		
Thermocouple Available thermal histories for single-shell tanks are summarized in RHO-CD- 1172, Survey of the Single-Shell Tank Thermal Histories. The thermal history for tank SX-110 starts in May 1960 and continues through June 1968 (RHO-CD-1172. Temperature plots show tank SX-110 waste temperature reached a maximum of ~310 ± 10°F in May, 1966, staying at this temperature through June, 1968. In August, 1979 when the tank was interim stabilized the Probe #3 temperature	Leak	Alt. Hypoth.	NA
was 189°F, and the Probe #1 temperature was 119°F (HNF-SD-RE-TI-178 p273).			
Salt well screen	Leak	Alt. Hypoth.	NA
Standard Hydrogen Monitoring System	Leak	Alt. Hypoth.	NA
Photos/Videos	Leak	Alt. Hypoth.	NA.
Weather conditions	Leak	Alt. Hypoth.	NA
Barometric pressure	Leak	Alt. Hypoth.	NA
Precipitation	Leak	Alt. Hypoth.	NA
Temperature	Leak	Alt. Hypoth.	NA
Surface flooding	Leak	Alt. Hypoth.	NA
Process history RPP-ENV-39658 Rev. 0 (Draft):	Leak	Alt. Hypoth.	NA
REDOX High-Level Waste Storage (1960 -1964): Prior to receipt of waste, 9,000 gallons of water were added to to rank SX-110 in August 1959 (HW-61952 page 8). In April, and May, 1960, 170 kgal of aged REDOX HLW supernate from tank SX-112 were transferred into the tank for pre-heat prior to the introduction of higher heat waste (HW-65272 page 8, HW-65643 page 8, RHO-R-39). The waste temperature was ~100F after the additions. Between November, 1960, and July, 1961, tank SX-110 received ~714 kgal of high-heat HLW from the 202-S REDOX Plant (HW-68291 page 8, HW-68292 page 8, HW-71610 page 8, HW-83906-E-RD page 4). The temperature of the waste was ~220 ±10F following these transfers.			
An additional ~380.3 kgal of aged and dilute REDOX Plant wastes were transferred to tank SX-110 between August, 1961 and February, 1962 (HW-83906-E-RD page 4 and 5, HW-83906-E-RD page 14). The temperature of the waste i was approximately 240 ±10F following these transfers. No additional waste transfers were made into tank SX-110 from March 1962 through October 1965. However from April 1962 through January 1964, ~335,4 kgal of condensate from tank SX-106 and 55 kgal of water were added for temperature control and to prevent overconcentration (HW-83908-E-RD pages 13, 22-24, 31-33, 40-42, and 48-50).			
Spare Boiling Waste Tank for 241-SX Farm (1965): In March and April 1965, approximately 514 kgal of supernate were transferred from tank SX-110 into tank SX-103, leaving a 114 kgal heel (HW-83906-E-RD page 62b and RL-SEP-297 page 87). Tank SX-110 was designated as a spare tank. Tanks SX-113 and SX-115 had leaked waste, and tanks SX-107, SX-108, and SX-109 were suspected to be leaking based on radioactivity detected in their laterals and drywells.			

generated REDOX HLW by early November, 1965. Tank SX-110 was returned to normal service in November 1965.			
Second Filling with REDOX HLW (1965 - 1971): On November 3, 1965, the routing of REDOX Plant HLW was switched to tank SX-110 (RL-SEP-297 page 168). By the 1st quarter of CY 1966, the tank had received ~707.6 kgal of waste (HW-83906-E-RD pages 75 and 76, ISO-226 page 8). The waste in tank SX-110 began to boil and evaporate water after these waste transfers. During the remainder of CY 1966 the tank received additional REDOX HLW, followed by ~751.7 kgal of condensate and water additions to control the waste temperature that had reached ~300F in May 1966 and remained at this temperature through June 1968 (HW-83906-E-RD page 83 and 84, ISO-538 page 8, ISO-674 page 8). The total volume of waste in tank SX-110 was ~623 kgal following these water additions.			
In the 3rd quarter of CY 1968, tank SX-110 received 127 kgal of REDOX HLW supernate from tank SX-107 that was suspected of leaking (ARH-971 page 9). Tank SX-110 contained 776 kgal at the end of the quarter. On January 23, 1969, the tank received 139 kgal of REDOX HLW supernate from tank SX-112, also suspected of leaking (ARH-1200 A page 10). After the transfer, tank SX-110 contained 932 kgal of waste. No further waste additions were made to tank SX-110 for CY 1969 through 1st quarter CY 1971.			
B Plant Ion Exchange and Miscellaneous Wastes (1971 - 1976): In the 2nd quarter of CY 1971, 863 kgal of REDOX HLW supernate were transferred from tank SX-110 to tank SX-102 (ARH-2074 B page 10). An additional 116 kgal were transferred to tank SX-102 in the 3rd quarter of CY 1971 (ARH-2074 C page 10). Following these transfers, tank SX-110 contained ~215, kgal of REDOX HLW supernate and 32 kgal of REDOX HLW sludge.			
In the 3rd quarter of CY 1971, tank SX-110 received 734,000 gallons of Cs-137- strippped REDOX lon Exchange (RIX) waste from tank SX-105 (ARH-2074 C page 10). No additional waste transfers into or out of tank SX-110 occurred until 1974.			
In the 3rd quarter of CY 1974, 516 kgal of supernate were transferred from tank SX- 110 to tank S-110 for staging as feed to the 242-S Evaporator/Crystallizer (ARH- CD-133 C page 8). An additional 221, kgal of supernate were transferred from tank SX-110 to tank SX-102 in the 3rd quarter of CY 1975 to be staged as evaporator feed (ARH-CD-336 C page 8).			
From the 4th quarter of CY 1975 through 2nd quarter CY 1976, tank SX-110 was used to receive dilute supernate wastes from the 200-East Area tank farms for staging to tank SX-102 and eventual processing in the 242-S Evaporator/Crystallizer. The tank contained ~336 kgal of waste as of April 28, 1976 (ARHCO Occurrence Report 76-91).			
Construction history	Leak	Alt. Hypoth.	NA
Gas Release Events	Leak	Alt. Hypoth.	NA
Equipment maintenance calibration	Leak	Alt. Hypoth.	NA
Waste characteristics	Leak	Alt. Hypoth.	NA
In-tank operations	Leak	Alt. Hypoth.	NA

RPP-ASMT-47140 Revision 0

Interim Stabilization (1979)	Leak	Alt. Hypoth.	NA
After transferring the remaining supernate to tank SX-102, tank SX-110 was connected to the 241-SX Farm sludge cooler. The residual supernate and interstitial liquid evaporated. The waste surface in tank SX-110 was estimated to be 99% dry solids based on in tank photographs obtained July 26, 1977. Based on these photographs, tank SX-110 was declared interim stabilized as of August 31, 1979 (HNF-SD-RE-TI-178 revision 9 page 273).		The Type of	
Other (specify)	Leak	Alt. Hypoth.	NA
Other (specify)	Leak	Alt. Hypoth.	NA

TABLE C-2. EX-TANK DATA

IISTORICAL GROSS GAMMA LOGS (GGL)	Observations			
istribution				
Sign. peak at bottom of tank?	acti	ual data	No or NA	
There was no increase in the radioactivity detected in the drywells or laterals in June 1976 when the evaporation rate for the waste was measured as -0.3-in/week, and later as -0.15-ing/week on June 30, 1976 (ARHCO Occurrence Report 78-91). The radioactivity detected in drywells 41-10-08 and 41-11-03 was to be associated with waste loss from tank SX-111 (IDMS Accession #D194052957), which occurred in May 1974.		an dad	1001101	
Sign. peak near surface?	acti	ual data	No or NA No or NA	
Sign. increased activity in between?	acti	ual data		
Sign. increased activity below tank?	actual data		No or NA	
ctivity across boreholes				
Multiple boreholes?	Yes	No	NA	
Consistent across boreholes?	Yes	No	NA	
ctivity over time				
Abrupt increase (bottom)?	Yes	No	NA	
Abrupt increase (elsewhere)?	Yes	No	NA	
Gradual increase (bottom)?	Yes	No	NA	
Gradual increase (elsewhere)?	Yes	No	NA	
ORROBORATING EVIDENCE	Corrobo	Corroborates SGL or GGL Data Given		
oisture Probe	Leak	Alt. Hypoth.	NA	
sychrometrics	Leak	Alt. Hypoth.	NA	
ore hole core sample	Leak	Alt. Hypoth.	NA	
			<u> </u>	
aterals	Leak	Alt. Hypoth.	NA	

Tank 241-SX-110 Leak Assessment E (from HNF-3747, Rev. 0)			
SPECTRAL GAMMA LOGS (SGL)		Observation	
Radionuclides			
Man-made?	Yes	No	NA
Multiple?	Yes	No	NA
Distribution			
Sisting at 101			
Peak at bottom of tank?	actual	data	No or NA
Peak near surface?	actua	l data	No or NA
Increased activity in between?	actua	l data	No or NA
Increased activity below tank?	actua	l data	No or NA
GJ-HAN-12 Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank SX-110, December 1995: Surface Cs-137 contamination is identified in all of the boreholes surrounding tank SX-110 and is uniform in intensity. The depth of contaminant migration is the greatest in boreholes 41-10-03, 41-10-05, and 41-10-06. These boreholes are located adjacent to each other on the southeastern side of the tank. The contamination migration in these boreholes suggests a localized event such as a surface spill or leak. The subsurface Cs-137 contamination zones observed in boreholes 41-10-01 and 41-10-11 are most likely related to leakage from tank SX-107. No information in the log data indicates this contamination resulted from leakage from tank SX-110. The only elevated activity in the tank SX-110 lateral data was related to the leakage from tank SX-107. In 1974 and 1975, the Tank Farms logging system detected an elevated count-rate zone in borehole 41-10-08 at a depth of about 55 ft. This zone occurs at the approximate depth of the tank bottom. This anomaly may have resulted from a radionuclide with a short half-life, such as Ru-106. The zone at about 55 ft may correlate with data related to tank SX-111 (to be published). The continuous Cs-137 contamination observed in borehole 41-10-03 appears to have originated at the surface and has migrated down the casing. As previously discussed, the boreholes located on the eastern side of tank SX-107 exhibit the most surface contamination. Leakage at the surface on the eastern side of the			
tank may have been close to borehole 41-10-03 and may have migrated down the outside of the casing. Tank SX-110 is designated as an assumed leaker (Hanlon 1995); however, there is no contamination in the vadose zone that can be positively attributed to leakage from tank SX-110. All of the contamination detected in the boreholes surrounding the tank can be correlated to sources other than the tank itself.			
Activity across boreholes			
Multiple boreholes?	Yes	No	NA
Activity over time			
Increased activity?	Yes	No	NA NA

	Observation	
Yes	No	NA
Yes	No	NA
actua	Ldata	No or NA
actual	i data	No or NA
actua	l data	No or NA
actua	l data	No or NA
actua	ıl data	No or NA
Yes	No	NA
Yes	No	NA
	actua actua actua	Yes No Yes No actual data actual data actual data actual data Actual data Actual data Actual data Actual data

Weathe	r conditions			
	Barometric pressure	Leak	Alt. Hypoth.	NA
	Precipitation	Leak	Alt. Hypoth.	NA
	Temperature	Leak	Alt. Hypoth.	NA
Surface	flooding	Leak	Alt. Hypoth.	NA
Process	s history	Leak	Alt. Hypoth.	NA
Drywell	drilling logs	Leak	Alt. Hypoth.	NA
	ence reports			NA NA
in three the tank supernal per weel indicate switched the venti during the tank ventilation has beer flowrates Occurre to to cated the SX-110 sign SX-111 drywells to the 24 storage sign services.	ence Report 74-132, September 1974: The surface level decreased 1-in days, exceeding the decrease criterion of 0.5-in in seven days. None of laterals or drywells showed any change. The tank contained 400 kgal of tant and 32 kgal of sludge, and had sufficient heat to evaporate ~ 0.25-in k. Prior to the OR, there was a two week period when the MT did not a decrease from evaporation. Following the decrease, the tank was I from the SX ventilation system to the SX Farm sludge cooler, increasing illation rate from 60 cfm to ~1000 cfm. The surface level decreased -1-in he next 3 days compared to actual psychrometric measurements indicating should have lost -1.4-in per week. The tank was reconnected to the SX in system. A note in the Preliminary OR indicates that this level behavior in observed in other tanks with ALCs. The tank has four ALCs, with so fo ~ 5 cfm each. Pince Report 75-04, January 1975: Drywells 41-10-08 and 41-11-03, between tanks SX-110 and SX-111 showed increased radiation at 53-ft-ank SX-110 Contained ~ 393 kgal of supernatant and 32 kgal of sludgeg. -111 was declared a leaker in May, 1974, and contained ~ 125 kgal of Both tanks were ventilated at the time of occurrence. The surface level of was decreasing due to evaporation, and was within leak detection criteria; contained only sludge. Final OR noted that the radiation levels in the had stabilized; and hints that once the SX-110 supernatant is transferred of terminal liquor (i.e., 242-S concentrated product).			
seven da psychrol 0.3-in pe readings decreas Letter J surface	ence Report 76-91, June 1976: The surface level decreased -0.75-in in ays, exceeding the -0.5-in in 7 days decrease criterion. Two metric analyses completed during June reported evaporation losses of ear week and -0.15-in per week. The June 30, 1976 MT surface levels were erratic, with one of three readings - 127.25-in - exceeding the e criterion. Drywell and lateral readings were stable. No corrective action uly 21, 1976 (IDMS D196225037): Tank is being watched because of a level decrease of -3.5-in. with -1.5-in not explained by evaporation and			
cooling. leak.	The tank's 9 drywells and 3 laterals do not exhibit any evidence of a tank			
Surface	spills	Leak	Alt. Hypoth.	NA
Transfe	r line leaks	Leak	Alt. Hypoth.	NA.

		1	I
Construction history	Leak	Alt. Hypoth.	NA
Equipment maintenance calibration	Leak	Alt. Hypoth.	NA
Waste characteristics	Leak	Alt. Hypoth.	NA
In-tank operations	Leak	Alt. Hypoth.	NA
Leak Assessments	Leak	Alt. Hypoth.	NA NA
July 21, 1976 (D194023422): The Energy Research and Development Administration (ERDA) issued a letter to ARHCO on July 21, 1976 to remove tank SX-110 from service due to questionable integrity (EDRA 1976). ERDA stated in this letter: "This decision is based on the fact that ARHCO's long-range tank use projection does not indicate a continued need for this tank, which obviously does not justify risking continued use with an apparent unexplained liquid level loss over the past two months in excess of one inch." 1980 Leak Assessment: Rockwell Hanford Operations (RHO) convened an independent panel to review the integrity of tank SX-110 in 1980 (RHO-CD-896). This panel reviewed the ARHCO Occurrence Report 76-91, drywell radiation readings, and the operational history of tank SX-110. The RHO tank integrity assessment panel noted that 300 c/s was first detected in 1973 in drywell 41-10-01 (drilled in 1962) at ~64-ft level and had slowly decreased to 60 cps by 1980. Tank SX-107 was confirmed as leaking waste in 1964, which could be the source of activity detected in drywell 41-10-01. The RHO panel also described possible corrosion of the steel liner in tank SX-110 between the 304 to 360-inch levels. Consistent with the rules in-place at the time, the panel recommended that tank SX-110 continue to be classified as of Questionable Integrity, since there was insufficient information to warrant reclassification of this tank as a confirmed leaker at the 95% confidence level. The panel identified possible corrosion of the tank steel liner between 304 and 360-in levels, based on unclear photographs taken on October 15, 1975. Photographs taken inside tank SX-110 on July 23, 1976 (IDMS 766879-1cn [N2128533] thru 766879-36cn [N2128935]) were located and reviewed. The July 23, 1976 photographs are black and white images whereas the February 20, 1987 photographs do not show any evidence of corrosion of the steel liner walls, but the 1976 photographs do not show any evidence of corrosion of the steel liner in liner. The Februar			
Other (specify)	Leak	Alt. Hypoth.	NA NA
		J	

APPENDIX D

Tank SX-110 Leak Assessment Team Expert Elicitation Forms

ELICITATION FORMS

Expert Opinion: D. A. Barnes

				Tank S.	Tank SX-110 Lask Assessment Expert Elicitation Form 2010-06-16 (From HNF-3747, Rev. 0)	
	Oxenano					
Elicitation from:	D. A. Barnes					
Eliciation by:	Leak Assessment Team	E				
Hypotheses:						
Leaker:	The surface level deci- combined effects of er	The surface knet decrees occurring between the April and md July 1976 was due to the combined effects of exaccision and a tank leak	late April and md July	1976 was due to the		
Non-Leaker:	The surface level decrewance evaporation.	The surface level decrease occurring between late April and mid July 1976 was due to oversoration.	late April and mid July	r 1976 was due to		
		u.	Prior Probability - Part 1			
		True State	State	Likilhood Ratio		
		,	ŧ		0.50 chosen so that no pre-analysis bias would be introduced.	
		D(L)	p (ML)	ď		The "party opposition by an assumed enter law as a saided given only two gives at information" is a supplied set of the "proofs" cate or past suffice lines deeps or except the control of the proofs cate or past suffice lines directly entered and proof in the control of the c
		0.50	0.50	1.00		
		Conditional	Conditional Probabilities			
	1	In-Tank Data Surface Le	Data Surface Level Measurement - Part 2	art 2		
	Surface Level Measurement	p(SLVIL) off no SLM, order NA, here and in Parts 4 and 5)	p(SLM NL.)	(SLM)	The loss rate is reasonably wal supported by engoration calculations, particularly since the data was complicated by flushes and tapulpurment repracements.	Conscioung the purifical level insequenced data reviewed for the lace assessment. PSMM, = ["posterior"] probability that the service well resolvement data would be observed, of that tank is a least. PSMM, = ["posterior"] probability that the service level increasurement data would be observed, if the tank is a non-release. pSSMMS, 1 = 1 pSSMM, in the service level increasurement data would be observed, if the tank is a non-release. pSSMMS, pSSMMS, 1 = 1 pSSMM, in the service level increasurement (as a pSSMMS, pSSMMS, pSSMM), is staticle level increasurement (as pSSMMS, PSS, MT), the probabilities inhold be assessed only for the more disposition should be assessed only for the more disposition should be assessed only for the more disposition and release to the post-basis to the pSSMMS of the more disposition and release to the pSSMMS.
		0.10	06:0	0.11		
		In-Tank Data Liquid Observation Well - Part 3	bservation Well - Parl	13		
	Liquid Observation Well	Ucuid Observation ((f no LCW, enter IA) Well here and in Pats 4 and 5)	(TKI MOT)	ר(ניסאי)		Conscioung the intertital loud late invelvend for the leak assistent in \$10,000 Position of probability that the LOPI intertible liquid level data would be observed, if the tank is a leave. [ULOVI] = [Consteror] probability that the LOVI intertible liquid level data would be deserved. If he tank is most a leave, policytely, OVIPPL.) If LOVI interational liquid level data are not available to this leaks assessment, leave LLOVI) = [ULOVI] = [Consteror] and [Consteror] are also assistant and available to this leaks assessment, leave LLOVI] = [Consteror] and [Consteror] are also assistant and available to this leaks assessment.
		NA	¥.	1.00		

Surface Le	Surface Level Measurement - Liquid Observation Well Interdependence - Part 4	Observation Well Interd	ependence - Part 4		
Surfice Lavil Ressurement Liquid Observation Vell Interdependence	th the p(SLMILOWL) actor (of no LOM, order NA) nice	(SLM LOW,ALL)	г(згиігом)		Considering that in-land data sources may be inheritopedent. #SAMLOY(L) = ["proteiner"] probability that this surface lived invasivement data would be observed fine LOW investigational level data are observed, and this tasks is lessed. #SAMLOY(NL) = "proteiner"] probability that his surface lived innasements data would be observed if the LOW #SAMLOY(NL) = "proteiner"] proteiner as well as well as level in a surface lived in a source lived
Liquid Obs	Liquid Observation Wei - Surface Level Measurement Interdependence - Part 5	NA.	1.00 ependence - Part 5		
Liquid Observation Well - Surface Level Reseaurement Interdependence	ston p(LOW/SJAL) at (f no SJM, enter NA)) p(LOWISLUAL)	(WISIMOT) T		Considering that in-lant data sources may be intradependent. ALOWISIALL) = ["postered"] probability that has LOW intensitial level deal would be observed if a surface west insuppose as coloured, and if the text is a ballot. ALOWISIAN III, iii. "posterior"] probability that a LOW mee staininguid level measurement decreases would be hard a suppose of a suppose of a suppose of the colour suppos
	NA	¥	1:00		
	Ex-Tank Data · Gross Gamma Drywell Logs - Part 6	Samma Drywell Logs - F	art6		
Gross Gamma Drywell Logs	p(OGL L) p(OGL L) prodel, enter FA here and in Parts 8 and 9)	(COFINE)	(106)	All dywells and/or later date was completely clean, except for some confamiliation near other known leaker ianks. There is no drywel or lateral evicience to support a leak from SXT 10.	Desicning the historical gross parms downth logs reviewed furth tele assessment: GOGLILL Footener pobability that the gross gamma bay would be observed, if the tank is a historical and the pross gamma logs would be deserved, if the tank is a non - helder of COLINL 1 - FOOGLIL. GOGLINL Footener F
	0.20	0.30	0.25		
	Ex-Tank Data - Spectral	Data - Spectral Gamma Drywell Logs - Part 7	Part 7		
Spettal Garma Drywell Logs	pRSCL(L) pRSCL(L) from SGL, enter NA hore and in Parts 8 and 9)	p(serlur)	('88')	The specific garmes surveys confirm that the drywals surrounding SX110 are oben, and the equipment is rauch more sensitive than the gross garmes boss. This kinds condibility to the non-back byochheiss.	Descenting the special gamma dywel logs revened for the lake assessment. SIGNLL 1: [Posteror*] posteroity that the special gamma dywell togs would be obserore; (if the tank is a season, All 11. [Posteror*] redeability that the special gamma dywell logs would be diserved; if the tank is a new Hower, (SIGNLM) = 1 (SIGNLM)
	0.20	0.80	0.25		
Gros	Gross Gamma Log - Spectral G	Lcg - Spectral Gamma Log Interdependence - Part 8	lence - Part 8		
Gross Gamma Log- Spectral Garma Log Interdependence	rna p(6GL SGL,L)	MGGL[SGL,NL)	(198r) r(000r)		Considering that extent cats assures way for interdependent. Considering that extent cats assures way for interdependent to the considering parties to pay an extended, and if the task is a state of the task is a subsequent to the considering that the gress gamma logs are devised. The postering format and the task is a non-water profice (SGL, NL = 1 · JGRALSSL.) (COGASC, = PCOLSSCL, NL = POSTERING STALL Fellow gross gamma logs are not maked for the subsequent postering formation are as assurement to the considering state of the subsequent payons gamma logs are not maked for the subsequent to the considering state of the considering sta
	NA	NA.	1.00		

Spectral Gamma Log - Gross Gamma Log Interdependence	() b(8dr 6dr,L)	D(SGL GGL,RL)	(1991)961)	A value of 0.4 but set home he per several per several per several edge, since if ones support the same conclusion as the gross gamma data. A value of C.50 would give 100% weight to the gross gamma and 0% to the spectral data.	Considering that exclusic dast sources may be intensependent. [SEGLOGAL, 1 Experisor probability that he spectral jamma logs would be absented if the goest gamma upgs and controlled that is a tileate. [SEGLOGAL, 2 Experisor probability that the spectral gamma logs would be observed. Whe groups gamma logs are are densemed, and this are no exclusion. The controlled that the spectral gamma logs were proposed to the property of the prop
	0.40	09:0	0.67		
	Combined L	Combined Likilhood Ratios			
L(SLM)	L(LOW) 1.00	L(SLM LOW)	L(LOWISLIN)		
L(GGL)	L(SGL) 0.25	L(GGL SGL)	1(3GL GGL) (1951		
W	ich In-Tank Condition	Which In-Tank Condition Applies? (Mart X in Box)	Box)		
SLM & No LOW?			×		
LOW & No SLM? SLM & LOW; SLM most	st important? (Mark Part 4 NA)	Part 4 NA)			
SLM & LOW; LOW most important? (Mark Part 5 NA)	ostimportant? (Mark	k Part 6 NA)			
In-Tank Likihood Ratio			L(SLM,LOW)		TERM and FOW and EOW most important. USSIMLOW) = ULOWISMIN K. USMIN) FERM and EOW USMIN (SIGNEDON) = USMIN) FERM and EOW USMIN (SIGNEDON) = USMIN) FERM and EOW USMIN (SIGNEDON) = USMIN)
			0.11		
Whi	ich Ex-Tank Conditio	Which Ex-Tank Condition Applies? (Mark X in Box)	Box)		
GGL & No SGL?					
SGL & No GGL?			,		
GGL & SGL; SGL most	st important? (Mark Part 9 NA)	Part 9 NA)	<		
Ex-Tank Likilhood Rado			(199, 661)		COZ, and no. SCI. L. (SCI. COS.) = L(COS.) (SCI. and no. COZ. L. (SCI. COS.) = L(COJ.) (SCI. and SCI. and GOZ, most myotime. L(SCI. COS.) = L(SCI.(COJ.) L(L(COJ.) (COZ. and SCI. and SCI. most myotime. L(SCI. COJ.) = L(SCI.(COJ.)
			0.17		
Combined Likelihood Ratio for Leak Hypothesis			L(in,ex)	This indicales that here is approximately a 2% chance that he tank leaked, but was not identified from either the surface level data of over the drywell later at data, Given the strong support for the non-leak hypothesis, this value seems reasonable.	ήν (κα) = (15/04/2014) χι (15/04/05.)
			0.02		
	Posterior Probabilit	Posterior Probability for Leak Hypothesis			
	p(L in,ex)	p(NL[in,ex)	ď		Ω_1 - postance (postales) exercatives in favor of lead hypothesis. Ω_1 - ((if exc.); Δ_2) $\Omega_1(\Omega_1, \sigma_2)$ p(Lincos) excellently postales assessment that the table is a state. (An $\alpha_2 = \Omega_1(\Omega_1, \sigma_2)$ p(Lincos) postales (postales) assessment) the the table is severe. (QUL, α_1) = $\Gamma_2(\Omega_1, \alpha_2)$
	0.02	0.98	0.02		

Expert Opinion: L. W. Ficklin

				Tank S.	Tank SX-110 Leav Assessment Expert Elicitation Form 2010-06-15 (Frem HNF-3747, Rev. 0)	
Elicitation Date:	6/16/2010					
Elicitation from:	J. W. Ficklin					
Eliciation by:	Leak Assessment Team	us.				
Hypotheses:						
Lesker:	The surface level dec combined effects of e	The surface level docreese occurring between late April and mid. July 1976 was due for the combined effects of evaporation and a tank leak.	late April and mid July ak.	7 1976 was due to the		
Non-Leaker:	The surface level dec evaporation.	The surface level decrease occurring between late April and mid July 1978 was due to evaporation.	late April and mid July	7976 was due to		
			Prior Probability - Part 1	=		
		Ě	State	Ē		
		<u>1</u>	N	å å	There were several known leakers in SX. Farm and aso a history of high-heat laths.	$H_i(x) = T_i \sin x^2$ probability that an assumed sound tent has belied given any two pares at information. If it is a substituted that $H_i(x) = T_i \cos x^2$ and $H_i(x) = $
		60	4			
		0000	0.40	000		
		Conditional	Conditional Probabilities			
		In-Tank Data Surface Le	Data Surface Level Measurement - Part 2	art 2		
	Surface Level Measurement		b(Strikint.)	וי(פרא)	Surface evel messurerients were consistent with raniables inherent to obtaining manual tape maintigs and evaporation.	Considering the surface level measurement data melevant be the level assurance. #GMA_F [prosterior] probability that the surface level measurement is in world be observed, if the said is a surface level measurement is surface. The surface level measurement star would be observed, if the said is a marker. #GMA_F[CMA_F] [SMA_F] [SMA_F] is a possible to the surface level data are not a vestion and it is described. The surface level data are not a vestion to t
		0.20	0.30	0.25		
		In-Tank Data Liquid Observation Well - Part 3	bservation Well - Part			
	Liquid Observation Well	Liquid Observation (if no LOW, order No.) Neil have and in Patts 4 and 5:	p(LOVV)(4L.)	יונרסאנ		Designing the retestivalisated break data revened for the leak societies. #U.DVAL = ['posterior'] probably that the LDV inventional is paid level data would be observed, if that trank is a stake in the probability that the LDV inherstine it paid feer dust module observed, if the trank is set a haber of probability that the LDV inherstine it paid feer dust module observed, if the trank is set a haber of probability that the LDV inherstine it paid feer data module in the haber as a sessenment, the LDV inherstine it paid feer data are not mentable for the haber as sessenment.
		ž	₹	1.00		

					Cons de ingthat in-an's dea a surces may be introde-endent. p[SUNLOVIL] = "postnion"] probability tost he surfice level mass sement dea would be observed if the LOW intentials found feat are desented, and if the task, as lasker.
=	p(SUM LOW,L) (i*no LOW, onter NA)	p(SLM LOW,NL)	L(SLMILOWY)		FISHMUNYLL = I posteror1 probability this a surface level measurement data vould be observed if the LOW plantition level measurement dera are observed, and if the lant is a non-leaker, p[SLMLOWIN] = 1 - p[SLMLOWIN].
Interdependence					LCULLOV) = $\mu(3.0M_{\odot}V/L)\mu(3.0M_{\odot}V/M_{\odot})$. If then so they level measurement only or LOV intensities liquid level data are not real libe for the least assistants, then L(SL-RLCVV) = 1. If there is no LOVM safe to the next and the
	NA	2	1.00		
C feer and C	Well Curface	A total Control Manustrated to the Manustrated Manustr	100		
					Conside ingither in-rank dera syurces may be interdemented in the design would be observed if a runface pLCMSIMU, = [posested probability that the LCM interestinal liquid lovel dera would be observed, and if it is not a scheder.
	p(Low SLM,L) (if no SLM, enter NA,)	p(_OW SLM.NL)	(LOWISLM)		pLCV/QUANUL = I'pserior/ probability that a "CVV atenzial liquid tertimeau emant decesses vecals be Cobered it a take feet measurement discisse is disamed, and i'the tark it a non-eaker, piLCVVSLIA, M.— -1 psec/CVVSLIA, J.)
Interdependence					LLC-WISLM = y_COWPSLM.LIPELCMSSLUJA). If schere surface heat data or _DW investifier liquid level data are used for the lead assessment, then LLC-WISLM) = 1. Hithous is no unifice.
	NA	ž	1.00		TOTAL DE STATE DE STA
, W	Tank Data - Gross Ga	Ex-Tank Data - Gross Gamma Drywell Logs - Part 6	at 6		
	r(GGIL)				Considering the historical gross gamms drywall lags reviewed for the leak assessment.
Gross Gamma Drywell Logs	(if no GGL, enter NA nere and in Parts 8 and 3)	p(coulnu)	r(cor)		Florid, "I postrior, providing that the gross gamma logs would be obserred, if the tank is a non-likelyer Florid, NJ = I' potkrior probability that the gross gamma logs would be obserred, if the tank is a non-likelyer Florid, NJ = I + p(GGLL)
					$L(GQ_i)=p[GQ_i]Q_ip(GQ_i V_i)$. If gives gaintria bigs are not realiable for the leak assessment, then $L(GG_i)=1$
	0:30	0.70	0.43		
F-X	ank Data - Spectral G	Ex-Tank Daia - Spectral Camma Drywel Logs - Part ?	Part 7		
Spectral Gamma Drywell Logs	p(SGL L) (if no S/GL, enfrer NA nere end in Parts 8 end 3)	p(SGLINL)	(1881;	esking tanks SK-107 & 111.	Condiding the spectral gramms of ywell ligs winwed for the loak accessment: \$\(\)\{ \)\{ \)\{ \) \} \} \ \ \ \ \ \ \ \ \ \ \ \ \
	0:30	0.70	0.43		
Gross Gam	ma Log - Spectral Ga	Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8	ence - Part 8		
Gross Gamma Log - Spectral Gamma Log Interdependence	F(GSL SSL,L)	p(GGL SG.,NL)	(1981-99)1	Spectral gamme readings observed were much lower tran those levels that would be associated with a tank leak.	Considering than extank data courses may be introdependent. [GOLISCL) = [posterior] probability that he gross garman logs vould be observed if the spectral gamma (gOLISCL) = [posterior] probability that he gross garman logs would be observed if the operating gamma (spanse abserved and if the table is a non-basilist probability that he gross gamma logs would be observed and if the table is a non-basilist p(GOLISCL, M) = 1 + p(GSLISCL, M) =
	AA	¥	1,00		

Spectral	Specifal Gamma Log - Gross Gamma Log		interdependence - Fart 9		
Spectral Gamma Log - Gross Gamma Log Interdependence	p(serleer.L)	p(SGL GGL,NL)	(1891 691)	Relied more on Gross Gamma readings than on Spectral Gamma readings; GGL had more history available.	Considering that ex-tank data sources may be intendependent. p(SGLIGGLL) = [posterior*] probability that the spectral gamma logs would be observed if the gross gamma logs are observed, and if the tank is a leaker. p(SGLIGGLN) = [rosterior*] probability that the spectral gamma logs would be observed if the gross gamma logs are are observed, and if the tank is a non-leaker, p(GGLIGGLN, = p(SGLIGGLL)) L(SGLIGGL) = p(SGLIGGLL) p(SGLIGGLN). If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(SGLIGGL) = 1.
	0.30	0.70	0.43		
	Combined	Combined Liklihood Ratios			
L(SLM) 0.25	L(LOW) 1.00	L(SLM LOW) 1.00	L(LOWISLM)		
L(GGL) 0.43	L(SGL) 0.43	L(GGL SGL)	L(SGL GGL) 0.43		
A	hich In-Tank Condition	Which In-Tank Condition Applies? (Mark X in Box)	Box)		
SLM & No LOW?			×		
SLM & LOW; LOW IT	SLM & LOW; SLM most important? (Mark Part 4 NA) SLM & LOW; LOW most important? (Mark Part 5 NA)	k Part 6 NA)			
In-Tank Liklihood Ratio			(SLM,LOW)		F SLM and on LOW L(SLM LOW) = L(SLM) If LOW and on SLM LCM(LOW) = L(CLM) = L(CLM) If SLM and LOW and SLM most important. L(SLM,LOW) = L(SLM,COW) = L
W	hich Ev Tank Conditi	Which Ev. Tank Condition Annies ? Mark Y in Box	0.25		
		and Samuel . Sounded	(vac		
SGL & No GGL?			;		
GGL & SGL; SGL mc	GGL & SGL; GGL most important? (Mark Part 8 NA) GGL & SGL; SGL most important? (Mark Part 9 NA)	Part 8 NA)	×		
Ex-Tank Liklihood Ratio			L(SGL,GGL)		FGGL and an SGL L(SGL,GGL) = L(GGL) F(SGL,GGL) = L(SGL,GGL) + L(GGL) F(SGL, and SGL, and GGL, and GGL, and GGL, and GGL, and GGL, and SGL, an
			0.18		
Combined Likelihood Ratio for Leak Hypothesis			L(in,ex)		Γ(ω' ων) = Γ(ΒΓΜΤΟΝ) Σ-Γ(ΒΘΓ'ΘΘΓ)
			0.05		
	Posterior Probabil	Posterior Probability for Leak Hypothesis			
	p(L in,ex)	p(NL in,ex)	ď		Ω_1 = posterior (post-leak assessment) odds in flavor of leak hypothesis. Ω_1 = $U(n,s_2) \times \Omega_2$ p($L[n,s_3)$ = posterior probability (post-leak assessment) that the tank is a leaker. ($L[n,s_3]$ = $\Omega_2(\Omega_1+1)$ p($VL[n,s_3)$ = posterior probability (post-leak assessment) that the tank is a leaker. p($VL[n,s_3]$ = 1. p($L[n,s_3]$
	0.06	0.94	20.0		

Expert Opinion: Expert Opinion: J. G. Field

Elletation Date; U.G. Field Elletation from: U.G. Field Elletation by: Least-Assessment Team Hypothrases: The surface level decrease occurring between liter April and mid. July 1976 was due to the erespectation. The surface level decrease occurring between liter April and mid. July 1976 was due to the erespectation. Thus State in the Filtre State in the Ellipsod Fate in the Literature of the Ellipsod Fate in the Literature in the Literature in the Literature in the Conditional Probabilities Conditional Probabilities Conditional Probabilities Conditional Probabilities In-Tank Date Surface Level Messurement - Part 2 State State In the CELM schert In the CELM schert In the State In the CELM schert In the State In the St					Tank S	Tank SX-110 Leak Assessment Expert Elicitation Form 2010:06-16 (From HNF-3747, Rev. 0)	
1. G. Field Leak-Assessment Team Leak-Assessment Team The surface level decrease occurring between late April and mid July 1976 was due to the contained level decrease occurring between late April and mid July 1976 was due to be weight call to late late late. The surface level decrease occurring between late April and mid July 1976 was due to be weight call to the state of the probabilities. Conditional Probabilities In-Teak Data Surface Level Measurement - Part 2 April Data Surface Level Measurement - Part 2 In-Teak Data Surface Level Measurement - Part 2 In-Teak Data Liquid Observation Well - Part 3 In-Teak Data Liquid Data Liquid Deservation Well - Part 3 In-Teak Data Liquid Data Liquid Deservation Well - Part 3 In-Teak Data Liquid Data Liquid Deservation Well - Part 3 In-Teak Data Liquid Data Liquid Deservation Well - Part 3 In-Teak Data Liquid Data Liquid Deservation Well - Part 3							
Leak Assessment Team The surface lawl decrease occurring between late April and mid July 1976 was due to the curtor real effects or systemethem at a lark helek. The surface lawl decrease occurring between late April and mid July 1976 was due to everycration. The surface lawl decrease occurring between late April and mid July 1976 was due to everycration. The surface lawl decrease occurring between late April and mid July 1976 was due to everycration. Conditional Probabilities Conditional Probabilities In-Tenk Data Surface Lawel Measurement - Part 2 In-Tenk Data Liquid Observation Well - Part 3		6/16/2010					
The surface level decrease occurring between late April and mid. July 1976 was due to the contained bed offerease occurring between late April and mid. July 1976 was due to evergoration. The surface level decrease occurring between late April and mid. July 1976 was due to evergoration. L Thue State Photosibility - Part 1 L:/L Conditional Probabilities Conditional Probabilities In-Trink Data Surface Level Measurement - Part 2 Policy Policy Policy Part 3 Policy Policy Part 4		J. G. Field					
The surface level decrease occurring between late April and mid July 1976 was due to the control and decrease occurring between late April and mid July 1976 was due to evaporation. The surface level decrease occurring between late April and mid July 1976 was due to evaporation. Conditional Probabilities Conditional Probabilities Conditional Probabilities Conditional Probabilities Conditional Probabilities In-Tank Data Surface Level Measurement - Part 2 Surface Level (Inno Low) arter NA p(SLMIL.) Sourface Level (Inno Low) arter NA p(SLMIL.) Liquid Observation (Inno Low) arter NA p(Low)NL.) Liquid Observation (Inno Low) arter NA and 5) Liquid Observation (Inno Low) arter NA p(Low)NL.) Liquid Observation (Inno Low) arter NA and 5)		Leak Assessment Tear	E.				
The surface lawd decrease occurring between late April and mid July 1976 was due to respect after and a tank held. The surface lawd decrease occurring between late April and mid July 1976 was due to evepcration. True State NLL NLL Likilhood Ratio Conditional Probability - Part 1 Likilhood Ratio Likilhood Ratio Conditional Probabilities D40 150 Conditional Probabilities Conditional Probabilities Conditional Probabilities D50 150 Surface Level (Inn SUM, enter NA Weasurement - Part 2 Surface Level (Inn SUM, enter NA enter NA Weasurement D10 D90 D11 Liquid Observation (Inn CUVILL) D10 D11 D10	lypotheses:						
Prior Probability - Part 1 True State		The surface lavel decri- combined effects of av-	ease occurring between aperation and a tank lea	ate April	1976 was due to the		
Prior Probability - Part 1 State NIL LINIL LINIL 0.40 1.50 Probabilities vel Measurement - Part 2 p(SLM NL) 0.90 0.11 bservation Well - Part 3 p(LOW) NL L(LOW)		The surface lavel decry evaporation.	ease occurring between	late April and mid July	1976 was due to		
Probabilities			o o	nor Prohability . Part			
NIL			TrueS	state			
P(NL) Cb 1.50 1.50 Probabilities Probabilities Probabilities Probabilities					L:N		
150 150			(1)d	p(NL)	đ	SX tanks in:tuding SX-110 received hid PEDOX weste. SX farm tanks surrounding SX-110 confirmed to have leaked (SX-107, 106, 111, 113.114).	$p(\lambda)$ = "prior" probability that an assumed sound task has leaded given only the prices of information: it is a single-electric variable with the probability assuments an approximation of the properties of the probability that an assumed sound task has not leaded given the same data, $p(M_{\rm eff} = - p(\lambda))$ and of data if from other leads $p(M_{\rm eff} = - p(\lambda))$ and of the lead is problemate. (by = $p(\lambda)p(M_{\rm eff})$
Probabilities evel Measurement - Part 2 p(SLM NL) L(SLM) bservation Well - Part 3 p(LOW NL) L(COW)			0.60	070	9 1		
Probabilities pvElMiRL) pvELMIRL) 0.90 0.11 pcLOW/IRL) p(LOW/IRL) L(SLMi L(SLMi L(SLMi L(SLMi L(SLMi L(SLMi L(SLMi L(LOW)			800	25	3		
p(SLM NL) L(SLM) 0.90 0.11 bservation Well - Part 3 p(LOW) NL) L(SLM)			Conditional	Probabilities			
pvel Measurement - Part 2 pvSLM NL) 0.90 0.11 bservation Well - Part 3 pv(LOVV NL.) L(LOW)							
p(SLM NL) L(SLM: 0.90 0.11 bservation Well - Part 3 p(LOW NL.) L(LOW)		Ē	-Tank Data Surface Lev	vel Measurement - Pa	rt 2		
090 bservation Well - Part 3 p(LOW NL)		Surface Level Measurement	p(SLNIL) (II no SLM, enter NA here and in Perts 4 and 5)	p(SLMIML)	(KS.M)	The 0.75 inch surface level decrease is accounted for by evaluoration beload on tank lempe sture measurements at the time of the beforease. At flow restable in enough surface in photos and could have impected measurements. Manual tape measurements reported erratio reading during this period. "We settler evaluations concluded the surface level floring this period." Two settler evaluations concluded the surface level floring this period. "We settler evaluations concluded the surface level."	The 0.75 inch surface level decrease is accounted for by weapondion between the surface level decreases. At flow resulted on a rough surface in photos and could not meeting the surface level decrease. At flow resulted on a rough surface in photos and could not meeting measurements. Natura tape measurements reported erratio readings on lasks, p(SLML) = 1-p(SLML). L(SLML) = 1-p(SLML). L(SLML) = p(SLML) is undersulted in a single wealth of the surface wheel this are not available for the less assessment, then L(SLM) = 1-p(SLML). L(SLML) = p(SLML) is undersulted are available for the less assessment, then L(SLM) = 1-p(SLML). The table is a single wealth of a size of by a tank halk. If these are several sessitility when an available for the less assessment, then L(SLM) = 1-p(SLML). The possible is a size of the surface when the size of the surface with the size of the surface when the size of the size of the surface when the size of the s
bservation Well - Part 3			0.10	06:0	0.11		
p(Lowjal.)			In-Tank Data Liquid Ob	servation Well - Part	8		
		Liquid Observation Viell	pitOW L) (ifno LCW, erfer NA. here ard in Ports 4. and 5)	p(LOW]NL)	ר(רסאי		Considering the intensital ajud level data received for the leak assessment: p. (LVV) = [*posterior*] probability that the LOV intentifial liquid level data would be observed, if the tank is a p. (LOVVIX) = [*posterior*] probability that the LOV intentifial liquid level cata would be observed, if the tank is not a leaker. p. (LOVVIX) = [*p. (LOVVIX)]. [*LOVOX*] p. (COVLY) p. (COVLY) p. (LOV intentifial liquid level data are not available for the lask assessment, then (LOV) = 1.
NA NA 1.00			NA	NA	1.00		

Surface Level Measurement - Liquid Observation Well Interdependence					Considering that intank date source may be intendependent:
Surface Level Meaning Observed On Liquid Observed On Interdependence					Considering that intank data sources may be intendependent:
Surface Level Measurement: Liquid Observation Interdependence			-		
Measurement - Liquid Overation Interdependence					p(SLMILOWX).) = ['posterior'] probability that the surface level measurement data would be observed if the LOW interstrial liquid level data are observed, and if the tank is a leaker.
Well Interdependence	p(SLM LOW,L)	p(SLM LOW,NL)	L(SLMILOW)		$p(SLMLOW,M_s) = [$ posterior] publishing that a surface level measurement data would be observed if the LOW intensitial liquid level measurement data are observed, and if the tank is a non-leaker. $p(SLMLOW,M_s) = 1$.
Interdependence					p(3kMkDW,k)
					L(SLMLOW) = p(SLMLOW/L)p(SLMLOW)NL). If either surface level resaurement data or LOW intersitial liquid level data are not available for the leak assessment, it en L(SLMLOW) = 1.
					If there is no LOW, skip to the next part.
	NA.	NA	1.03		
Liquid Observat	Liquid Observation Well - Surface Level Measurement Interdependence - Part 5	Measurement Interde	ependence - Part 5		
					Considering that intenk date sources may be intendependent:
					p(LOWISLMLL) = ["posterior"] probability that the LOW interstitial liquid level gata would be observed if a surface level measurement decreased in observed, and if the tank is a leaker.
Liquid Observation Well - Surface Level Measurement	p(LOW SLM,L)	p(now[stm,nt)	L(LOWISLM)		p.(LOWISUA.NL.) = ("posterior") probability that a LOW/intensisal legici fereil messurment decrease would be observed of a surface Level missurement decrease is abserved, and if the "ank is a non-leaker, p.(LOWISLA.NL.)
Interdependence					= 1 ppuccessance, L(LOWISINg = ptc.WELM LXPLOWISILLVM). If either surface level data or LOW intensitial liquid level data are not evaluable for the lask sessessment, then LUCOWISILDs = 1.
					If there is no surface
	¥.	NA.	1.00		
8	Ex-Tank Data - Gross Gamma Drywell Logs - Part 6	mma Drywel Logs - P	arte		
					Considering to historical constraints of forms of forms and make the first has been recent
Gross Gamma	p(5GLJL) (if no GGL, enter NA	p(GGLINL)	(1997)	No evidence of activity in drywells or laterals except low activity at the end of lateral at a thributed to SK-111. Laterals under the tank should have shown between an articles of the strong transfer of the strong transfer.	PCOURT Prosterior probability that the gross gamens logs would be charmed, if he tend is a leaker
Drywell Logs	nere and in Parts a			higher levels of activity as was abserved for other SX farm tathes it a leak occurred. However laterals could have missed a small halk.	POCKETAL = 1 procedul presenty than original presents that the book several, a treatment or a more resent procedul = 1 procedul presents that the procedul procedul presents the procedul procedul presents the procedul procedul presents the procedul procedu
	07.0	0.80	0.20		
ž u	Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7	amma Drywell Logs -	Part 7		
Spectral Gamma Drywell Logs	p(SGL)L) (if no SGL, enfor NA here and in Parts 8 and 9)	p(SGLINL)	(205)	SQLS s nowed to drywell evidence of a leak, but drywels are limited and may have missed the plume.	Considering the special garway already logs reviewed for the leak assessment: Profile Protection probability that the special garway dynell logs vanid has decreved, if the track is a PSSLEAL Protection protection processing that is a profile garway dynell logs vanid has observed, if the track is a new PSSLEAL Protection protection processing that is a profile garway dynell logs when the above to the profile Past PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL Past PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSLEAL PSSL
	0.30	0.70	0.43		
and and a	Gross Gamma Log - Spectral Gamma Log Interdependence - Part R	mms Loo Interdepend	ence - Part B		
					Considering has exclused data searches may be intendesentant
Gross Garma Log- Spectral Garma Log Interdependence	b(GGL SGL.L)	p(eer ser.nr.)	(168/169/1		FOCULOCAL.) = [Posterior] probability that ne gross garmin logs would be observed if the spectral sparmes logs are an observed, and first the tris is whelst. The process garmin logs are observed, and first the business process garmina logs would be observed if the spectral sparmes logs are determed, and first task as a constraint on the group logical, but a re-produced and first task as a constraint on the group logical, but a re-produced and first task as a constraint on the group logical and and a constraint of the group logical and a property of the group logic
					L(COLISOL) = p(COLISOL). Up(COLISOLM). I taken gers gamena logs or spectral gamena logs are not evalable for the leak assessment, then L(COLISOL) = 1.
	ΔĀ	¥Z.	1.03		

					Considering that exitank data sources may be interdependent.
Spettral Gamma Log - Gross Gamma Log Interdependence	p(S6. G6.L)	MSSCHGGL,NL)	(19911991)	inches garman in Anywike and state was occurred to the control to	
	090	0.50	1.00		
	Combined	Combined Likilhood Ratios			
L(SUM) 0.11	100 (100 kg)	(staltow)	L(LOWISLM) 1.00		
920 (1007)	L(8GL) 0.43	njagukau.)	L(SOLJCGL)		
3	hich In-Tank Condition	Which In-Tank Condition Applies? (Mark X in Box)	Borl		
			×		
LOW & No SLM? SLM & LOW; SLM most important? (Mark Part 4 NA)	ost important? (Mark	Part 4 NA)			
SLM & LOW; LOW r	SLM & LOW; LOW most important? (Mark Part 5 NA)	k Part 6 NA)			
In-Tank Liklihood Ratio			ר(פרשירםא)		WOTH NOWTHEN SOUTHEN TO WATER TO WITH WE WAS TO WE WAS TO WE WAS TO WOTH WAS TO WOTH WOTH WOTH WOTH WOTH WOTH WOTH W
			0.11		
W	hich Ex-Tank Conditi	Which Ex-Tink Condition Applies? (Mark X in Box)	Box)		
CGL & No SGL?					
GGL & SGL; GGL most important? (Mark Part 9 NA) GGL & SGL; SGL most important? (Mark Part 9 NA)	ost important? (Mark ost important? (Mark	Part 8 NA) Part 9 NA)	×		
Ex-Truk Likilhood Radio			(801'001)		(1967) 1 (1959) 601 - (196 - 196) 1 statutus satu 10 504 16 (8 18 10 10 10 10 10 10 10 10 10 10 10 10 10
			0.25		
Combined Likelihood Ratio for			L(in,et)		r(uwi) = r(Sru(row) = r(Sgr(ogr)
Leas riypotheses			0.03		
	Posterior Probabil	Posterior Probability for Leak Hypothesis			
	p(L in,ex)	p(NLJin,ex)	ď		On position goes has assessment sets in these of that hypothesis. On the color is Ω_0 polyton of polyton of the sets as taken (BLOGS 10,01), Ω_0 polyton of π potent or probability (contain assessment) that the task is taken π polyton (π, π) polyton of π polyton (π, π) polyton $(\pi$

Expert Opinion: Expert Opinion: M. A. Fish

				Tank S	Tank SX-110 Leak Assessment Expert Elicitation Form 2010-06-16 (From HNF-3747, Rev. 0)	
Elicitation Date:	6/16/2010					
Elicitation from:	M. A. Fish					
Eliciation by:	Leak Assessment Team	Ε				
Hypotheses:						
Leaker:	The surface lavel decri-	The surface lawd decrease occurring between late April and mid July 1976 was due to the control of electrons of a lank leek.	I late April and mid July ak.	1976 was due to the		
Non-Leaker:	The surface laval decrevence evaporation.	The surface laws decrease occurring between late April and mid July 1976 was due to evaporation.	late April and mid July	1976 was due to		
			Prior Probability - Part 1	13		
			True Stats	Liklihood Ratio		
		(1)d	P(NL)	ਰੂੰ ਫ	This was a high hear tank in SK farm. As other trigh heat tanks in the SK-107 to SK-115 series have leaked there is a better than even chance that this tank also leaked.	$F(\xi)$ = "Yelov probability that are assumed sound tank has leaked given only two pieces of information: it is a single-bestlank, and in either a significant or or M . Any specific data one past surface level drops or extent referenceds are ground. Fig. 10 or 21 workship that in assumed sound tank has not leaked given the same data, $F(R_{\rm B}) = - F(\xi)$. Fig. 10 professor from other least apportant. $G(R_{\rm B}) = - F(\xi)$
		900	0.35	981		
		•				
		Conditional	Conditional Procabilities			
	5	In-Tank Data Surface Level Measurement - Part 2	evel Measurement - Pa	art 2		
	Surface Level Measurement	p(SLM L) (II no SLM, enter NA here and in Parts 4 and 5)	p(SLM[ML)	ПSIM	The surface level measurement decrease is very likely to be caused by avaparation and not a stark leak. Recent evaporation cidicultiture based on the mistorical data can account for all of the level drop in 1976.	Consoloring the surface level measurement ofta reviewed for the leak assessment $\varphi(SLM, j = \Gamma)$ posts to Γ probability that the surface level measurement data would be observed, if the rank is a leafur. FigSLM(4,j = Γ) costsory probability that the surface level measurement of the would be observed, if the task is a non-issker, $\varphi(SLM(M)) = \Gamma \cdot \varphi(SLM(M))$. If or face level dist are not available for the leak assessment, then $\Gamma(SLX) = \Gamma$ if there are several resecutions at sortically videorized sortice level for reacurements (e.g. $ENGX^2$, FIC , MT), the probabilities should be exerced to the new reversal configuration and reliable or one.
		0.20	080	0.25		
		In-Tank Data Liquid Observation Well - Part 3	bservation Well - Par	8		
	Liquid Observation Well	Liquid Observation (if no LCW, ertler NA, bere ard in Perts 4 and 5)	p(Lowinl.)	רורסאט	NA	Considering the intensible input level data reviewed for the lear assessment: PLOWIL) = ["posterior"] probability that the LOW intensitial licuid level data would be cleared, if the tank is a leafer. PLOWIND = ["posterior"] probability that it is _OV/ intensitial liquid level cata would be observed, if the tank is not a leaker, IPLOWIND = 1 - IPLOWIN.) LLOW = IPLOWIND = V - IPLOWIND = V - IPLOW intensitial liquid level data are not available for the liak assessment, then LLOW = 1
		NA	NA	1.00		

SULISCO Level M	ascrement - Liquid Or	Servation Well Interd	Aveil interdependence - Fart 4		Considering that in-tank date sources may be intendedent
Surface Level					p(SURLOW),) = [notation] probability that the surface level measurement data would be observed if the LOW intestitial liquid level data are observed, and if the task is a leaker.
Measurement - Liquid Observation Well	p(SLM LOW,L) (if no LOW, enter NA)	p(SLM LOW,NL)	(worlwis)	NA	$\rho(SMCOW)M$ is "postered" prohibiting that a sortice livel measurement data vosible be observed first LOW interstituting level measurement data are observed, and if the task is a non-leak or $\rho(DMCOW)M_{\rm C} = 1$.
Intercependence					L(SLMLDW) = p(SLMLDWLV) p(SLMLDWVNL) If either surface limit in easurement data or LOW intensitival liquid front data are not available for the leak assurants, then $L(SLMLDW) = 1$.
	NA	NA	1.00		If there is no LOW, akip to the next part.
frequency Disease	Then in the second of the second seco	Measurement Interd	and		
		The same of the sa	o vie - acceptance		Considering that intank data sources may be intendependent:
Liquid Observation Well - Surface Level Measurement	p(Low[SLM,L)	p(row srm.nl.)	(KTOWISTW)	NJA.	Anaching that have an every every proportional specification of a subject physical proportion of a property of a subject physical property of the party is a least of the proportional property determined for the party is a least of the party of the part
Intercependence					CLOMISSIAR PROMISSIAND PROMISSIAND. Herbut surface level data or LOW let enite all liquid level data are not available for the label accessment. Then LCOMISSURJ = 1.
					If there is ne surface
	NA.	Š.	1.00		
Ě	Ex-Tank Data - Gross Gamma Drywell Logs - Part 6	mma Drywell Logs - P	Part 6		
Gross Gamma Drywell Logs	pt GGLL) (if no GGL, order NA here and in Parts 8 and 9)	p(GGLPL.)	(1661)	The Gross Gamma logs and Lateral Logs provide little evidence of a tank waste beautiful controlled to the fact of the standard controlled to the fact and foreign to institute to a leading sink. Low level parms -ray additive found in one dry well (4-107-07) and at the end of one leanns (44-10-07) is also, to have come from SX-107 leak.	Considering to Published gress general drywell logs studies for the label exsessment: \$\(\text{POOLILE} = \text{Posterior}\)\$ probablish that the gress general logs would be observed, if the stud is a near-taken \$\text{POOLILE}\) = \(\text{Posterior}\)\$ probablish that the gress general logs would be observed, if the stud is a near-taken \$\text{POOLILE}\) = \(\text{POOLILE}\) = \(\text{POOLILE}\). \$\(\text{POOLILE}\) = \(\text{POOLILE}\), if gress general logs we retilied for the back assessment. Fine \$\text{LQOOL}\) = \(\text{LQOOLILE}\).
	0.15	0.85	0.18		
	Total Cate Canada Canada Canada Cate Cate Cate Cate Cate Cate Cate Cat	Doored Local	Dart 7		
Spectral Gamma Drywell Logs	(If no SGL, enter NA, here and in Parts 8 and 9)	p(SGLPL)	(108)11	As the Gross Garrers logs cover a much larger period than the Spacified are constructed from Logs grown but for forces garrens larger results. Heree executions is at its restorted from special garrens region is executed in the special garrens region is executed in the special garrens region in the special garrens of the special garrens region in the special garrens i	Considering the specifiel garmina. By well logs reviewed for the leak assessment: \$\psign(SQLL) = ["societion"]\$ pickability that the specifiel garmina deposit logs vectod loss observed, if the tarm's is a sub- \$\psign(SQLL) = ["societion"]\$ is absolutely that the specifiel garmina deposit logs vectod loss due eved, if the leak is a non- **Leaker, \$\psign(SQLR) = (-\psign(SQLL))\$ if specifiel garmina deposit logs was not available for the leaker sub- \$\psign(SQLL) = \psign(SQLL))\$ if specifiel garmina deposit logs was not available for the leaker sub- \$\psign(SQLL) = \psign(SQLL))\$ if specifiel garmina deposit logs was not available for the leaker sub- \$\psign(SQL) = \psign(SQLL))\$ if specifiel garmina deposit logs was not available for the latest sub- \$\psign(SQL) = \psign(SQLL))\$ if specifiel garmina deposit logs was not available for the latest sub- \$\psign(SQL) = \psign(SQLL))\$ if specifiel garmina deposit logs was not available for the latest sub- \$\psign(SQL) = \psign(SQLL))\$ if specifiel garmina deposit logs we not available for the latest sub- \$\psign(SQLL) = \psign(SQLL))\$ if specifiel garmina deposit logs we not available for the latest sub- \$\psign(SQLL) = \psign(SQLL))\$ if specifiel garmina deposit logs we not available for the latest sub- \$\psign(SQLL) = \psign(SQLL) = \psign(SQLL
	0.50	0.50	1.00		
Gross Gar	Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8	rma Log Interdepend	dence - Part 8		
Gross Gamma Log - Spectral Gamma Log Interdependence	b(GGL SGL.L)	p(eerlser'nr)	(100F 100F)	N/A	Considering that extent data scores may be interdependent. gloculosul, a pressure pression in the training of the operated gramma logs as are covered inthe spectral gramma logs as are observed, and fine task is a time to gloculosul, the property of the spectral gramma logs are are covered, and fine task is a sen inter. The gloculosule is property gramma logs are determined, and fine a ground gramma logs are spectral gramma logs. The fine gramma logs are spectral gramma logs are found and the second gramma logs are found from the second gramma logs are found gramma logs are found from the second gramma logs are found gramma logs are gramma logs.
	NA	NA	1.00		

Spectral Ga	amma Log - Gross Gi	Spectral Gamms Log - Gross Gamma Log Interdependence - Part 9	ence - Part 9		
Spectral Gamma Log - Gross Gamma Log Interdependence	KSGL GGL,L)	p(SGL(GGL,NL)	(1897)991)	The corrolation between the gross garmine log and specifial garma log is not considered histogram or indicative in this case.	Considering Viscos and an extent data section may be interpreted in the great grown a program or prevently and the time is a trace. The section grown bigs would be observed if the great grown a logs are or between dark first first as a trace. The section grown lays would be observed if the great grown logs are are decreased, and first laws for a but to section grown lays would be observed if the great grown program are decreased, and first law for a the section grown lays would be observed in the program of the section of the section of the section of the section of the program of the section of the section of the section of the section of the program of the section of the program of the section of the sectio
	0.50	09'0	1.00		
	Combined	Combined Likilhood Ratios			
L(SLM) 0.26	L(LOW)	L(SLMILOW)	1.00 1.00		
L(GGL) 0.18	1,00 1,00	1.00	1:00 1:00		
, in	rich in-Tank Conditio	Which in-Tank Condition Applies? (Mark X in Box)	Jox		
			×		
LOW & No SLM? SLM & LOW; SLM most important? (Mark Part 4 NA)	st important? (Mark	Part 4 NA)			
SLM & LOW; LOW most important? (Mark Part 6 NA)	ost important? (Man	Part b NA)			
In-Tank Likilhood Ratio			r(stw/row)		Y SUM work to LOVY. LISTALLOWS & LISTAN If LOW work to SUM, LISTALLOWS & LLOW SUM, SUM, SUM, SUM, SUM, SUM, SUM, SUM,
			0.25		
	Which Ex-Tank Condition Applies?	on Applies? (Mark X in Box)	Box)		
SGL & No GGL?					
GGL & SGL; GGL most important? (Mark Part 9 NA) GGL & SGL; SGL most important? (Mark Part 9 NA)	st important? (Mark st important? (Mark f	Part 8 NA)	×	Much more available Gross Gama log information. Hence GGL information is considered more important.	
Ex-Tank Likilhood Ratio			(831,661)		רופסיי) אייר (מפיר מופסיי) אייר (מפיר מפיר מפיר מפיר מפיר מפיר מפיר מפיר
			0.18		
Combined Likelihood Ratio for			L(in.ex)		760-71 = FERWIOW) = FERMION = FERMIO
			0.04		
	Posterior Probability for Leak	ty for Leak Hypothesis			
	b(L∥n,ex)	p(NLJin,ex)	đ		Ch. a posterior (post teat accessorency) and in a foot of teat hypothesis. Ch. Liftures) is Co. a posterior pobability (past-sak a sessormed) that the tank is a leader. Clinc and = Ch.(Ch.+1) plulin, any = posterior probability (post-less accessorency) that the tank is a leader. Policin at 1 - plulin, any plulin, any
	0.08	0.92	0.08		

Expert Opinion: D. G. Harlow

Elicitation Date: Elicitation from:						
licitation Date: licitation from:						
licitation from:	6/16/2010					
	D. G. Harlow					
Eliciation by:	Leak Assessment Team	н				
Hypotheses:						
Leaker:	The surface lavel decri- combined effects of av-	The surface lavel decrease occurring between late April conton ed effects of evegoration and a lank leak.	late April and mid July ak.	and mid July 1976 was due to the		
Non-Leaker:	The surface lavel decnevage evaporation.	The surface laws decrease occurring between late April evepcration.		and mid July 1976 was due to		
		a	Prior Probability - Part	-		
		True State	State	Liklihood Ratio		
		7	뉟	L:NL		
		(1)d	p(NL.)	đ	Tenk SX-* 10 boiling REDOX HLW. Several SX Farm tenks have leeked.	F() = 'prior' probability that are assumed sound tank has leaked given only two prices of information: it is a supplies that that is only a facility or a supplies or necessarily are supplies or that indeastining are supurments are ignored. Fig. 1) = "prior" indeasting measurements are ignored. G ₀ = "prior" indeasting that in assumed sound tank has not leaked given the same data, F(NLL = "p(L) C0 = "prior" odds or favor of the ties is hypothesis. (Ver p(L) P(D(L))
		990	0.35	186		
		i di la constanti di la consta	Consideration Description			
			L CO a DIIII C S			
	5	In-Tank Data Surface Level Measurement - Part 2	vel Measurement - Pa	ut 2		
	Surface Level Measurement	p(SLNIL) (II no SLM, enter NA here and in Parts 4 and 5)	p(SLMINL.)	ILSLM	An evaporation cedulation indicated that the entire figural level decrease from April 21 to July 21 to July 2 a eccounted 5 to by evaporation. Operation of all 11/11 sirrulations cause of popp surface conditions which could explain the C.75-rownek (quid level corpasse in late June 197). Notes with the name tape 'eading data sheet indicated clifficulty in otta ning consistent quid level and eadings. The sink was considered sound for confinued use in CR-76-81 for the late June I quid level decrease.	Considering the surface level restauranter data reviewed for the liab assessment the pstaud.) = ["posts ion"] probability that this surface level measurement data would be preserved, if the "anh is a leader." FIGSLAM != ["posts ion"] probability that the surface level measurement data would be observed, first state is pstaudisher, pstaudityly [SLMpHU] = 1 -pstaudity, that the surface level measurement data would be observed, then LQSLM) = 1 (SLMp = pstaudityly) [SLMpHU] if surface level data are not an arealable for the lesk assessment, then LQSLM) = 1 (If these are severes a severally reduce at states level measurements (e.g., EMRA?, RO, MT), the probabilities include by sessess a for its the more dayout and reliable one.
		0.10	06:0	0.11		
		In-Tank Data Liquid Observation Well - Part 3	bservation Well - Part	8		
	Liquid Observation Viell	DILOWIL) Liquid Observation (if no LOW, erfer IAA Neal here and in Parts 4 and 5)	p(LOWINL.)	ר(רסאי)		Considering the intersital ajud jurel data reviewed for the lax assessment: \$\begin{align*} \text{\$\text{\$\$}}\end{align*} \text{\$\$} \] \$\text{\$\$\$} \text{\$\$} \$
		NA	NA	1.00		

Surface Level M	Surface Level Measurement - Liquid Observation	Observation Well Interd	Well interdependence - Part 4		
Surface Level				the state of the s	Consistent that instance case sources may be reterepredient. Consistent that instances case sources may be reterepredient. Pp(CMA) = "[posterior"] probability that the surface level measurement data would be observed if the LOW.
Messurement - Liquid Observation Well	p(SUMLOW.L) (if no LOW, enter NA)	p(SLM LOW,NL)	L(SLMILOW)	Manual Company	p(SURLOVAL) = ['postnior'] pecability that is evoluce level measurement data would be observed if the LOW intential liquid roof measurement than are observed, and if he task is a non-leafers. p(SUMLOVA'NL) = 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1
Interdependence				The state of the s	LISTARLOW) = p(SLABLOW LIPESUAL OW ALL). If either sudder level measurement data or LOW intersitable input little level data are on solitions for the leak altersorement, then LISLARLOW) = 1.
	NA,	N.A.	1.00		in their is not. Owe, saip to the next part.
			1		
aviered object	Light Conservation west - oursess reversivement interesting to the	Display in the man in the second in the seco	e bendende - Fari o	Con	Considering that in tunk cata sources may be interdependent:
				D.H.C.	ph.CWSLM.L.) = ["sorterior"] probability that the LCW interestical liquid level data would be observed if a surface level measurement decrease is observed, and if the tank is a leaker.
Well - Surface Level	(if no SLM, enter NA)	p(LOW]SLM,NL)	L(LOW SLM)	PUCO	pit.COWISUA(N) = [your Hole"] pro bability that is LOW intensitial fquid heel measurement decrease would be a fair med for surface level measurement decrease is observed, and if the tank is a non-leaker. pit.COWISUA(N),
interdependence				True Control C	LLCOWSIDD, = PQLOMSIDALIDELOMSIDALARI. If either surface level state or LDW interestrial liquid front data are not evabled for the access recent, then LLCOW/SIDD; = 1.
	NA	NA	1.00		
Ü	Ex-Tank Data - Gross Gamma Drywell Logs - Part 6	amma Drywell Logs - P	art6		
Grees Gamma Drywell Logs	p(GGL L) (If no GGL, enter N4, here and in Perts 8 and 9)	p(GGL NL.)	ר(פפר)	Considerly the historical gard drywalls did not take any indication that the tank was proceed, a present and a system as a part of the state of the	Considering the historical gross garman seyved to the leak extrement of the leak extrement; the stark is a teaker, p(OOCLE) if [partering] probability final the gross garman logs would be observed, of the tank is a teaker. p(OOCLE) if probability that the gross garman logs would be observed, of the tank is a non-teaker p(OOCLE) if probability that the gross garman logs are not evenible for the leak basessmeal, than L(OOL) = L(OOL) = p(OOLLE)/p(OOLLE).
	0.20	0.80	0.25		
×	Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7	Samma Drywell Logs -	Part 7		
Spectral Gamma Drywel Logs	p(SGL L) (If no SGL, enfer NA Pere and in Parts 8 and 9)	p(SGL NL)		Coros garmine logs of the lateries and drywels cover the period in question and legs of the state of the SGLS which are performed later and only a feature occur, the drywels.	Considering the spectral soronal drywall age shokewed for the least accession and proposally a "procession") probability that the spectral garmen drywall lags would be observed. The last is a reader "procession" probability that the spectral garmen drywall lags would be observed, if the task is a near "sector "procession" in the spectral garmen drywall lags are not available for the last essentment, then LGGGL," procession.
	0.10	0.50	0.11		
50 mm o c c c c c c c c c c c c c c c c c	Gross Gamma Log - Spectral Gamma Log Interdependence - Part B	amma Log Interdesend	ence - Par		
				Can	Considering that extents data sources may be intendependent.
Gross Gamma Log Spectral Gamma Log Interdependence	(GGC SGL.L)	p(GGL SGL,NL)	(198TS97)	Texas DOJT JODI Bibli DOJd DOJd	prijectical, y "personal" prohibitor, you the grees general loga would be deserved. The special gamens ting are are observed, and it is that is a hankle to the property of the property of the special gamens frogs are conserved, and the work is a reviewer projectical plant, in "projectical," a frog that conserved, and the work is a reviewer projectical plant, in "projectical," and projectical plant group projectical, by conserved and a plant group gamens but or spectral gamens but are not areals for this leads assertment, the LCG GCGCAL is, "the hours gamens but or spectral gamens but are not
	NA	NA	1.00		

	Log - Gross Garma pi			L(SLM)	L(GGL) 0.26	Which I	LOW & No SLM?	SLM & LOW; SLM most important? (Mark Part 4 NA) SLM & LOW; LOW most important? (Mark Part 5 NA)	In-Tank Likilhood Ratio		Which	GGL & No SGL?	GGL & SGL; GGL most important? (Mark Part 8 NA) GGL & SGL; SGL most important? (Mark Part 9 NA)	Ex-Tank Liklihood Ratio		Combined	Likelihood Ratio for Leak Hypothesis		Po	
	p(\$GL GGL,L)	0.50	Combined	L(LOW) 1.00	L(SGL) 0.11	Which In-Tank Condition Applies?		mportant? (Mark important? (Mark			Which Ex-Tank Candition Applies?		nportant? (Mark sportant? (Mark I						sterior Probabili	p(Llin,ex)
	MSGL(GGL,NL)	0.60	Combined Liklihood Ratios	L(SLMILOW)	L(GGL SGL)	on Applies? (Mark X in Box)		Part 4 NA) k Part 5 NA)			on Applies? (Mark X in Box)		Part 8 NA) Part 9 NA)						Posterior Probability for Leak Hypothesis	p(NLJin,ex)
	r(80r 66L)	1.00		L(LOWISLM)	L(saylaat)	30x)	¢		r(stm;cow)	0.11	Box)		×	L(SGL,GGL)	0.25		L(in,ex)	0.03		ď
	Orosa garren koja are considented more relarient to a tank SX-110 leak during. The period in question than the SGLS.												Gross germna most important.							
Considering that extend data sources may be idead openion: p(DCU,DCL,) = ['posterior'] probability that the spectral partmal logs would be observed if the gress gamma	Dept are obtained, and this test is a beaver. Dept are colorised, and This test is a beaver. Dept are we delivered, and first beautify then the specific garrent legs would be conserved that grown a popular set wherever, and the same is a non-basker, gold-GSG-AJA = 1 - pSG-GL/GG-LJ. Dept are we delivered, and first which is not beautiful garrent legs we repected garrent legs with the set of								If STAN and for the CONVERT ONLY ENGINEER (STAN ONLY ENGINEER ENGI					COST and SOST and S			L(n.ex) = L(SUMLOW) x L(SGL, GGL)			On e posterior (poot halk assessment) odds in fazor of leas hypotheria. On ELinca) x Oo pullan oo'n - posterior probability (post-halk assessment) that the tann is a leafer ("Unica) = Dalffin-ti) p(M.linca) = posterior probability (post-halk assessment) that the tank is a leafer in (M.Linca) = 1- p(M.Linca)

Expert Opinion: E. C. Shallman

				Tank S	Tank SX-110 Leak Assessment Expert Blicitation Form 2010-06-16 (From HNF-3747, Rev. 0)	
Elicitation Date:	0.102.010					
Eliciation by:	L. C. Orldman	8				
Hypotheses:						
Leaker:	The surface lavel decriping of an expectation of the control of th	The surface laws decrease occurring between late April and mid July 1976 was due to the contoured affacts or areaser after an a sark hear.	n late April and mid July ek.	1976 was due to the		
Non-Leaker:	The surface lavel decreevences	The surface lawk decrease occurring between late April and mid July 1978 was due to evencration.	late April and mid July	of eub sew 9761		
			Prior Probability - Part 1	7		
		True	True Stats	Liklihood Ratio		
		-	뉟	L:NL		
		(1)d	P(NL)	ਰੰ	Vary of the high-reat SX tanks have been shown to be leakers, and SX-110 was a high heat tank. As such, it is predisposed to be a leaker.	$P(\lambda) = Y_1 n n'$ pobability that are assumed sound take has leaded given only two prices of information: it is a single-deliation, and its either a high-heat rank or not. Any specific data on past surface heat depos or netant radioacting measurements are appropried. The surface population of the properties of the properties are not leaving given the same data. $p(NL) = -p(L)$ $D_0 = -p(L)$ and or data it has a specific size. $D_0 = -p(L)$ $P(L) = -p(L)$
		0.66	0.35	186		
		•				
		Conditional	Conditional Procabilities			
	<u>E</u>	In-Tank Data Surface Level Measurement - Part 2	evel Measurement - Pa	art 2		
	Surface Level Measurement	p(SLMIL) (If no SLM, enter NA. here and in Parts 4. and 5)	p(SLMIML)	rtsrwi	If the tank were actually leaking, the evacoration rates derived from the proporation study would not so closely match the base rates observed over the time period in question. Instead, the evaporation rates would be lower than the observed loss rates, which is not the case.	Core dering the surface level measurement data reviewed for the leak assessment. §SUM.) = [posts incr[preceability that the surface lever measurement data would be observed, if the rank is a leaker. §SUM.4.2. = [vosted] posteding that the surface level the examinent of the would be observed, fifth task is a non-lasker, p§SUM(3)=1-p[SUM(3)]=1-p[SUM(3)
		0.25	0.75	0.33		
		In-Tank Data Liquid O	In-Tank Data Liquid Observation Well - Part 3	13		
	Liquid Observation Viell	Liquid Observation (if no LCW, enter NA, Well here and in Pents 4 and 5)	p(Lowinl.)	רורסאט		Considering the interestical igual level data reviewed for the less assessment: \$\(\int \int \int \int \int \int \int \int
		NA	NA	1.00		

COLUMN PARTIES	Contract of the contract of th	on see Perel Management - Cidna Constructor and the see of the construction - Later	abandence - Late		
					Considering that initials data source may be interdependent.
Surface Level					p(SURLOVU))= [posterior] probability has the audice level measurement data would be observed if the LOW intensitial legate level data are observed, and if the task is a leases.
Measurement - Liquid Observation Well	p(SLM LOW,L) (if no LOW, erfer NA)	p(S.MILOW,NL.)	L(SUMILOW)		p(XMLON/NU) = ['patrior'] probability that a cultion level measurement distrincted libe observed if the LDW printedial again two inserted eath are conserved, and if the takin in a solicitater, p(SUMLON/NU) = 1 - printedial again to the conserved of the takin or a solicitater, p(SUMLON/NU) = 1 -
Interdependence					LSMLON) = $(SLMLOW, JN)SLMLOW, M$. If either ordice level measurement data or LOW interestival important and are until the level to the level and assessment, then LSDMLOM) = 1. If there is not 100W, why is the next part.
	NA	NA NA	1.00		
Liquid Observat	Liquid Observation Well - Surface Level Measurement Interdependence - Part 5	Measurement Interé	ependence - Part 5		
					Considering that locask data sources may be intendepredent:
Liquid Observation Well - Surface Level Measurement Interdependence	p(LOW)SLUL) (ifno SLM, erter NA)	p(LOW/SLARRL)	(rowistw)		representation of the property of all has an aware programmer of cleans in strateful and the has a water consent at select an extraorment occurred in produce that the consent decourance consent a restor and water consent occurred, and fraction is newhere the COPUS/MAI, consent as extraorment occurred, and fraction is newhere the proposition of the consent occurred. It is not new table to the restoration of the consent occurred to the consent occurred to the consent occurred to the consent occurred to the consent occurred to an one analysis for the loss occurrent the LLCP/GLM = 1.
	NA	NA	1.00		Il Dete is no sarface
á	1				
ú	Ex-Tank Data - Gross Garma Drywell Logs - Part 6	irma Orywell Logs - P	art 6		
Gross Gamma Drywell Logs	P(GGL L) (If no GGL, eather NA. here and in Parts 8 and 9)	(7d795)d	n(001)	The basis short intrib dynels were much too love to be indictible of it survivalles. In this own contribution of a surfix display sound to expect of the survival section and is decreased in \$2.110. Cartier, it is paid there have decourted in earlier received it is hely being old. Surface, such or migration of earlier received it is hely being old as table of surface of the implication of continuation tow labels then other tarks. The single lateral in subsidiary was a finished measurement with no adold received such or adolders in such as the inclined measurement with no adolders a suggesting that Sci 110 leader.	Conditions in this interest yours given by revent to the heat interestruct. Fig. 21,1 = Tracters of proceeding that the grous parmes lays would be debreased, of the last is a new high cold, and the process that we have the process that the pro
	0.20	0.80	0.25		
Ä	Ex-Tank Data - Spectral Ganma Drywell Logs - Part 7	amma Drywell Logs -	Part 7		
Spetral Gamma Orywell Logs	p(SOLL) (if no Sol., enter NA here and in Parts 8 and 0)	MSG(NT)	risor)	The vacority for the Gross Germa Digwell Logs applies to the Specifial Germa Logs are well. The poids surply aren't large enough to represent a task lest.	Constroing the special grows a faquett by restruction the back insensement. \$600.43 Printered Typich shall go at the special games or yeel topy used to chosened, if the task is a restrict or \$500.042 - Typich shall game the special games dryved by south to chosened, if the task is a restrict to \$500.042 - Typich shall game the special games dryved by south to chosened, if the task is a restrict to \$500.042 Typich shall games dryved bygs are not available for the task is supersoned, then \$1,000.042 Typich shall games dryved bygs are not available for the task is supersoned. Then
	0.20	0.80	0.25		
Gross Ga	Gross Gamma Log - Spectral Gamma Log Interdependence - Part B	mma Log interdepend	ence - Part 8		
					Considerion that exclass data sources may be interferended.
Gress Gamma Log - Spettral Gamma Log Interdependence	p(GG/SG**L)	p(60L 50L/L)	(1691)201)		PGAZSE, J.) "Determor probability to the general-parameter between desirend from specins persons polyziologi, via re-probability to the late in sinches polyziologi, via repetation for the properties of the probability of the person to probability of the probability of the probability of the person to JUSCAGO, «DOCAGO, »(DOCAGO,) for the pre-pre-pre-pre-pre-pre-pre-pre-pre- net has been executed to the probability of the pre- son that the pre-pre-pre-pre-pre-pre-pre-pre-pre-pre-
	NA.	NA	1.00		

LISELM) LISELM) 0.38 LICOLL & NO LOW? LOW & NO SLIM? LOW & NO SLIM? LOW & LOW; SLIM & SLIM & SCIL? MACALL GOLL Redio OGL & SCIL? WACALL SCIL GOLL OGL & SCIL; SCIL M COLL & SCIL SCIL SCIL SCIL M COLL & SCIL SCIL SCIL SCIL SCIL SCIL SCIL SCIL	Mhich Ex-7	1(50L,L) p(50L 00L,NL) Combined Likinosa Ratios Combined Likinosa Ratios COMMINES LISTANDON 100 200 100 200 100 200 100 200	C(©CL/OCL)	If the assumption is this the tank is leading, and the lateral idea is indicible of a last, fear, then we should be seeming corrobousion from the spectral gamma logs, but we are not seeming any solid corrobousion. There is a low chance of this if the tank were in fact a leasies:	Considering the state was assessing to excess may be received prevented by evolved by discovered if the grass gamma application. A plant are statement with the statement of the statement of the grass gamma application of the statement of the grass gamma application of the grass
Ex-Tank Likilhood Ratio			0.08 L(SGL,GGL)		F GOL wat no SGL, L(GOL,DGL) = L(GOL) F GOL wat SGL, and SGL, most reporter. L(SGL, GOL) = L(SGL, GOL) = L(GOL) F GOL wat SGL and SGL most reporter. L(SGL, GOL) = L(SGL, GOL) = L(GOL) F GOL wat SGL and SGL, most reporter.
Combined Likelihood Ratio for Leak Hypothesis	L.		L(in.ex)		Línea) = Lísbálový z Lísbálbol
	Posterior Probability for Leak	bility for Leak Hypothesis p(NLJIn.ex)			On was presented growth that access remain order in those of leash hypotheses. On Library is the picking of ρ in the problem of ρ is a constrained that the thriv is a leaser. (Alterial = $\Omega_{\rm p}(\Omega_{\rm p} + 1)$ picking ρ is posterior probability grost-half access access that the track is a leaser. (Alterial = $\Omega_{\rm p}(\Omega_{\rm p} + 1)$ picking ρ is posterior probability grost-half access stream of that the track is a leaser (Alterial = 1 picking ρ) in $\Omega_{\rm p}(\Omega_{\rm p} + 1)$
	0.05	0.95	0.05		

Expert Opinion: D. J. Washenfelder

				9	Tarin ox-110 Lean Assessment Expert Elicitation Form 20 10-00-10 (From HNF-3747, Rev. 0)		
Elicitation Date:	6/16/2010						
Elicitation from:	D. J. Washenfelder						
Eliciation by:	Leak Assessment Team	ш. —					
Hypotheses:							
Leaker:	The surface level decr	The surface level decrease occurring between late April and mid July 1978 was due to the combined affects of exeporation and a tank eak	n late April and mid July ak.	1976 was due to the			
Non-Leaker:	The surface level decreted	The surface level decrease occurring between late April and mid July 1976 was due to eveporation.	n late April and mid July	1976 was due to			
		_	Prior Probability - Part 1	- 5			
		u⊥	True State	Likiheod Ratio			
		_	¥	ij			
					This tark had been previously assessed and selemined to be sound. The tark was administratively sectored to be an Assumed Leaker in compliance with direction from the Dispartment of Energy.	Fig. 3 pice* probability that an assumed sounce that has lotated givin only two pieces of information: it is a energy and behalf in, and in them to high not service ment. May appear to stoom pool ourbace local drops on ex that siglicativity impagaments an intendet.	_
		(-)d	p(NL)	ପ	lowever, all of the other tanks in the south part of 241-3X tank farm - 3X-1C7-109, and SX-111-115, are desserted as healing tanks, including serveral that suffered categoria leaks. Affixight lank SX-110 operating history was afficient from these other tanks. Its association with this tank marker it association with this tank group makes it suspect without any unthair information being considered.	$p(M_j) = 'p_0 r'_f \ probability that it is assumed sound task has it is laived given the same data: \ p(M_j) = 'r_p(J_j) = 'p_0 r'_f \ p_0 r$	
		09'0	0,40	1.50			
		Conditional	Conditional Probabilities				
	_	C tred - tremerine Measurement - Part 2	Measurement - Pa	6			
						Considerable authors local management of the memoral for the last amagement	
	Surface Level Measurement	pKSLMIL) (If no SLM, onfor Nv. here and in Paris 4 and 5)	p(St. vj.NL.)	ГІЗЕМІ	The evergication analysis can account for most of the observed surface level FSLMM; a "possible" provisibly that a becrease. Horever, temperature cata available for the analysis do not seem sometizes the prosessing the analysis of not seem sometizes. Horever, temperature cata available for the analysis do not seem leave, analysis of consorted operating the analysis is now that to ESLMML; if such an analysis of processing of the love temperature difference between the LSLMM; if such a seed to most the needs pace temperature.	Considering the strate wort interactionant distriction on the overall seasonner. It is placed by that the surface ever measurement data would be observed, if the tank is a placed, at the surface interaction and an experimental distriction of probability that the surface interaction assurement data would be observed. If the tank is a point that the surface interaction measurement data would be observed. If the tank is a placed in the leak assessment, then LSLM) = I LSLM = PSLM(D)(D)(D)(D)(D)(D)(D)(D)(D)(D)(D)(D)(D)(7 7 7 8
		0.25	0.75	0.33			
		In-Tank Data Liquid O	In-Tank Data Liquid Observation Well - Part 3	m			
						Cons cering the intestitiel figuid level data sviewed for the leas assessment:	
	Liquid Observation Well	Liquid Observation (if no LOW, enter NA, here and in Parts 4 and 5)	p(LO'N AL)	(۲.0.۷)	vo LOW installed in the tank.	ELOONIA = Factived* prostally that it LOW interdial liqu d leaf cats would be deserved, if the Innic is a Robova to a section of probability that the LOW interdial liquid low cats would be deserved, if the Innic is p. p. DOWN = FOOVINLS = 1 - ALOWING =	a 0 E
		NA	A.	1.00			
			14	20:			

Surface Level	Surface Level Messurement - Liquid Observation Well Interdependence - Part 4	bservation Well Interd	bependence - Part 4		
					Considerion that include data common may be intendented and
Surface Level					p(SUE)OW)2 - Faithford Jecobility has the author less measurement data would be streeted fine LOW intention logic level data are observed, and if the task in a lease in
Measurement - Liquid Observation Well	p(SLM LOW,L) (if no LOYY, enter NA)	p(S:M LOW.NL)	(SMILOW)		p(XMLOR/NU) = ['patrior'] probability flat a cultion level mesonement distributed his observed if the LOW plate again were measurement stats are diserved, and if the task in a societater. p(SUMLOR/NU) = 1-ps(XMLOR/NU)
Interdependence					LEMBON) = $gEMLION JJpGMLOWJJJ$. Beine notice to inconserved the α LDW intentital lead lead of a new relevable by the last assessment, then LGDM O 00 = 1
					If here is no LOW, skip to the next part.
	NA.	¥¥	1.00		
Liquid Observ	Liquid Observation Well - Surface Level Measurement Interdependence - Part 5	el Measurement Interd	lependence - Part 5		
					Considering the fortalk data course may be interdependent. p(OMSUAC) = [patterer] probability that the UOM interestical layed level data would be observed if a surface better sourcement occasion is determed. The total is a lexical.
Liquid Observation Well - Surface Level Measurement	mel p(LOW SLV(L) (rfno SLV, erter NA)	p(LOW]SLM,NL.)	(rowistw)		$p_i(ON(SLM)R_i)$ = parasion* possibly that a LOW-resentes is positive measurement decreases would be conserved as under level measurement occurses in one-end, and fore-train in a new-leaker, $p_i(ON(SLM_iR_i))$ = 1 oppositive that the conserved occurses in one-end, and fore-train in a new-leaker, $p_i(ON(SLM_iR_i))$
Interdependence					LLOWING = sq.OWIS.M.UVILVMISIMUNI). Enther surface front data or LDW interstital liquid front data on not available for the load associated; then LLOWISLIA] = 1. If these is not written.
	NA	NA	1.00		
	Ex-Tank Data - Gross Garma Drywell Logs - Part 6	arma Drywell Logs - F	arté		
Gross Gamma Drywell Logs	p(eGL[L) (if to GGL, enter NA here and in Parts 8 and 9)	(rdechr)	1(661)	Leterardae (included with opposed data in this partitionance indications of tool conformation of the factory described by the size of the partition of the part	Lakerd data (rocks) with crywol data in this part) shown on indication of solid contained of the three area of the determined on the part) shown in the determined of the first in the second of the determination of the d
	0.10	060	0.11		
	Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7	Sanma Drywell Logs -	Part 7		
Spetral Garma Drywell Logs	p(SGLIL) (if no SGL, ender NA Tere and in Patts 8 and 9)	(Rochy)	(1884)	The SGLS drywell logs store soll contamination profiles wery similar to the historical prote parms drywell logs, confirming thereads, from the earlier 1924 - 1924 logs.	Condemy to special game is device by entered to be the interest of the consequence of the
	0.10	05:0	0.11		
Gross G	Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8	amma Log interdepend	dence - Part 8		
					Corosidering that ex-tank data sources may be interdependent:
Cross Garmas Log Spettral Garma Log Interdependence	b(GGF[SG-T])	b(GGL[SGL.NL)	riceriser		The state of the s
	NA	NA	1.00		

Special Camma Log - Gross Gamma Log Interdependence	p(SGL GGL,L)	MSGL GGL,NL)	(300Fleer)	Gross garrma logs were considered more important than the SGLS logs because they were celected over a = 23 year period, melving subtle trands in soil comministion exists. The SGLS backleing in the 1990's was a single-sample abeammation.	Considering that the tank data sources may be desidependent. p(DCLQCL,X) = [Posterior] peobability that the spectral parmins logs would be observed if the grass gamma logs are observed, and the same is a basic. Post are observed, and the same is a basic and a spectral parmin by the properties of the grass gamma logs are are determed, and fibratisk as a non-basic p(DCL,X) = 1 - p(DCL,X) = 1 - p(DCL,X). L(SOL,XCD, A) = p(DCL,XCL,X, P(SCL,XCL,X, X, P) = 1 - p(DCL,XCL,X) = 1 - p(DCL,XCL,X). L(SOL,XCD,X, P) = p(DCL,XCL,X, Y, P) = p(DCL,XCL,XCL,XCL,XCL,XCL,XCL,XCL,XCL,XCL,X
	0.15	0.86	0.18		
	Combined	Combined Likilhood Ratios			
L(SLM) 0.33	L(LOW) 1.00	L(SUMILOW)	L(LOWISLM)		
L(GGL) 0.11	L(SGL)	L(GGL SGL) 1.00	L(sarjage) 0.18		
5	Which In-Tank Condition Applies?	ion Applies? (Mark X in Box)	Box)		
SLM & No LOW?			×		
SLM & LOW; SLM IS	SLM & LOW; SLM most important? (Mark Part 4 NA) SLM & LOW; LOW most important? (Mark Part 5 NA)	k Part 4 NA) k Part 5 NA)			
In-Tank Likilhood Ratio			r(stw/row)		(WOD) 1. WADNESS = (MOT MYS) - THE MARKET SERVICE SERV
			0.33		
5	Which Ex-Tank Condition Applies?	ion Applies? (Mark X in Box)	Box)		
GGL & No SGL?					
GGL & SGL; GGL m	GGL & SGL; GGL most important? (Mark Part 9 NA) GGL & SGL; SGL most important? (Mark Part 9 NA)	Part 8 NA)	×		
Ex-Tank Liklihood Ratio			(88L,6GL)		ע פֿפֿר אות פּפֿר אות פֿפֿר אות פֿפֿר אות פֿפֿר אַ און פֿפֿר אַפֿפֿר פֿפֿר אַ אַר אַפֿפֿר פֿפֿר אַ אַר אַפֿפֿר אַפֿר אַפֿפֿר אַפֿר אַפֿפֿר אַפֿר אַפֿר אַפֿפֿר אַפֿפֿר אַפֿפֿר אַפֿר אַר אַפּר אַר אַר אַפּר אַר אַפּר אַר אַר אַפֿר אַפּר אַר אַפּר אַר אַפּר אַר אַפּר אַפּר אַר אַפּר אַר אַפּר אַר אַפּר אַר אַר אַפּר אַר אַפּר אַר אַפּר אַר אַר אַפּר אַר אַפּר אַר אַר אַפּר אַר אַר אַרא אַר אַפּר אַר אַרא אַראַ אַרא אַר אַפּר אַרא אַראַראַראַראַראַראַראַראַראַראַראַראַרא
			0.02		
Combined Likelihood Ratio for			L(in,ex)		(Tiper) = r(grw(row) × r(ger)ear)
Leak Hypothesis			0.01		
	Posterior Probability for Leak	iity for Leak Hypothesis			
	p(Llin,ex)	p(NLJin,ex)	ď		On a posterior good-bask assessment) odds in finos of heah hypotheria. On Elphra'd x No- pullin xol = posterior probability gost-bask assessment) that the tann is a teaker. ("Unicola in Priffic +1): pPhilin.ex) = posterior probability (post-heak assessment) that the tank is a feaker. InPhilin.ex) = i. pBilin.ex)
	0.04	0.00	0.01		

APPENDIX E

Executive Safety Review Board Briefing



241-SX-110 Leak Assessment

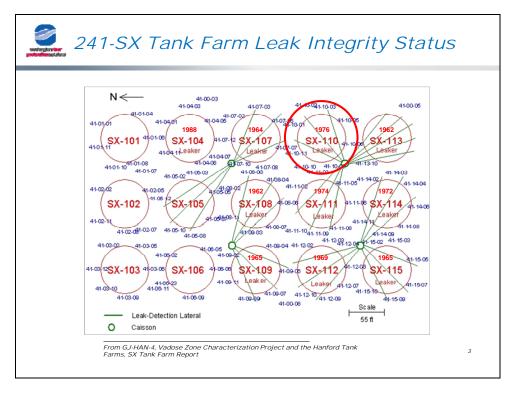
D. J. Washenfelder October 22, 2010





Background Tank SX-110 Leak Assessment

- · Reclassified as Questionable Integrity tank in 1976 after unexplained liquid level decrease
 - Investigation concluded tank was sound
 - ERDA directed change since tank space was not needed
- Re-evaluation in 1980 concluded tank was not leaking
- Formal Leak Assessment recommended by RPP-ENV-39658, "Hanford SX-Farm Leak Assessments Report" in 2010





Tank SX-110 History

- 1 Mgal single-shell tank in operation 1959 -1976
- Pumped to minimum heel in July, 1976 after OR 76-91 and ERDA directive
- · Administratively stabilized in 1979
- External leak detection via 3 laterals and 8 drywells
- Contains ~49 kgal sludge and 7 kgal saltcake high temperature solids



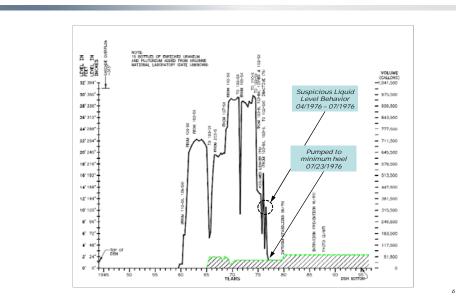
Tank SX-110 Waste Surface



Tank SX-110 Dry Waste Surface, June, 1982

Photograph 102314-15CN [N2126570] 1982-06-23

Tank SX-110 Process History



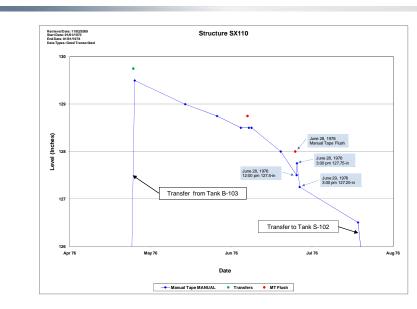


Basis for Questionable Integrity 🖢 Determination

- 0.75-in LL decrease in 7 days, June 22-28, 1976 (allowable decrease 0.5-in/week)
 - Time period bracketed by psychrometric determinations - 0.30-in/week two weeks before and 0.15-in/week immediately afterward
- Erratic LL readings noted on data sheets
 - Surface level readings affected by airlift circulator operation
- Dry well and lateral radiation readings stable
- OR 76-91 leak investigation concluded tank was sound



April – July, 1976 Liquid Level Decrease



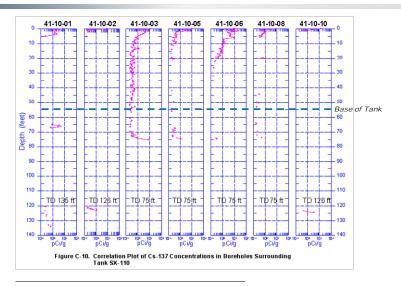


2010 Leak Assessment

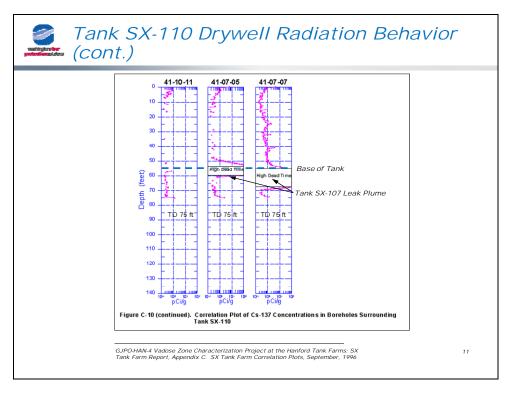
- Drywell Radiation Behavior
- Lateral Radiation Behavior
- · Erratic Liquid Level Measurement
- Liquid Level Decrease
 - Evaporation
 - Leak

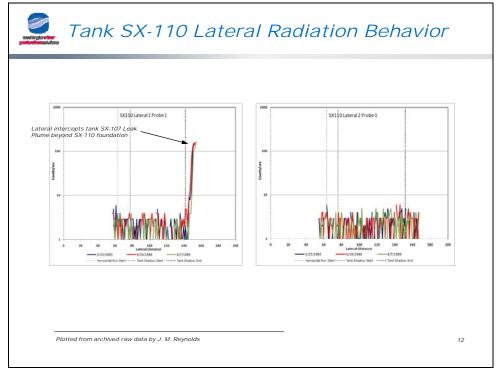


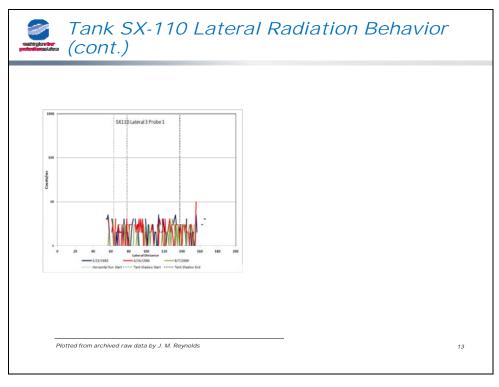
Tank SX-110 Drywell Radiation Behavior

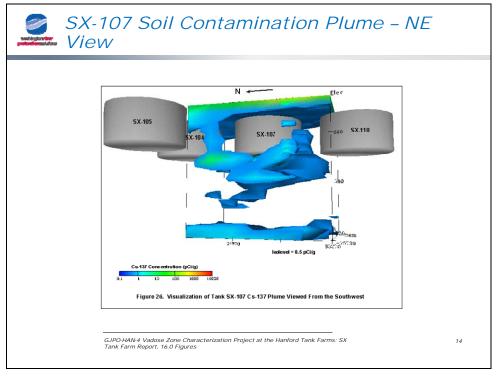


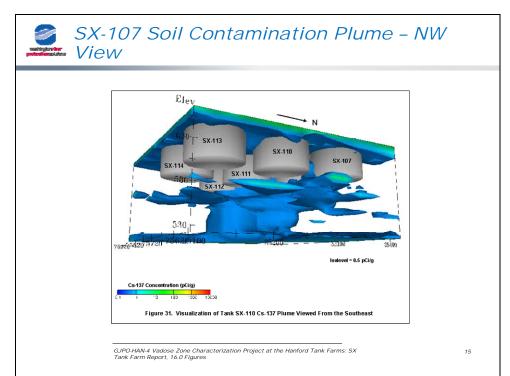
GJPO-HAN-4 Vadose Zone Characterization Project at the Hanford Tank Farms: SX Tank Farm Report, Appendix C. SX Tank Farm Correlation Plots, September, 1996













Drywell and Lateral Radiation – Summary

- Drywells
 - Surface contamination
 - No other soil contamination except for drywells intercepting tank SX-107 leak plume
 - Laterals
 - No soil contamination except for Lateral SX-110-01 intercepting tank SX-107 plume
 - Confirmed by Drywells 41-07-05 and 41-07-07



Erratic Liquid Level Measurements



Surface chop resulting from airlift circulator operation.

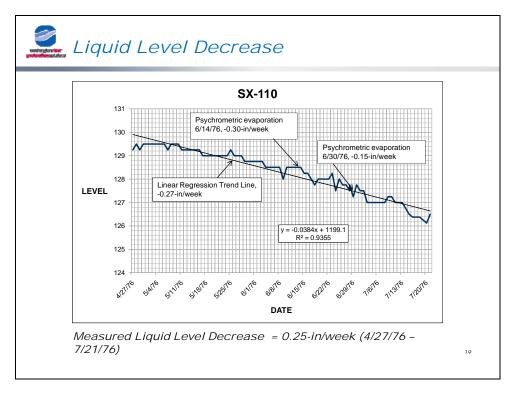
Photograph 743876-13cn 1974-06-12 29-ft - 4 125-ln (Manual Tape)

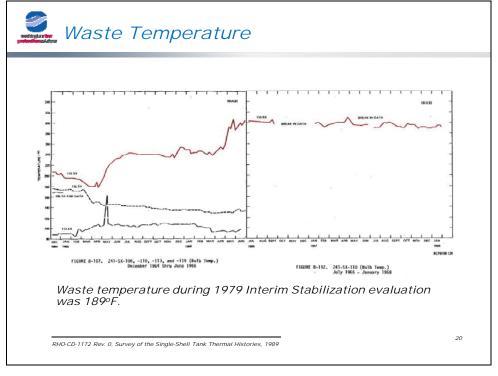


Erratic Liquid Level Measurements -Summary

- · Airlift circulator (ALC) operation results in wavy - choppy surface
- ALCs noted as "found operating" in July 12, 1976 Tank Farm Surveillance Weekly Report*
- · Manual tape located close to an ALC

During retrieval operations, surface monitoring is only used for quiescent periods







SX-110 Calculated Evaporation Rate

- Inputs:
 - Inlet water vapor concentration based on hourly ambient air data from Hanford Meteorological Station
 - Nominal outlet water vapor concentration derived from the June 14, 1976 and June 30, 1976 psychrometric measurements
 - Airflow through tank from measurement published September 15, 1977
- Result:
 - Evaporation rate, 0.26-in/week

RPP-CALC-46420, Rev. 0, Estimated Water Evaporated from Tank 241-SX-110 between April 27, 1976 and July 21, 1976, 2010

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SX-110 Evaporation Rate Summary

- For April 27, 1976 July 21 1976
 - 0.50-in/week allowable leak detection decrease criteria
 - 0.27-in/week, linear regression trend line
 - 0.25-in/week, actual liquid level decrease*
 - 0.26-in/week, water evaporation calculation
- The calculated evaporation rate matches both the linear regression trend line, and the actual liquid level decrease, indicating evaporation could account for all of the tank liquid level decrease

^{*} Two earlier periods of quiescent storage were examined for evaporation. Similar decrease rates were found: -0.21-in/week for the 8 months ending August, 1974: and -0.25-in/week for the 12 months ending September, 1975.



Leak Assessment Results

- Leak No-Leak Hypotheses
- · Leak Assessment Conclusion
- Recommendation

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Leak – No-Leak Hypotheses

- Leak Hypothesis:
 - "The surface level decrease occurring between late April and mid-July, 1976 was due to the combined effects of evaporation and a tank leak."
- No-Leak Hypothesis:
 - "The surface level decrease occurring between late April and mid-July, 1976 was due to evaporation."



Leak Assessment Conclusion

- In-Tank and Ex-Tank evidence is inconsistent with a leaking tank
 - Water evaporation calculation accounts for the late April to mid-July surface level decrease
 - ALC operation results in uneven, choppy surface causing erratic liquid level readings
 - Drywell and Lateral radiation logs were stable for the period, and throughout the tank's history
- The No-Leak Hypothesis evaporation– is the most likely explanation for the surface level decrease

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Leak Assessment Recommendation

Change tank SX-110 integrity status from "Assumed Leaker" to "Sound"

- Post-ESRB Review Actions:
 - Review leak assessment outcome with DOE-ORP and Washington State Department of Ecology
 - Brief Hanford Advisory Board Tank Waste Committee, if requested

