RPP-ASMT-47140
Revision 0

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 re-assess 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
R^2	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
ft	feet
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 re-assess 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.

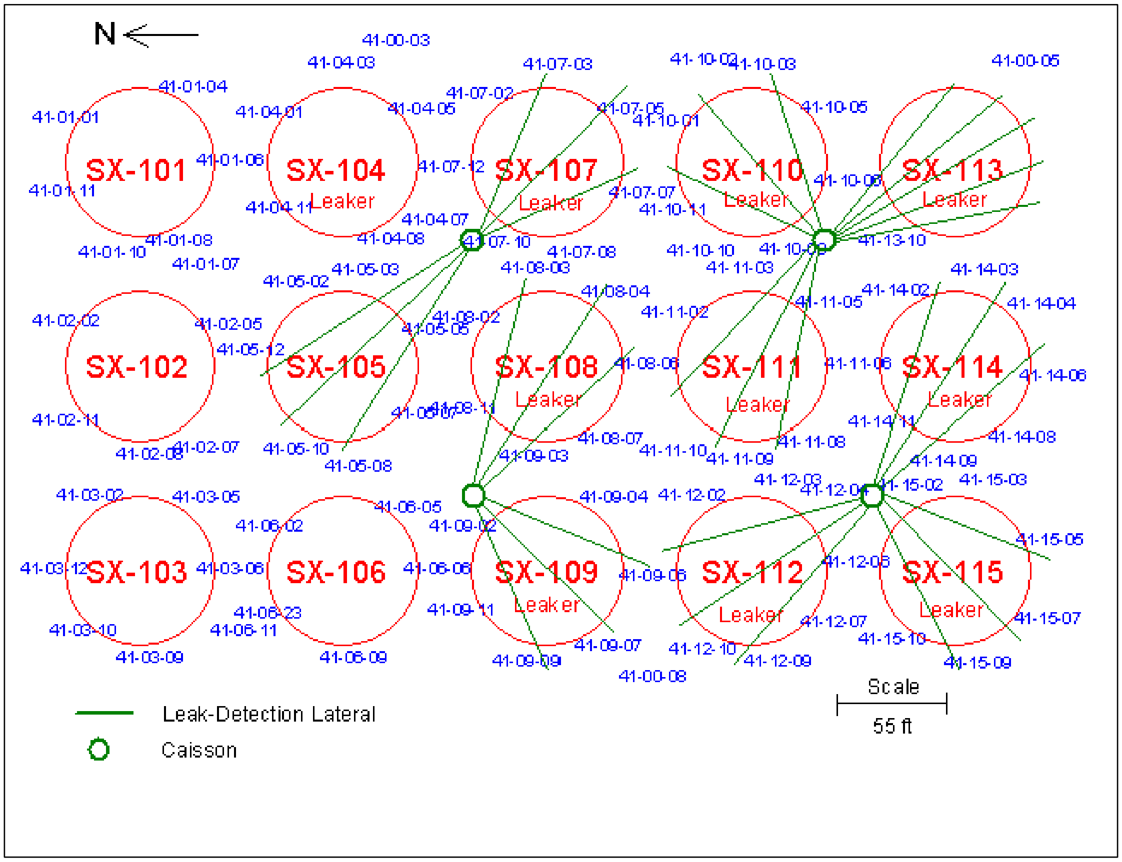
Tank SX-110 received REDOX HLW again in the fourth quarter 1965 and REDOX supernatant periodically through the first quarter of 1969. Self-boiling conditions were experienced during this period from November 1965, to June 1968.

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

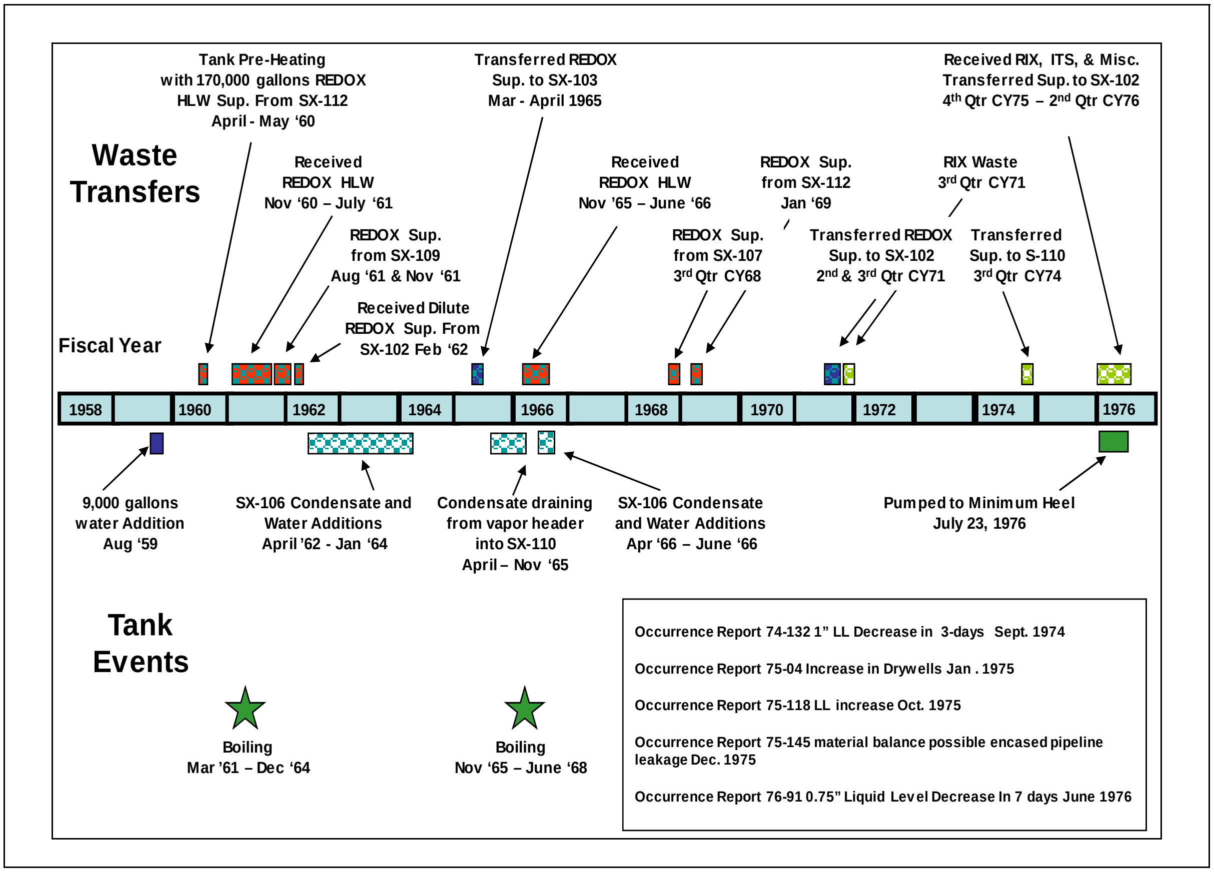


A tank SX-110 occurrence report 76-91 resulted in the tank being declared a questionable integrity tank. The occurrence report documented a liquid level decrease of 0.75-in in seven days. The decrease exceeded the action criteria of 0.50-in in a seven day period on June 30, 1976. The OR reported that 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)



Occurrence Report 74-132 1" LL Decrease in 3-days Sept. 1974

Occurrence Report 75-04 Increase in Drywells Jan . 1975

Occurrence Report 75-118 LL increase Oct. 1975

Occurrence Report 75-145 material balance possible encased pipeline leakage Dec. 1975

Occurrence Report 76-91 0.75" Liquid Level Decrease In 7 days June 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 in^3 / 11,685 cm^3 volume. A June, 1982 photograph of the dry and cracked waste surface in tank SX-110 indicates no supernatant is present in the tank.

Figure 3-3. Tank 241-SX-110 Dry Waste Surface, June, 1982. The polyethylene shipping bottles can be seen scattered on the waste surface.

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

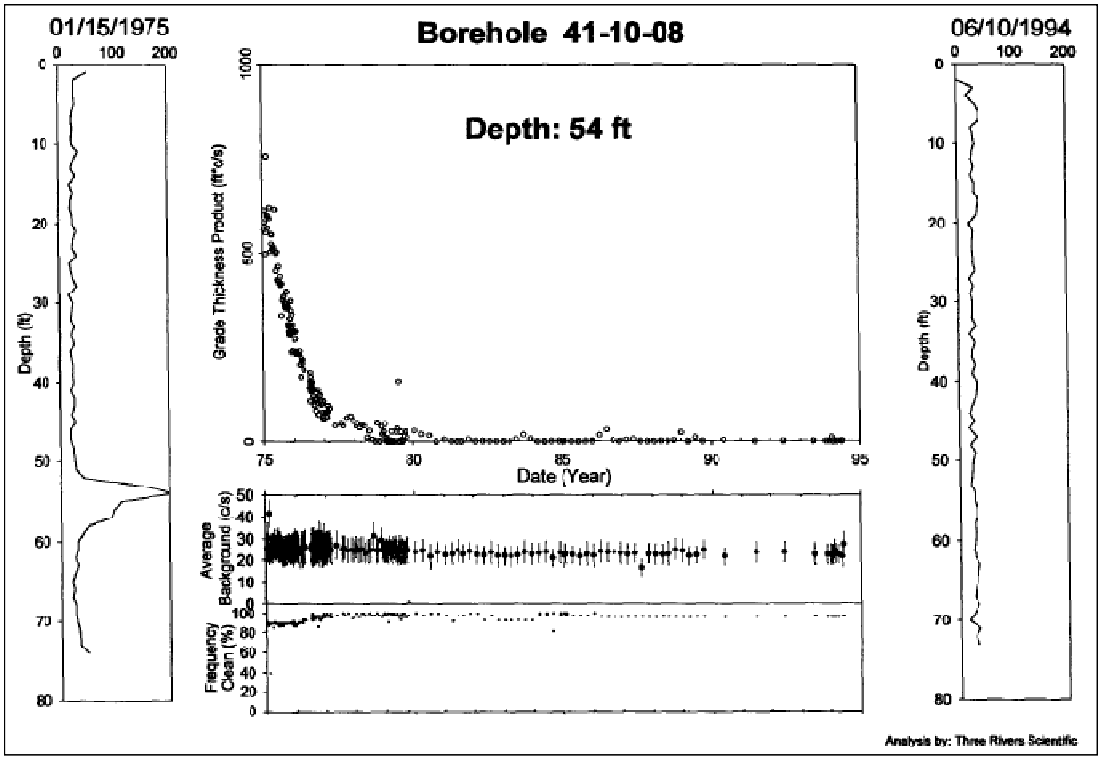
The 1980 leak assessment panel was chartered to review questionable integrity tanks for reclassification as assumed leakers. It had no authority to recommend reclassifying questionable integrity tanks as sound tanks. There is no evidence that the panel considered the possibility that some of the tanks 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.

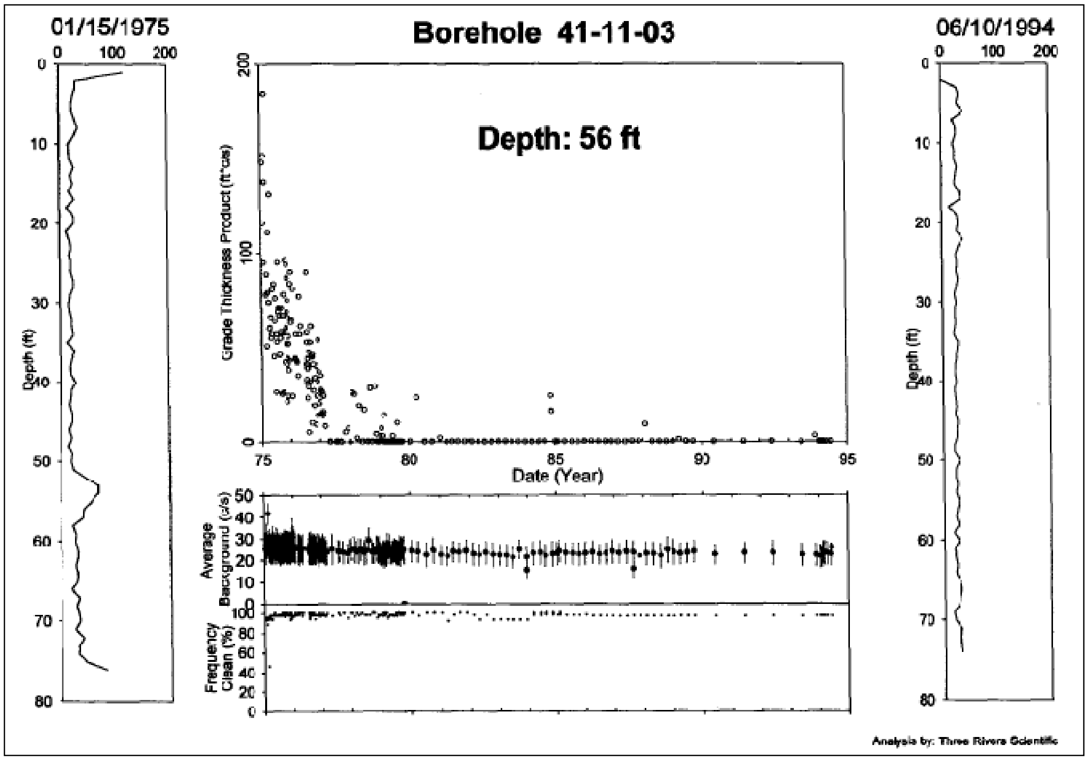
Figure 4-3. Drywell 41-10-08 Historical Radiation Readings
(*from HNF-3136, Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs*)



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."

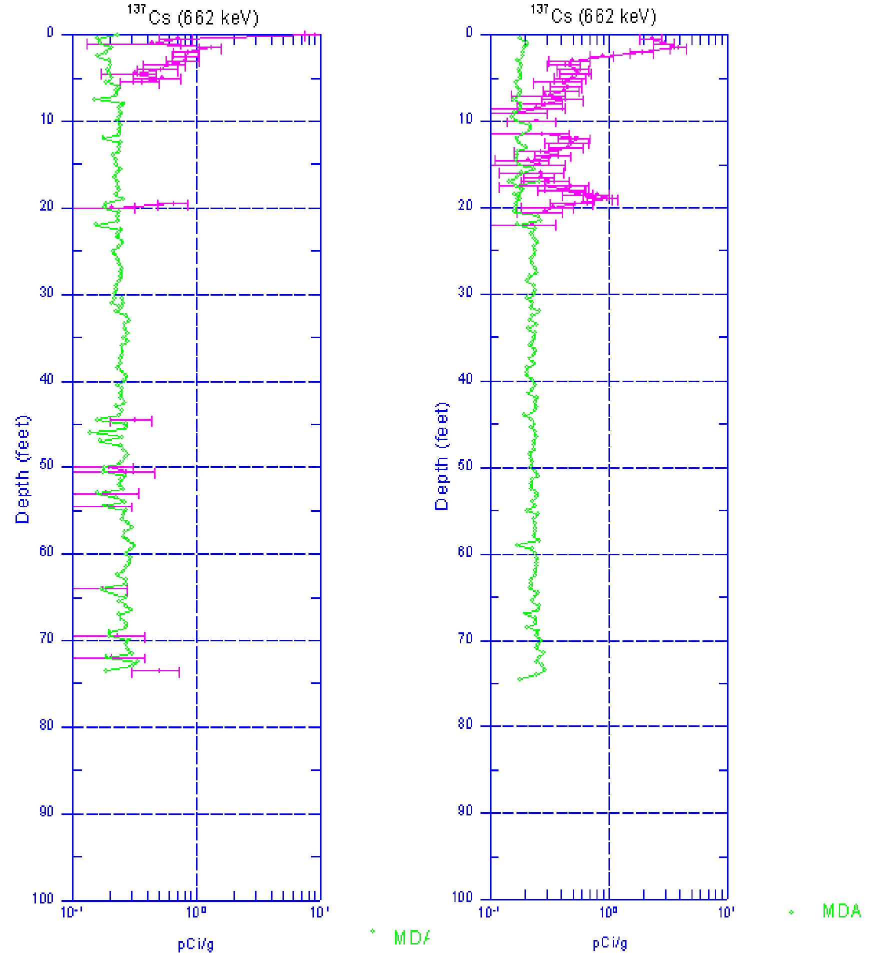
Figure 4-4. Drywell 41-11-03 Historical Radiation Readings
(*from HNF-3136, Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs*)



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)*

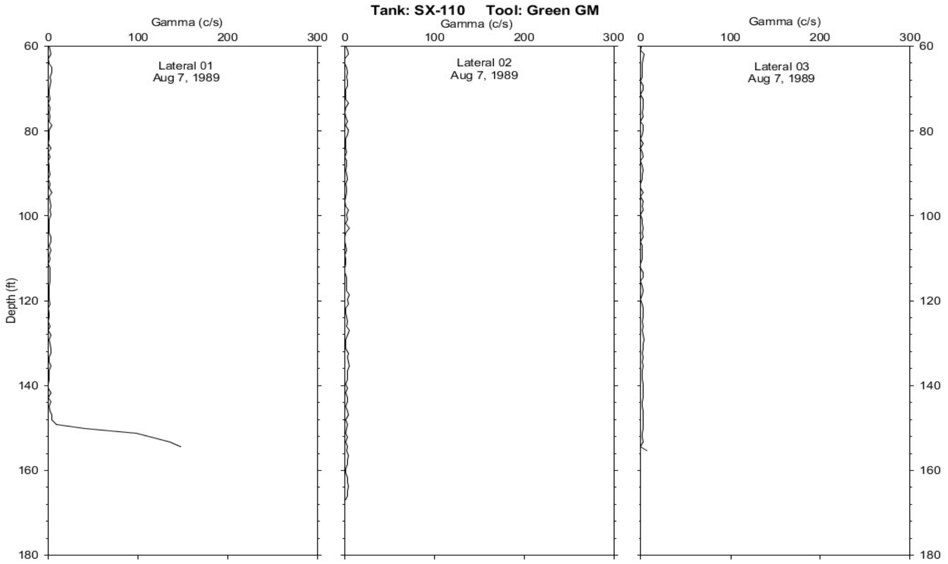


Figure 4-7. Drywell 41-07-05 Historical Radiation Readings

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

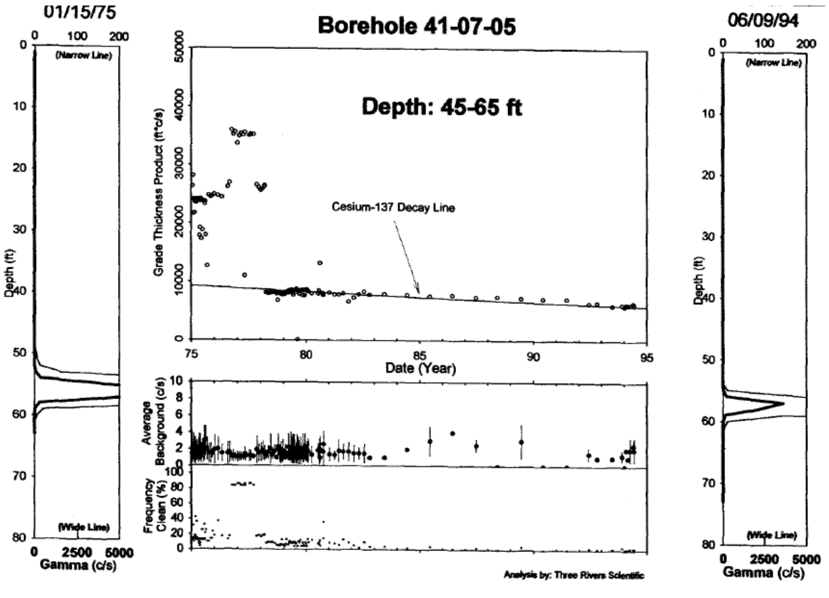
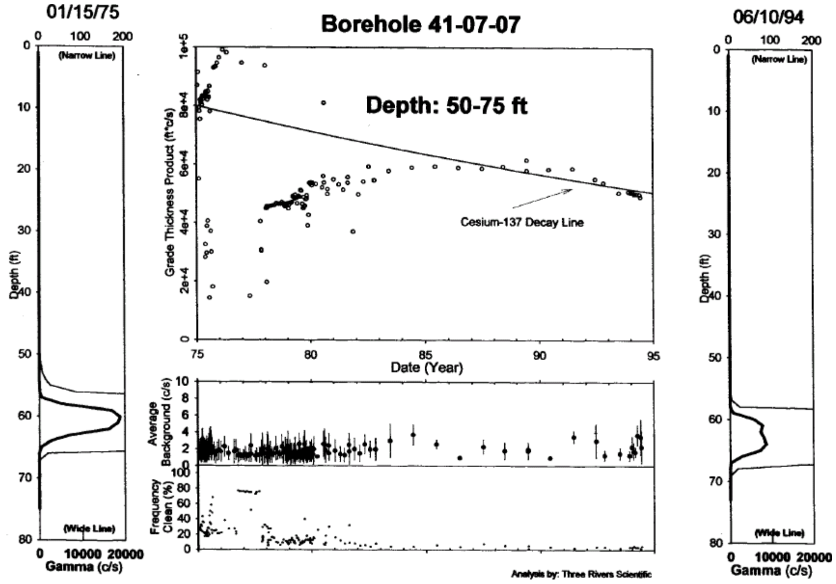


Figure 4-8. Drywell 41-07-07 Historical Radiation Readings
(*from HNF-3136, Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs*)



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.

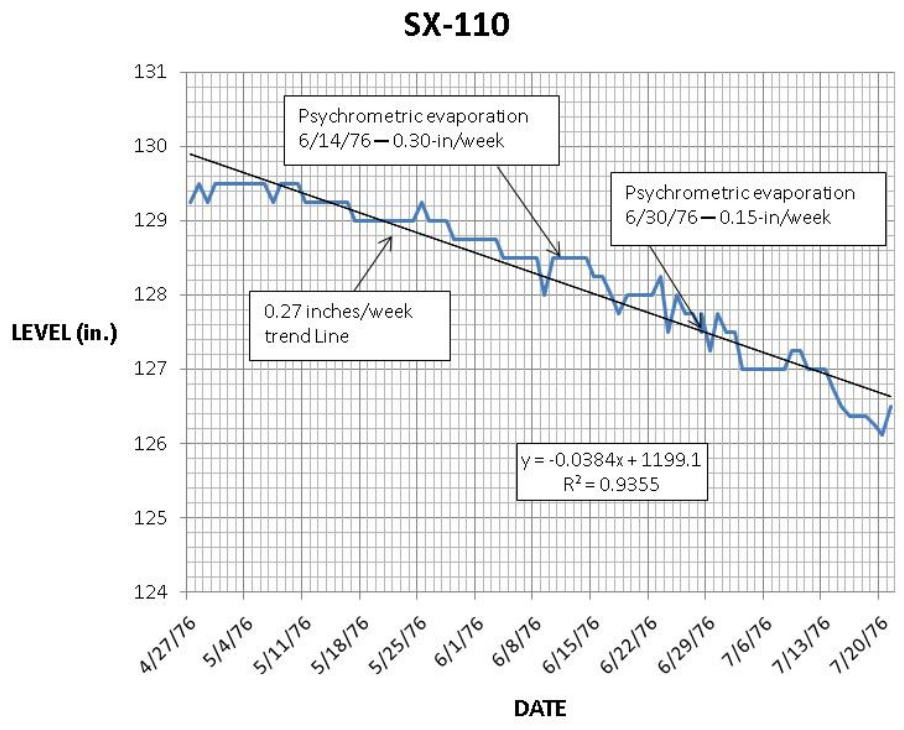
The first approach was a detailed review of the liquid level decrease over the entire period. The second involved an evaporation analysis using two independent methods.

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.

Figure 5-1. Tank SX-110 Liquid Level – April 27, 1976 to July 21, 1976



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 (R^2) indicating approximately the same level of curve fit. Either side of the breakpoint date results in divergent R^2 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.

Figure 5-2. Tank SX-110 Initial Period of Liquid Level Decrease 4/27/76 to 6/16/76

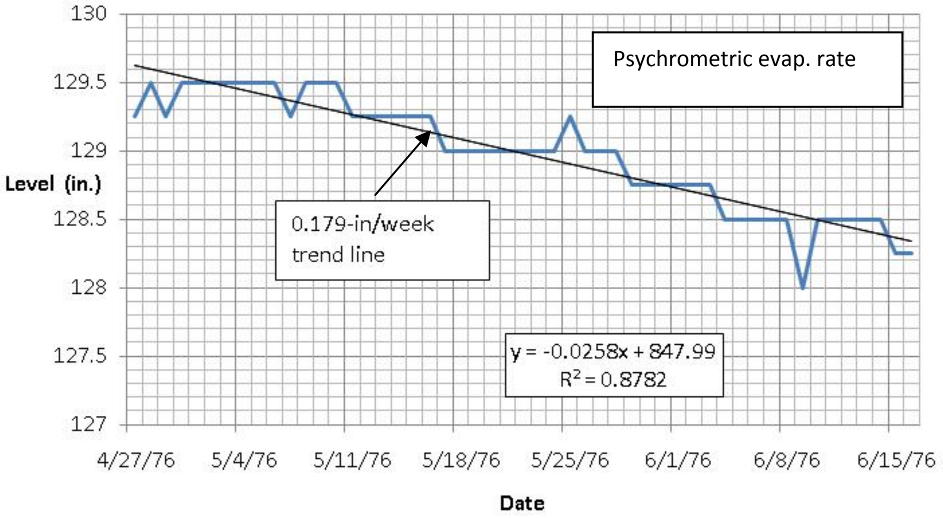
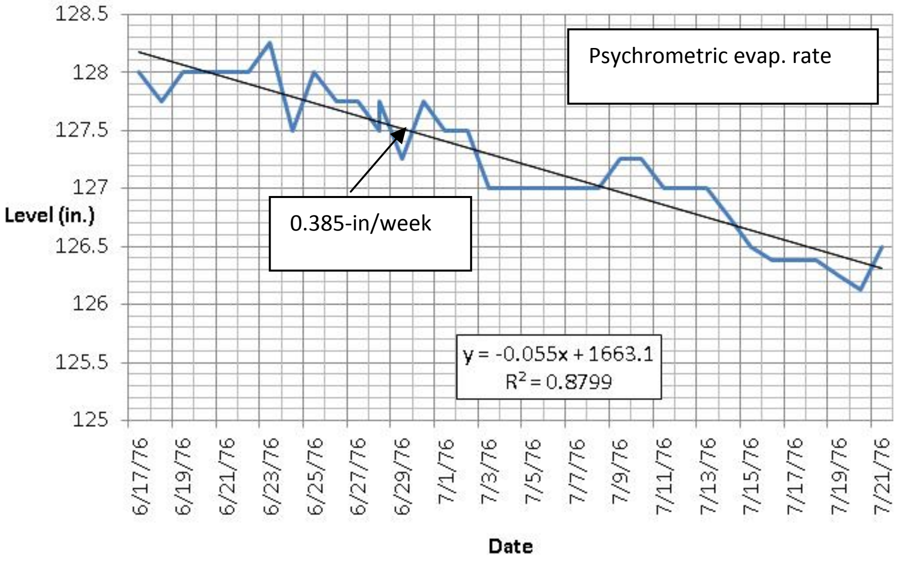


Figure 5-3. Tank SX-110 Final Period of Liquid Level Decrease 6/17/76 to 7/21/76



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 Reported In OR-76-91	0.30	6/14/1976
	0.15	6/30/1976
Liquid Level Decrease – Curve Fit	0.27	4/27/1976 – 7/21/1976*
	0.25	4/27/1976 – 7/21/1976**
	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-ft^3, 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*
    - 0.34-ft/sec w/ALC (0.2-ft/sec + total of 10-cfm over entire surface area)
- Surface area, 4418-ft^2, area of tank
- Length, 37.5-ft, radius of tank
- Diffusion coefficient, 1,000,000-ft^2/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/ft^3

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 from Tank Bottom (inches)	4/03/76 Temp (°F)	5/02/76 Temp (°F)	6/02/76 Temp (°F)	7/01/76 Temp (°F)	7/17/76 Temp (°F)	7/17/76 Temp (°F)	7/21/76 Temp (°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: Distribution	BUILDING: 2750E/A-229			
FROM: D. J. Washenfelder	CHAIRMAN: Same			
DEPARTMENT-OPERATION-COMPONENT Engineering - Technical Integration	AREA 200-E	SHIFT	DATE OF MEETING 09/21/2009	NUMBER ATTENDING 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 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 Inventorie*s. 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. *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:*
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. *Status:*
7.	J. G. Field	Review pipeline leak implications OR 75-145. *Status:*
8.	D. G. Harlow	Review OR 76-91 evaporation rates. *Status:*

References:

Briefings:

Date	Title

Correspondence - Emails:

Date	Title

Correspondence - Letters:

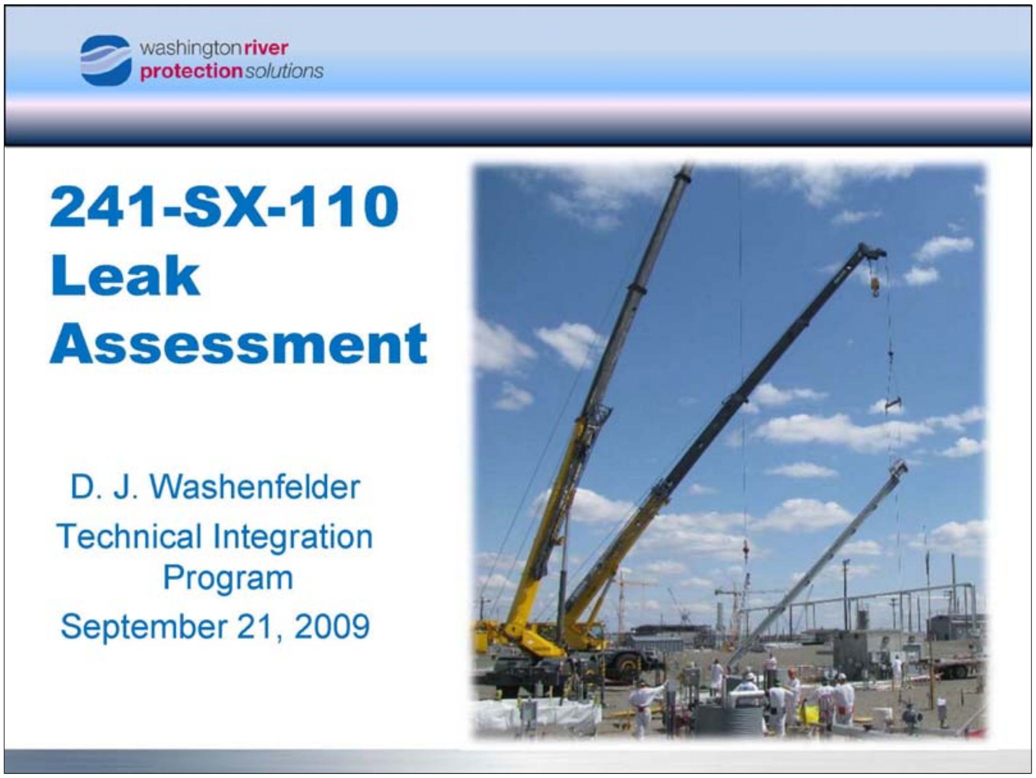
Number	Title

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

Drawings:

Number	Title



washington river protection solutions

241-SX-110 Leak Assessment

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

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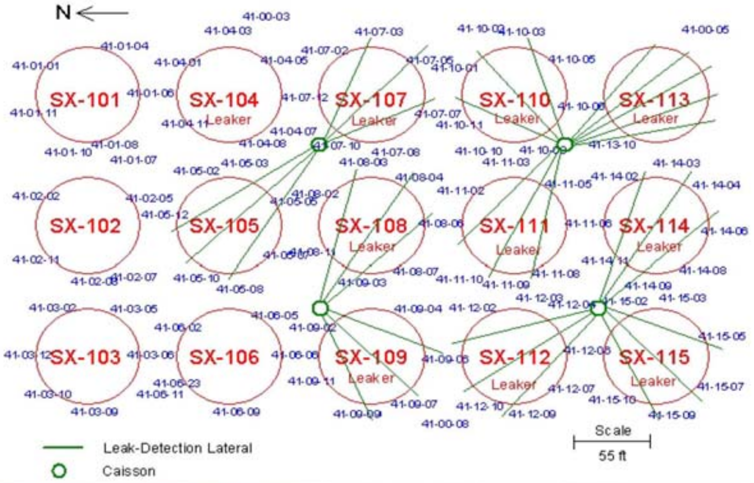
washington river protection solutions

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 Salt cake
- Also has 16 bottles (3" OD by 54" long) containing 204g ^{239}Pu and 6g enriched Uranium

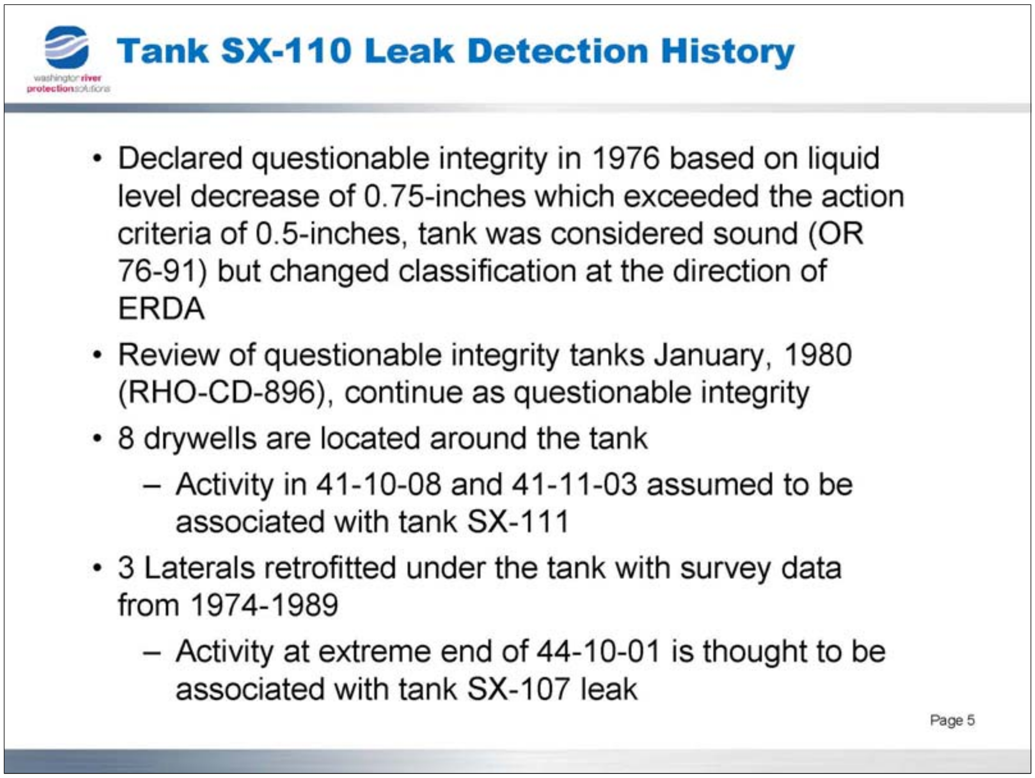
Tank SX-110 Leak Assessment Background (cont.)

Tank SX-110 Laterals and Drywells



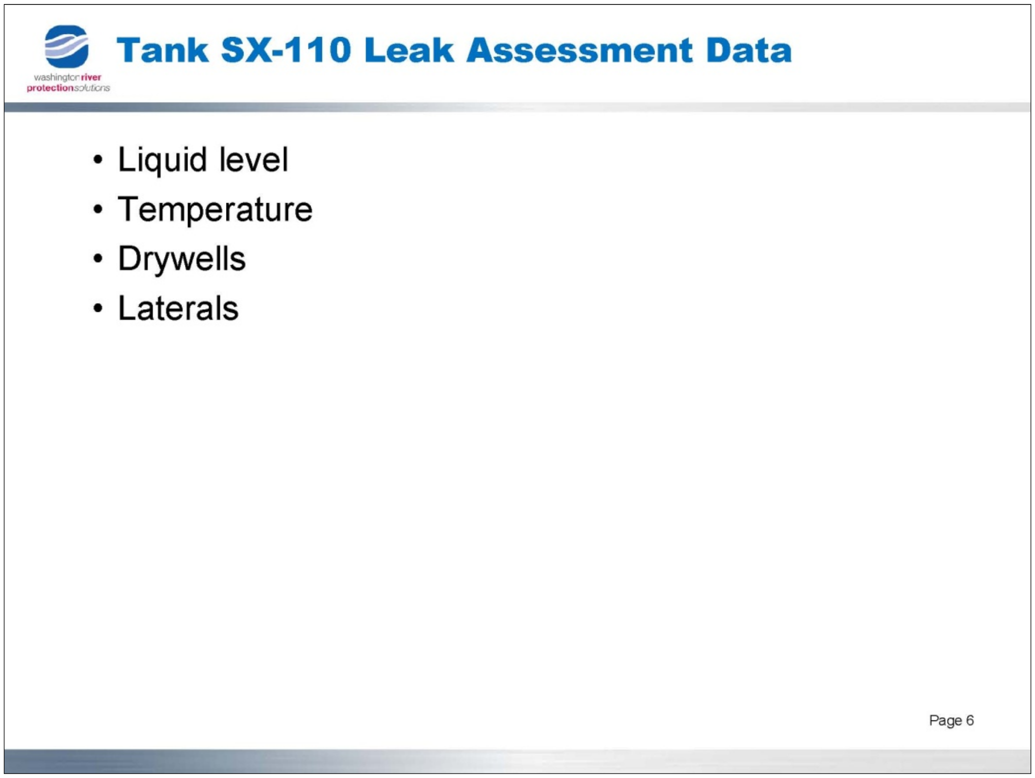
Tank SX-110 Leak Assessment Team

- **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**



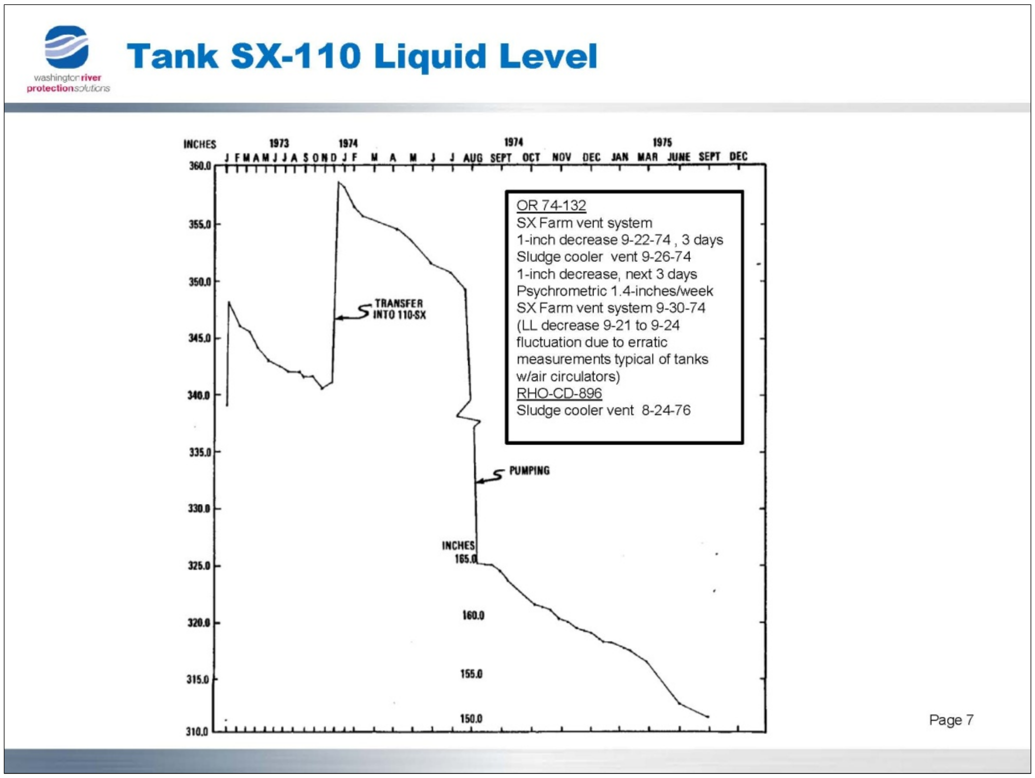
Tank SX-110 Leak Detection History

- 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



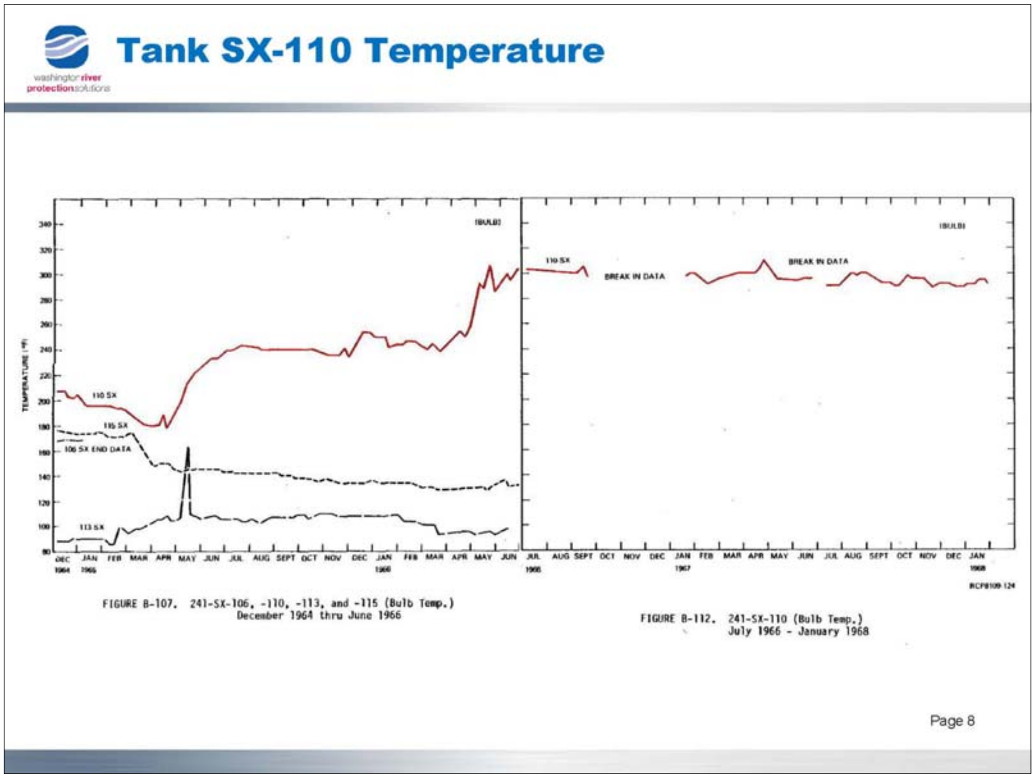
Tank SX-110 Leak Assessment Data

- Liquid level
- Temperature
- Drywells
- Laterals



Tank SX-110 Liquid Level

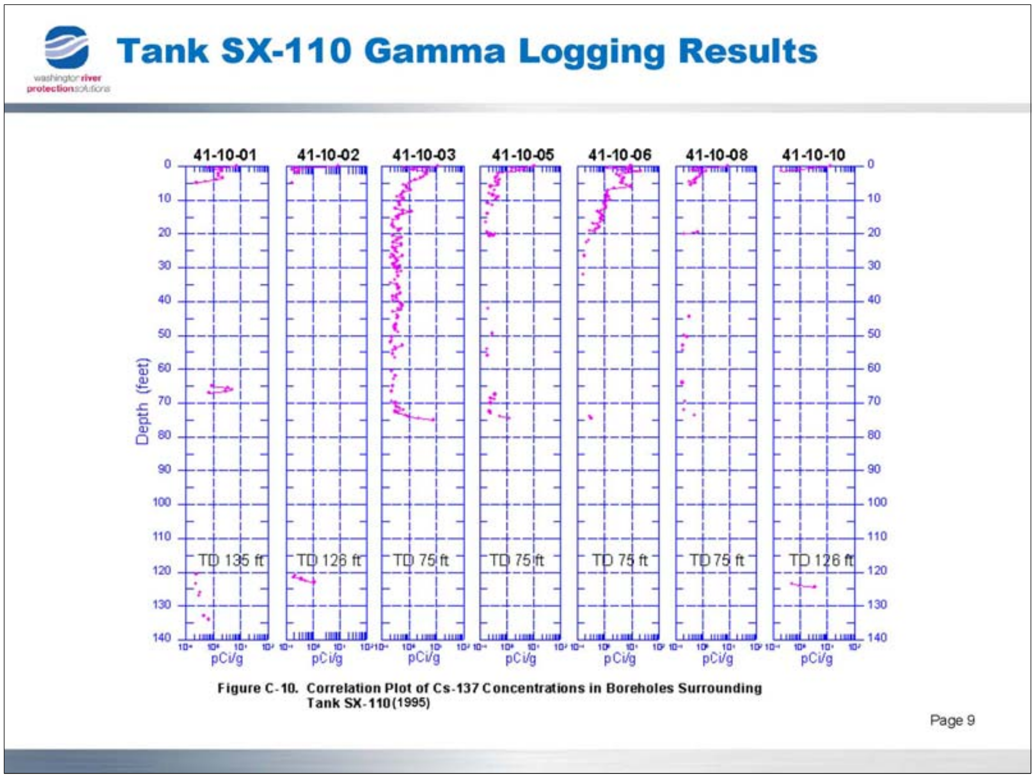
OR 74-132
SX Farm vent system
1-inch decrease 9-22-74 , 3 days
Sludge cooler vent 9-26-74
1-inch decrease, next 3 days
Psychrometric 1.4-inches/week
SX Farm vent system 9-30-74
(LL decrease 9-21 to 9-24
fluctuation due to erratic
measurements typical of tanks
w/air circulators)
RHO-CD-896
Sludge cooler vent 8-24-76



Tank SX-110 Temperature

FIGURE B-107. 241-SX-106, -110, -113, and -115 (Bulb Temp.)
December 1964 thru June 1966

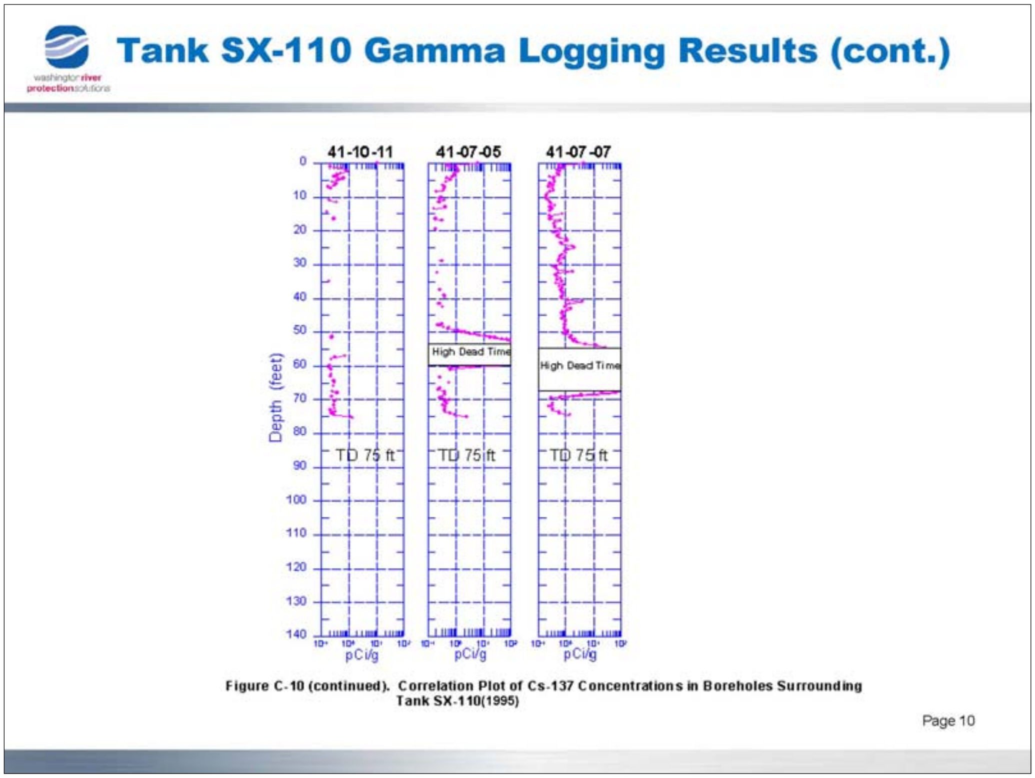
FIGURE B-112. 241-SX-110 (Bulb Temp.)
July 1966 - January 1968



Tank SX-110 Gamma Logging Results

Figure C-10. Correlation Plot of Cs-137 Concentrations in Boreholes Surrounding Tank SX-110 (1995)

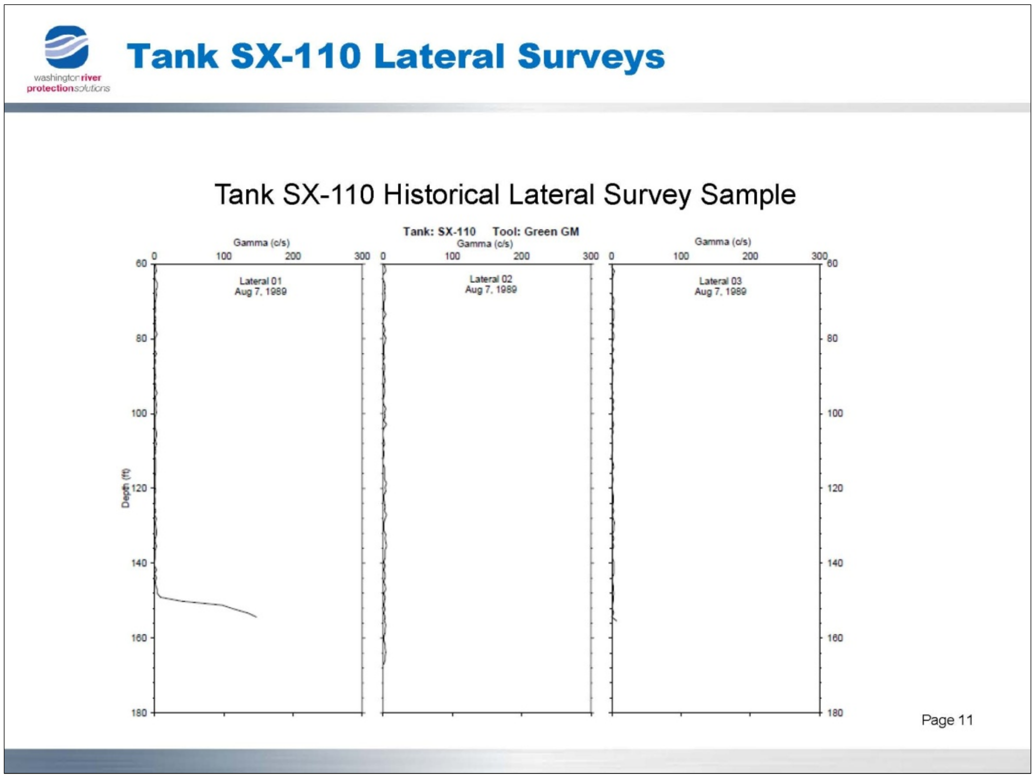
Page 9



Tank SX-110 Gamma Logging Results (cont.)

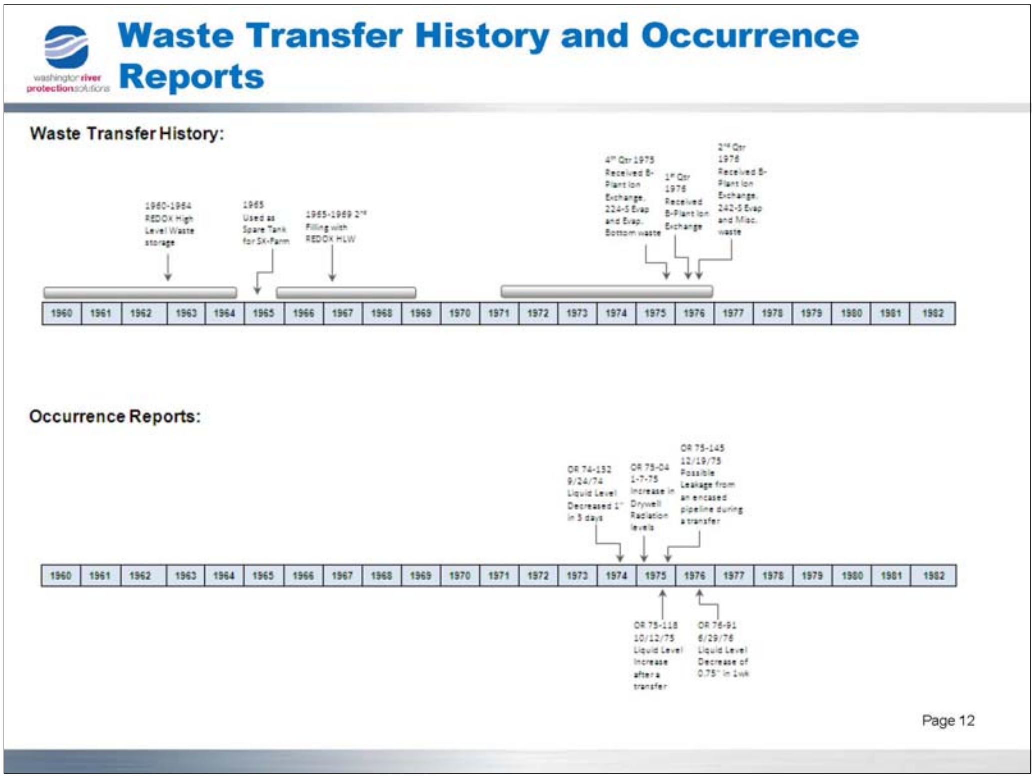
Figure C-10 (continued). Correlation Plot of Cs-137 Concentrations in Boreholes Surrounding Tank SX-110 (1995)

Page 10



Tank SX-110 Lateral Surveys

Tank SX-110 Historical Lateral Survey Sample



Waste Transfer History and Occurrence Reports

Waste Transfer History:

1960-1964 REDOX High Level Waste storage

1965 Used as Spare Tank for SX-Farm

1965-1969 2nd Filling with REDOX HLW

4th Qtr 1975 Received B-Plant Ion Exchange, 224-S Evap and Evap. Bottom waste

1st Qtr 1976 Received B-Plant Ion Exchange

2nd Qtr 1976 Received B-Plant Ion Exchange, 242-S Evap and Misc. waste

Occurrence Reports:

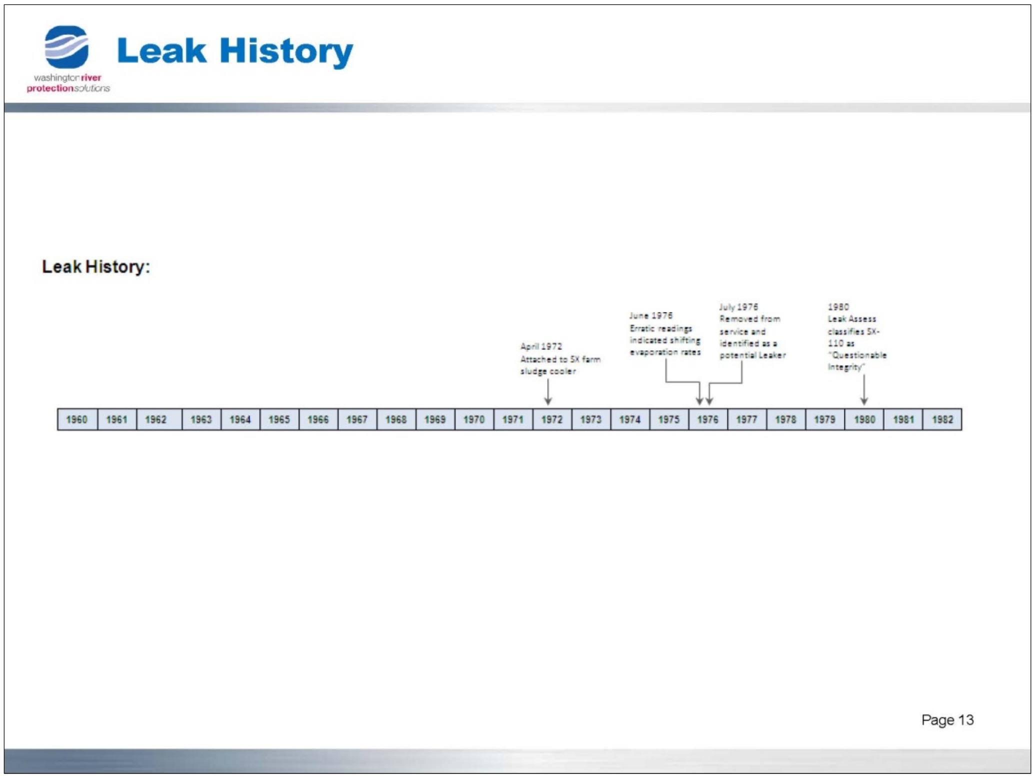
OR 74-132 9/24/74 Liquid Level Decreased 1" in 5 days

OR 75-04 1-7-75 Increase in Drywell Radiation levels

OR 75-145 12/19/75 Possible Leakage from an encased pipeline during a transfer

OR 75-118 10/12/75 Liquid Level Increase after a transfer

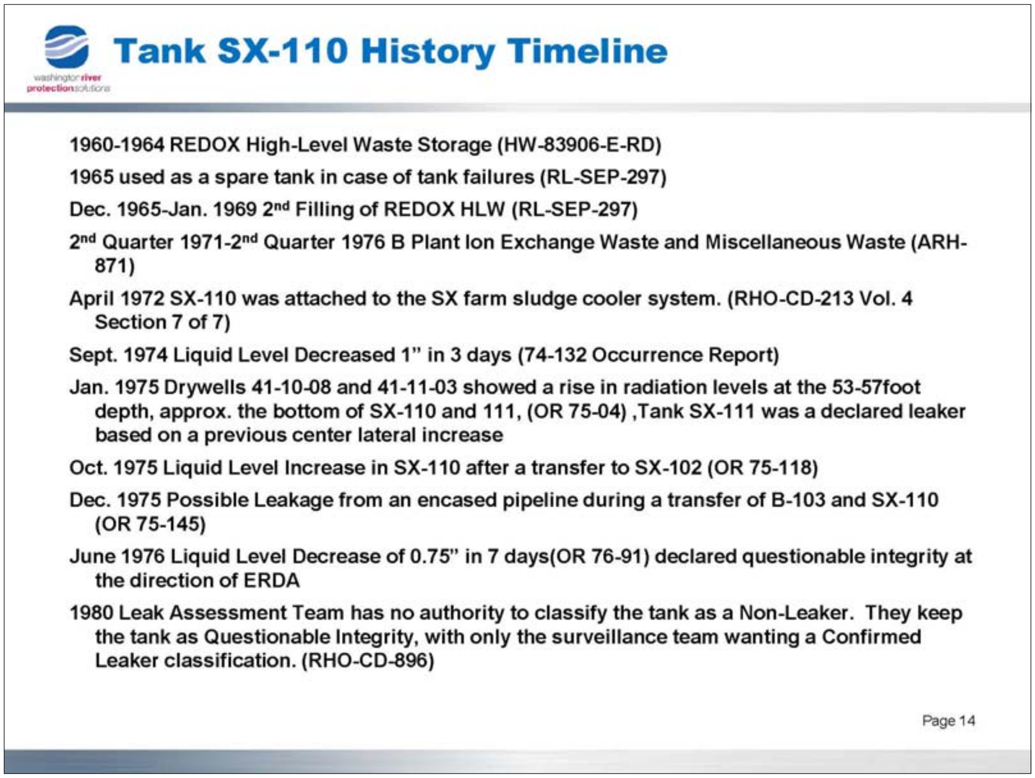
OR 76-91 6/29/76 Liquid Level Decrease of 0.75" in 1wk



Leak History

Leak History:

Page 13



Tank SX-110 History Timeline

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)

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B.2 MEETING #2

MEETING MINUTES

SUBJECT: Tank SX-110 Leak Assessment Meeting #2 Minutes				
TO: Distribution	BUILDING: 2750E/A-229			
FROM: D. J. Washenfelder	CHAIRMAN: Same			
DEPARTMENT-OPERATION-COMPONENT Engineering - Technical Integration	AREA 200-E	SHIFT	DATE OF MEETING 09/28/2009	NUMBER ATTENDING 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 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 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 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:*
7.	J. G. Field	Review pipeline leak implications OR 75-145. *Status:*
8.	D. G. Harlow	Review OR 76-91 evaporation rates. *Status:*

References:

Briefings:

Date	Title

Correspondence - Emails:

Date	Title

Correspondence - 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. 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, , “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	
Occurrence Report 74-132, 1974, “Decrease of Liquid Level in Tank 110-SX, Atlantic Richfield Hanford Company, Richland, Washington. (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)	
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)	
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

B3. MEETING #3

MEETING MINUTES

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

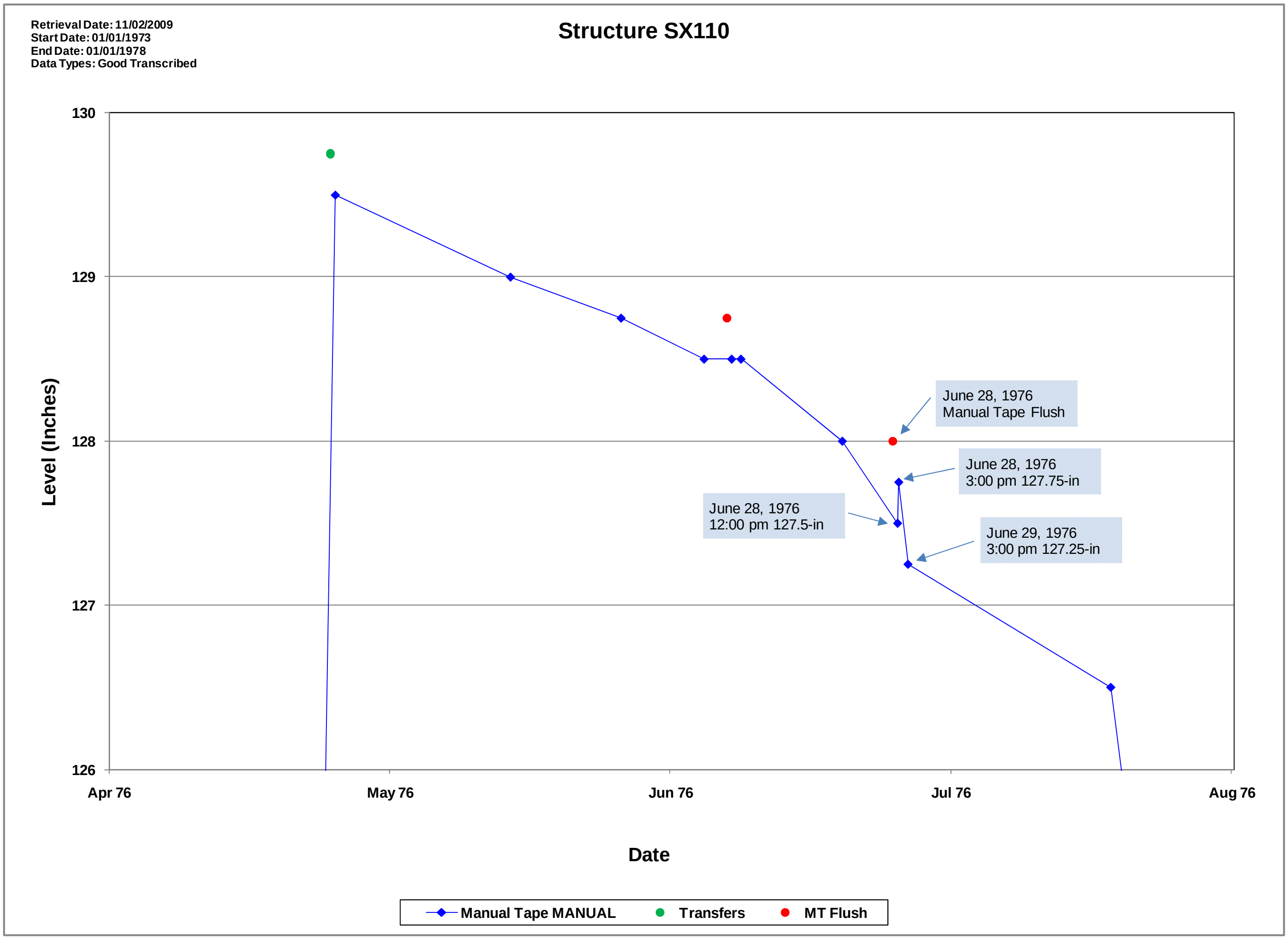
It is probable that characteristics of the waste and the waste surface were affecting the surface level measurements. We know this because of a third occurrence report, 75-145, reporting an irreconcilable material balance discrepancy in December, 1975 following a transfer into tank SX-110 from tank B-103. 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 *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: 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.

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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:*
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.*
•	• D. G. Harlow	• Review OR 76-91 evaporation rates. • *Status:*

References:

Briefings:

Date	Title

Correspondence - Emails:

Date	Title

Correspondence - Letters:

Number	Title

Documents:

<table>
<tr><th>Number</th><th>Title</th></tr>
<tr><td colspan="2">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</td></tr>
<tr><td colspan="2">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</td></tr>
<tr><td colspan="2">GJPO-HAN-12, , “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</td></tr>
<tr><td colspan="2">Occurrence Report 74-132, 1974, “Decrease of Liquid Level in Tank 110-SX, Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # D194052942)</td></tr>
<tr><td colspan="2">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)</td></tr>
<tr><td colspan="2">Occurrence Report 75-118, 1975, “Liquid Level Increase in Tank 110-SX,” Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # N/A)</td></tr>
<tr><td colspan="2">Occurrence Report 75-145, 1975, “Possible Leakage from an Encased Pipeline,” Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # D1940053029)</td></tr>
<tr><td colspan="2">Occurrence Report 76-91, 1976, “Liquid Level Decrease Exceeding Criteria for Tank 110-SX,” Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # N/A)</td></tr>
<tr><td colspan="2">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)</td></tr>
<tr><td colspan="2">RHO-CD-896, 1980. “Review of Classification of Nine Single-Shell “Questionable Integrity” Tanks.” Rockwell Hanford Operations, Richland, Washington. (IDMS Accession # D8434517)</td></tr>
<tr><td colspan="2">RPP-ENV-39658 Rev. 0 (Draft), “Hanford SX-Farm Leak Assessment Report,” Washington River Protection Solutions, LLC, Richland, Washington. (IDMS Accession # N/A)</td></tr>
<tr><td colspan="2">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)</td></tr>
<tr><td colspan="2"></td></tr>
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</table>

Drawings:

Number	Title

B4. MEETING #4

MEETING MINUTES

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

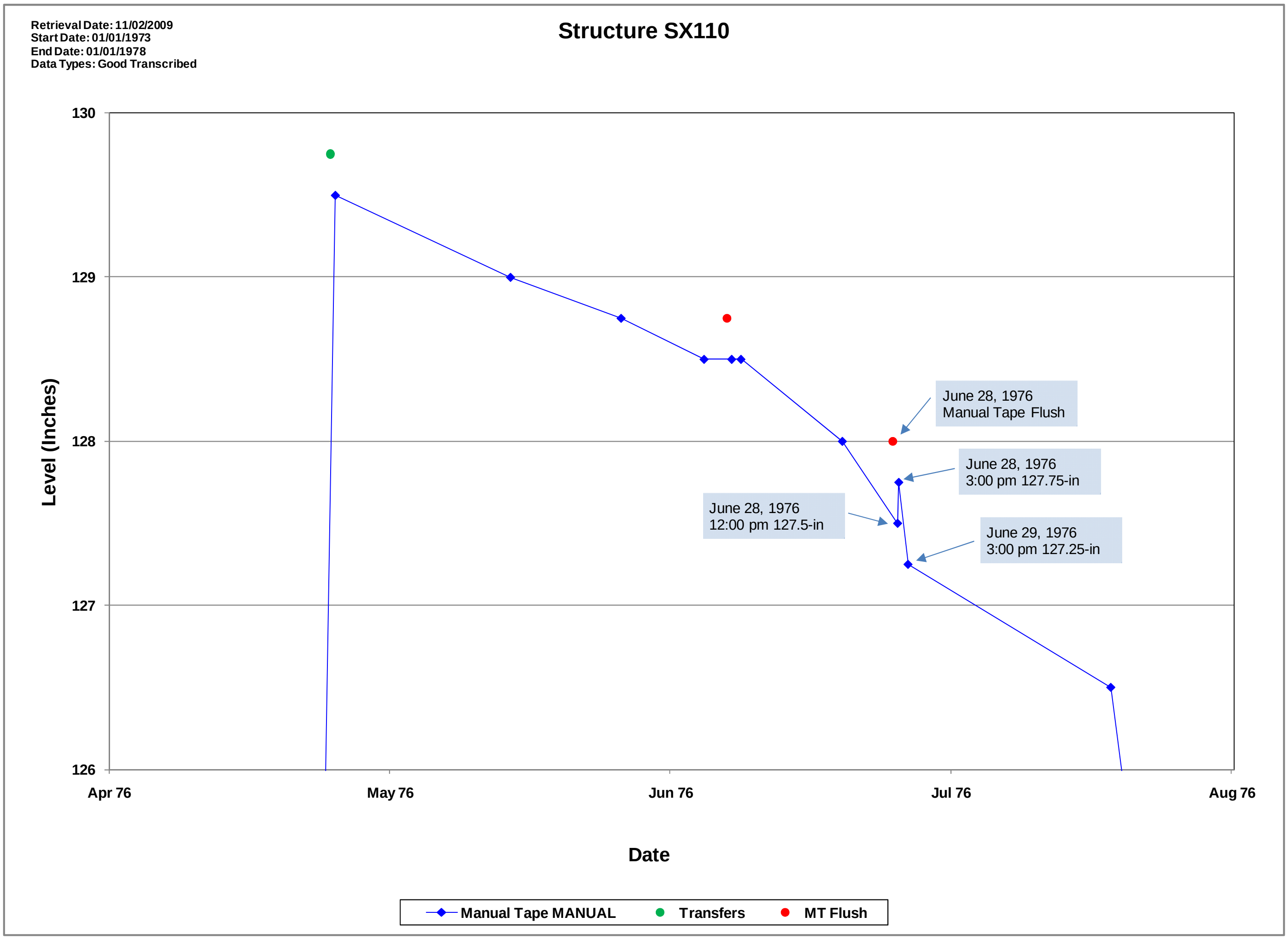
As a follow-up to Meeting #3's interpretation of the surface level measurement fluctuation that occurred before and after a flush of the manual tape June 28 – 29, 1976, in-tank photographs and waste transfers made during the period were reviewed. The interpretation was based on the assumption that the 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 ~ 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).

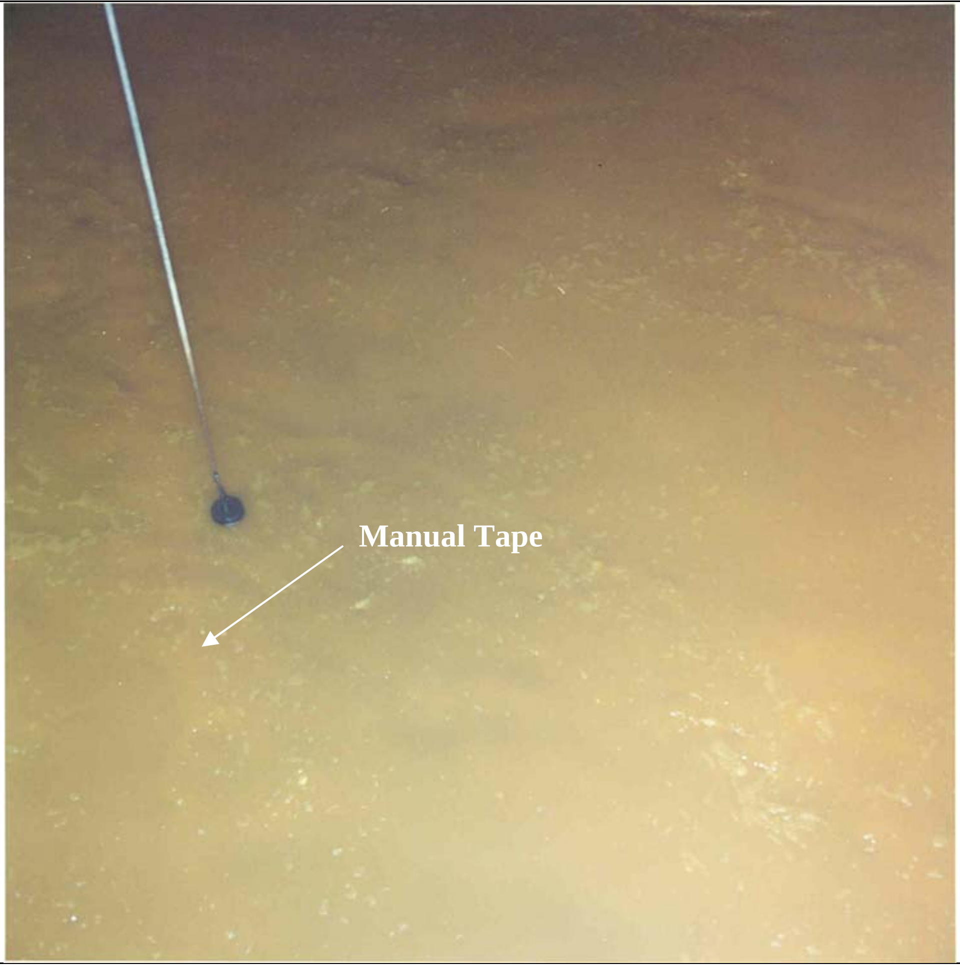
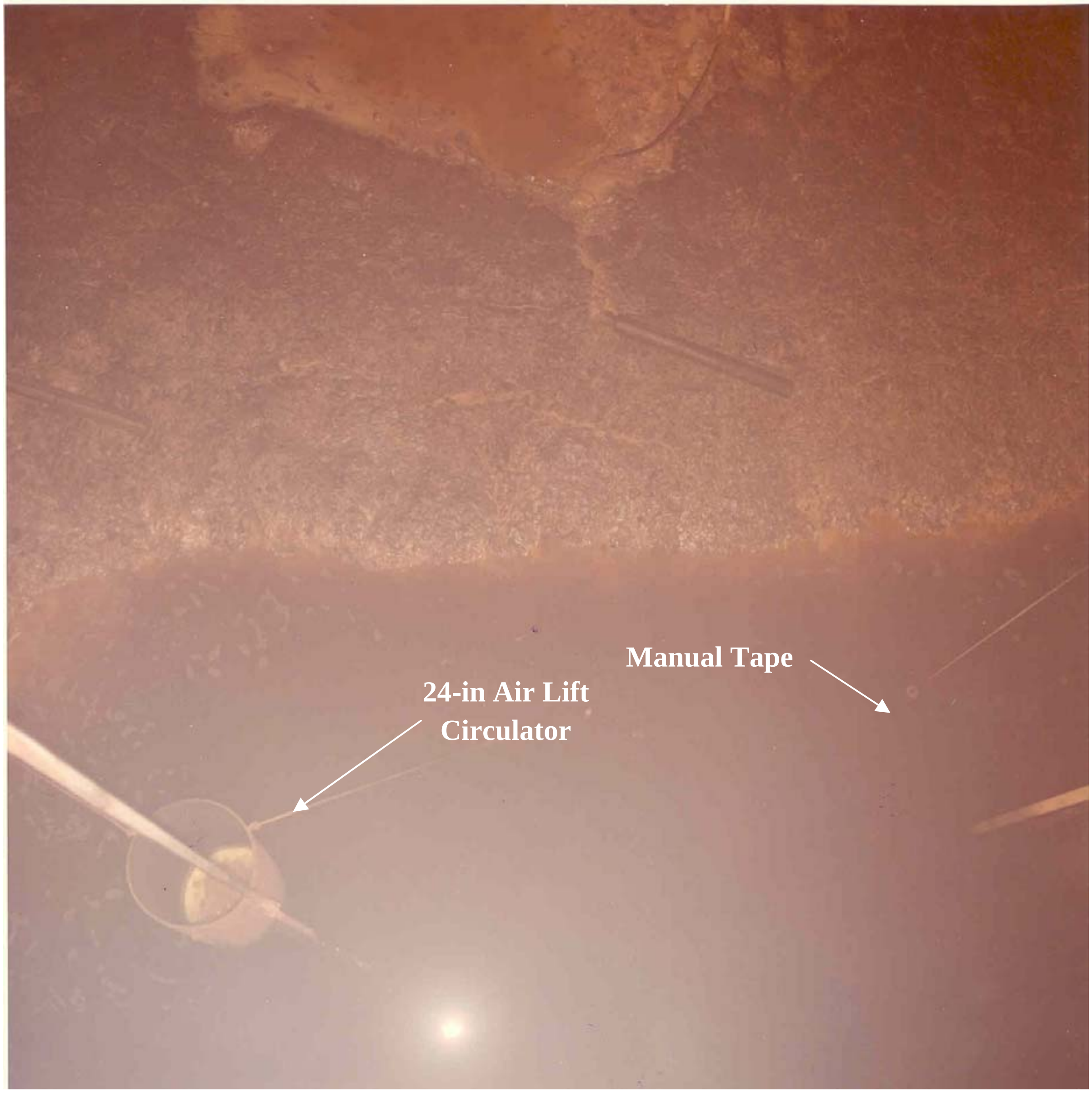


Figure 4-3 from the same photo mission shows considerable surface chop created by one of the air lift circulators.

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 ~ 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 Deviation	Measurement Precision Decrease from Air Lift Circulator Operating
No Air Lift Circulator Operating	± 0.005-in	
16-in Air Lift Circulator Operating	± 0.200-in	40X
16-in and 24-in Air Lift Circulators Operating	± 0.038-in	7.6X

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?

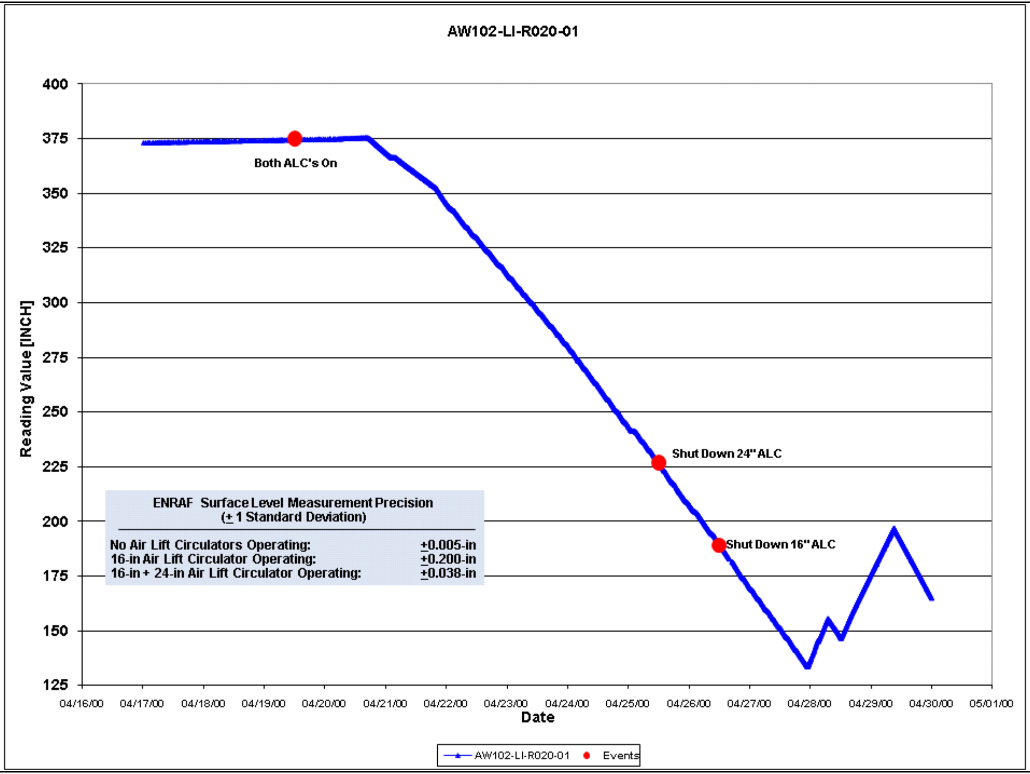
There are no recoverable tank SX-110 air lift circulator operating data available for the 1976 time period. However, records of 241-SX tank air lift circulator operating data exist in the REDOX Weekly Process Reports for the years 1965 and 1966. These reports indicate that air lift circulators were operated as standard practice whenever the tank sludge temperature ≥ ~ 200°F, the supernatant temperature ≥ ~ 195°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°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 ~ 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

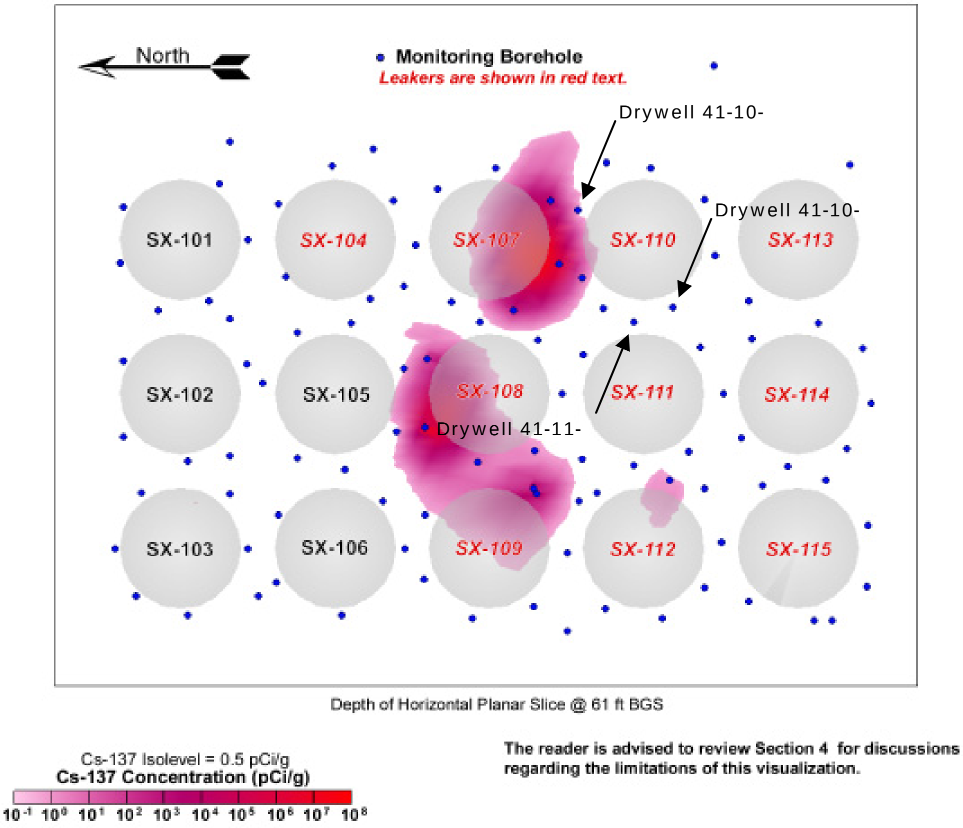
Two tank SX-110 drywells, 41-10-01 and 41-10-08, showed soil contamination during their logging history. Drywell 41-10-01 had peak count readings of ~ 300 – 400 counts/second at about 65-ft during the period between September, 1973 and July 10, 1974 (Occurrence Report 76-91 *Liquid Level Decrease Exceeding 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)*



The reader is advised to review Section 4 for discussions regarding the limitations of this visualization.

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^{o}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. *Status:*
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^{o}F – 210^{o}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
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: 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). *Status: Archived surface level and temperature records for the 1974 – 1976 period have been ordered from the Seattle National Archives Regional Repository.*
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. Discussed in drywell section above.*
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).

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.*

References:

Briefings:

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Correspondence - Emails:

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Documents:

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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

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)

Occurrence Report 74-132, 1974, “Decrease of Liquid Level in Tank 110-SX, Atlantic Richfield Hanford Company, Richland, Washington. (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)

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 Minutes				
TO: Distribution	BUILDING: 2750E/A-229			
FROM: D. J. Washenfelder	CHAIRMAN: Same			
DEPARTMENT-OPERATION-COMPONENT Engineering - Technical Integration	AREA 200-E	SHIFT	DATE OF MEETING 6/16/2010	NUMBER ATTENDING 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

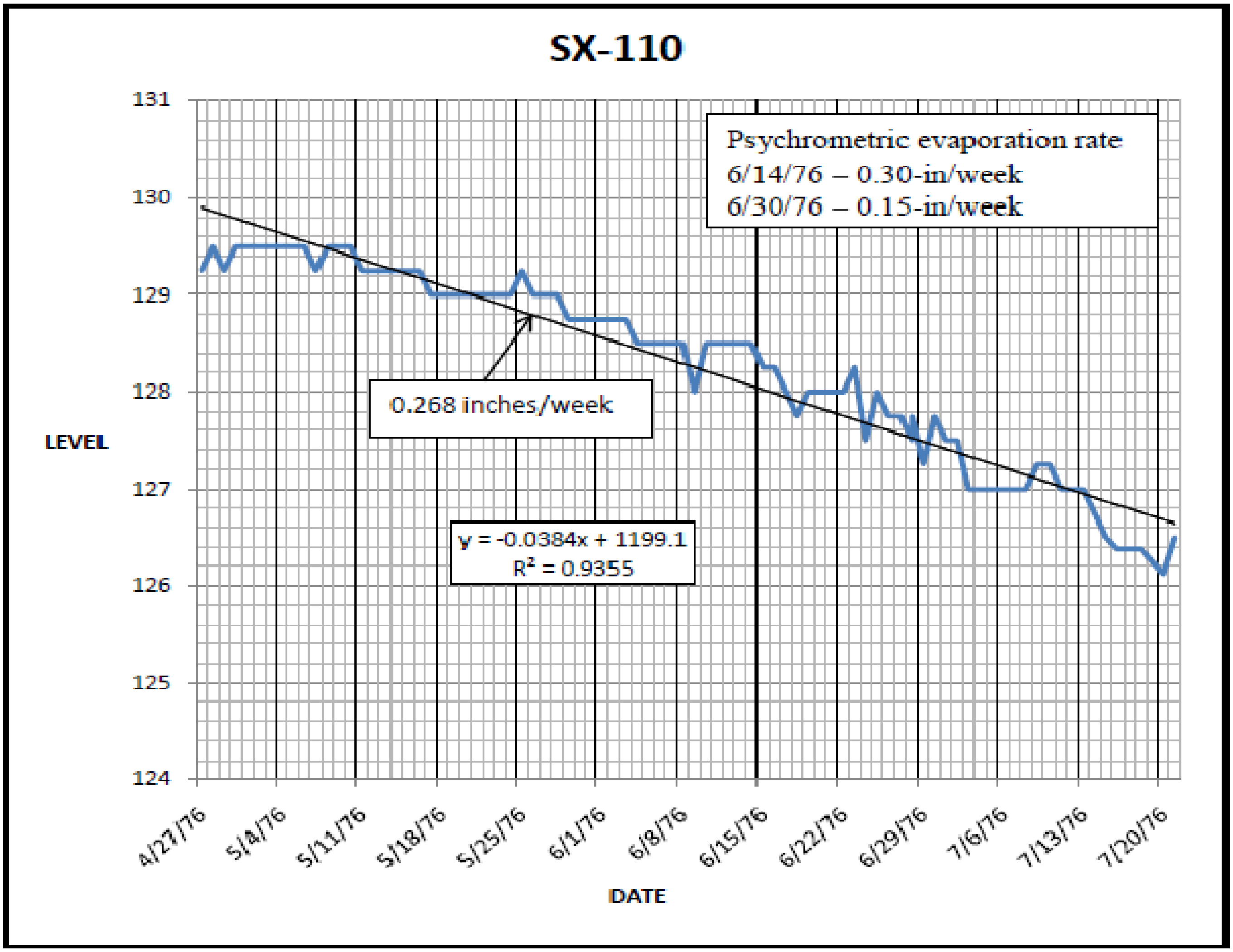
Thermocouple Distance from Tank Bottom (inches)	4/03/76 Temp (°F)	5/02/76 Temp (°F)	6/02/76 Temp (°F)	7/01/76 Temp (°F)	7/17/76 Temp (°F)	7/17/76 Temp (°F)	7/21/76 Temp (°F)
4	85	63	94	82	81	96	87
28	85	64	92	82	81	96	87
52	86	64	92	83	81	96	87
76	86	64	87	81	79	96	85
100	87	64	87	81	80	96	85
124	NA	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.

Figure 1 Tank SX-110 Liquid Level 4/27/1976 to 7/21/1976



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 ft^3, 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 ft^2, area of tank
- Length, 37.5-ft, radius of tank
- Diffusion coefficient, 1,000,000 ft^2, assuming no crust
- Crust thickness, 0.000,000,1 ft^2 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/ft^3

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 in/week	Time Period
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. *Status: Complete.* See Meeting Minutes #4. *Follow-up*: 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.*
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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: Archived surface level and temperature records for the 1974 – 1976 period have been ordered from the Seattle National Archives Regional Repository.*
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		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*

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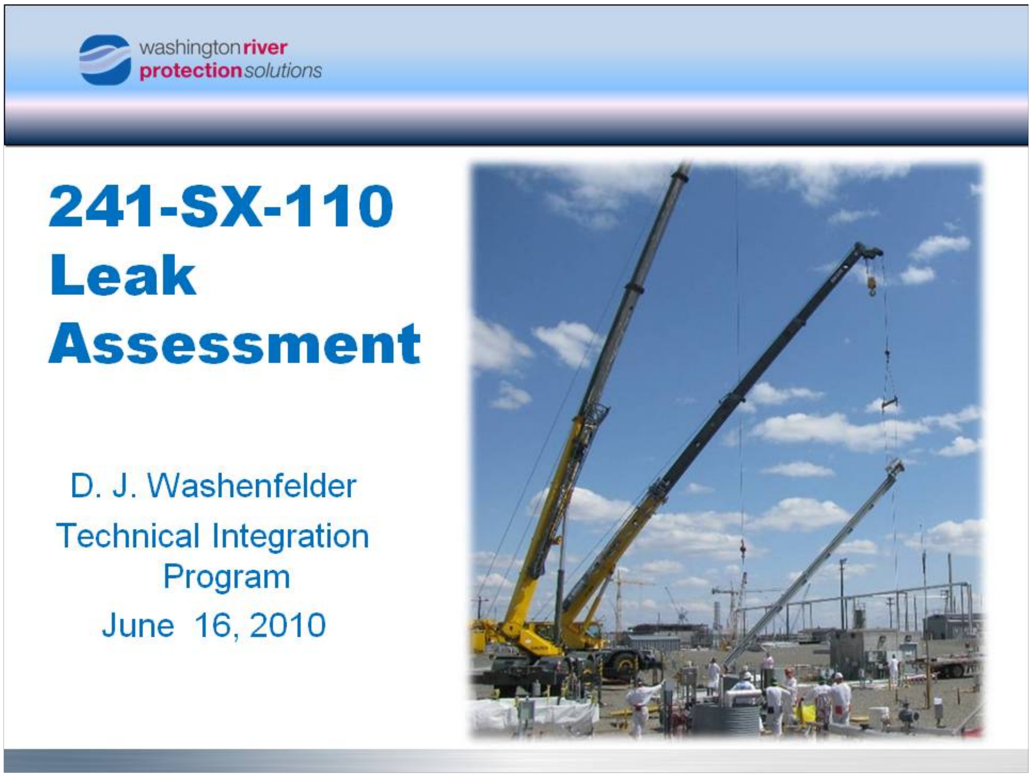
<tr><td colspan="2">H-2-29950 Sh 1. Rev. 21, 1956, “Details Air-Lift Circulator,” General Electric Corporation, Richland, Washington. (IDMS Accession # D9082552)</td></tr>
<tr><td colspan="2">H-2-39951 Sh. 1 Rev. 2, 1956, “Arrangement Air-Lift Circulators,” General Electric Corporation, Richland, Washington. (IDMS Accession # D9082557)</td></tr>
<tr><td colspan="2">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)</td></tr>
<tr><td colspan="2">HW-80202, 1964 [sic], “REDOX Weekly Process Reports January through December 1964,” General Electric Corporation, Richland, Washington. (IDMS Accession # D8558047)</td></tr>
<tr><td colspan="2">Internal Letter, 1977, *Status of Tanks Connected to the 241-SX Sludge Cooler,* Rockwell Hanford Operations, Richland, Washington.</td></tr>
<tr><td colspan="2">Occurrence Report 74-38, 1974, ”*Symptoms of Leakage from an Underground Waste Tank – 111-SX,”* Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # D194052926)</td></tr>
<tr><td colspan="2">Occurrence Report 74-132, 1974, “Decrease of Liquid Level in Tank 110-SX, Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # D194052942)</td></tr>
<tr><td colspan="2">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)</td></tr>
<tr><td colspan="2">Occurrence Report 75-118, 1975, “Liquid Level Increase in Tank 110-SX,” Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # N/A)</td></tr>
<tr><td colspan="2">Occurrence Report 75-145, 1975, “Possible Leakage from an Encased Pipeline,” Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # D1940053029)</td></tr>
<tr><td colspan="2">Occurrence Report 76-91, 1976, “Liquid Level Decrease Exceeding Criteria for Tank 110-SX,” Atlantic Richfield Hanford Company, Richland, Washington. (IDMS Accession # N/A)</td></tr>
<tr><td colspan="2">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)</td></tr>
<tr><td colspan="2">RHO-CD-896, 1980. “Review of Classification of Nine Single-Shell “Questionable Integrity” Tanks.” Rockwell Hanford Operations, Richland, Washington. (IDMS Accession # D8434517)</td></tr>
<tr><td colspan="2">RL SEP 297, 1965 [sic], “REDOX Weekly Process Reports January through December 1965,” General Electric Corporation, Richland, Washington. (IDMS Accession # D2707918)</td></tr>
<tr><td colspan="2">RPP-CALC-46420, draft, *Estimated Water Evaporated from Tank 241-SX-110 Between April 27, 1976 And July 21, 1976,* Washington River Protection Solutions, Richland, Washington.</td></tr>
<tr><td colspan="2">RPP-ENV-39658 Rev. 0 (Draft), “Hanford SX-Farm Leak Assessment Report,” Washington River Protection Solutions, LLC, Richland, Washington. (IDMS Accession # N/A)</td></tr>
</table>

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.



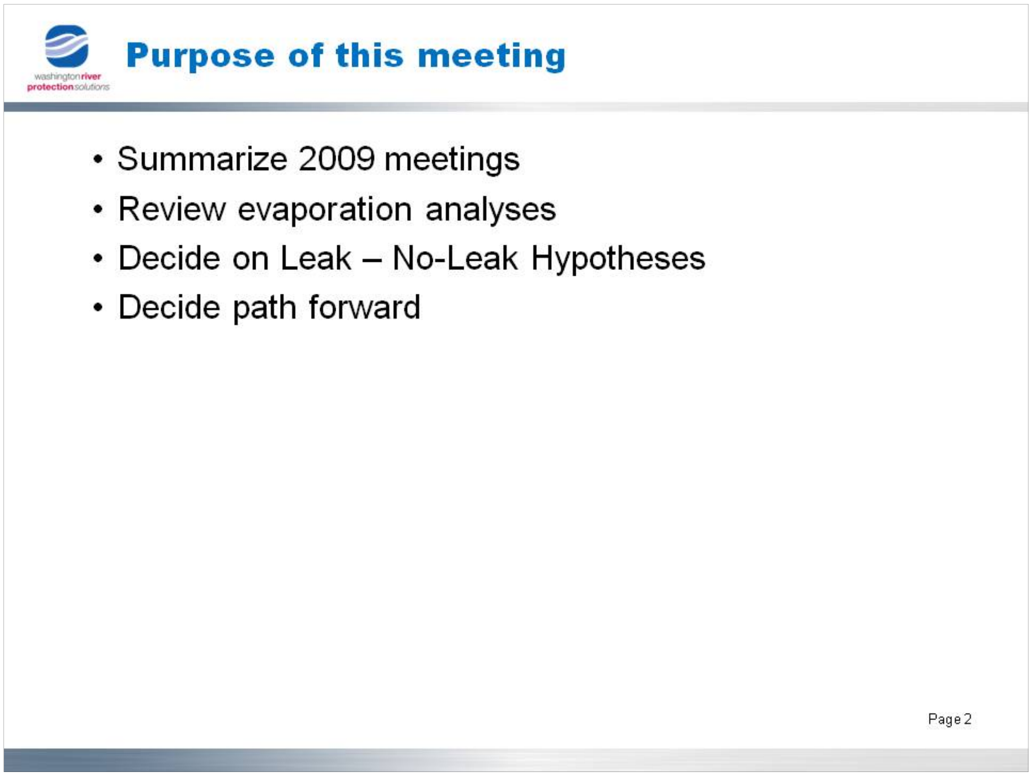
washington river protection solutions

241-SX-110 Leak Assessment

D. J. Washenfelder

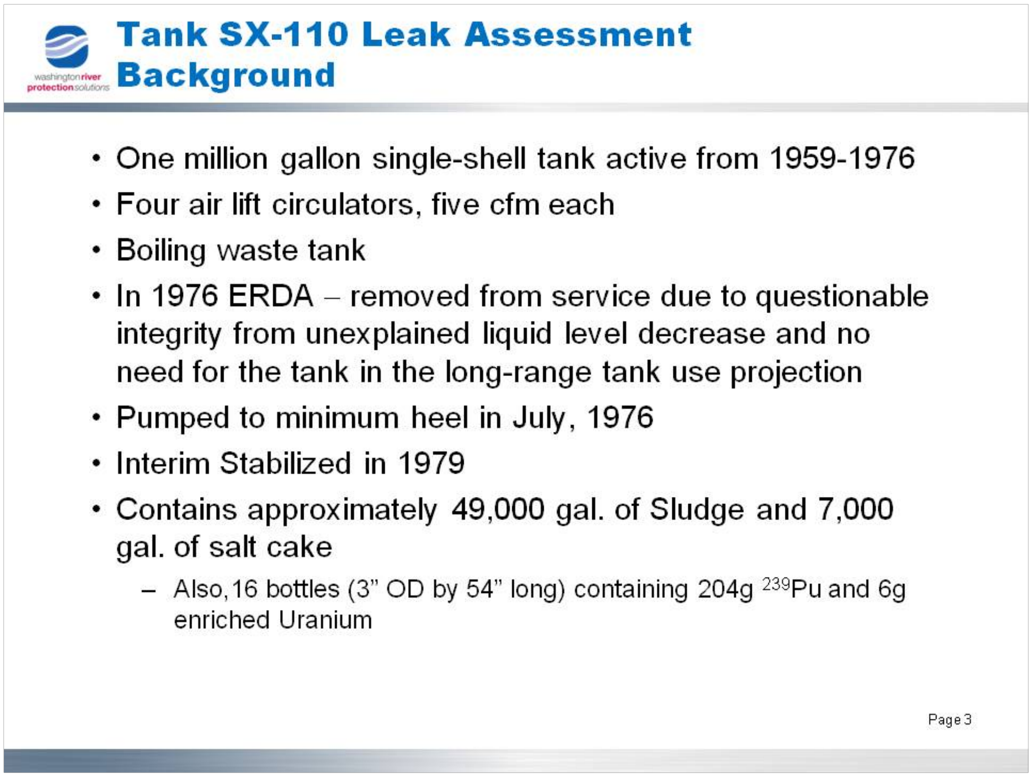
Technical Integration Program

June 16, 2010



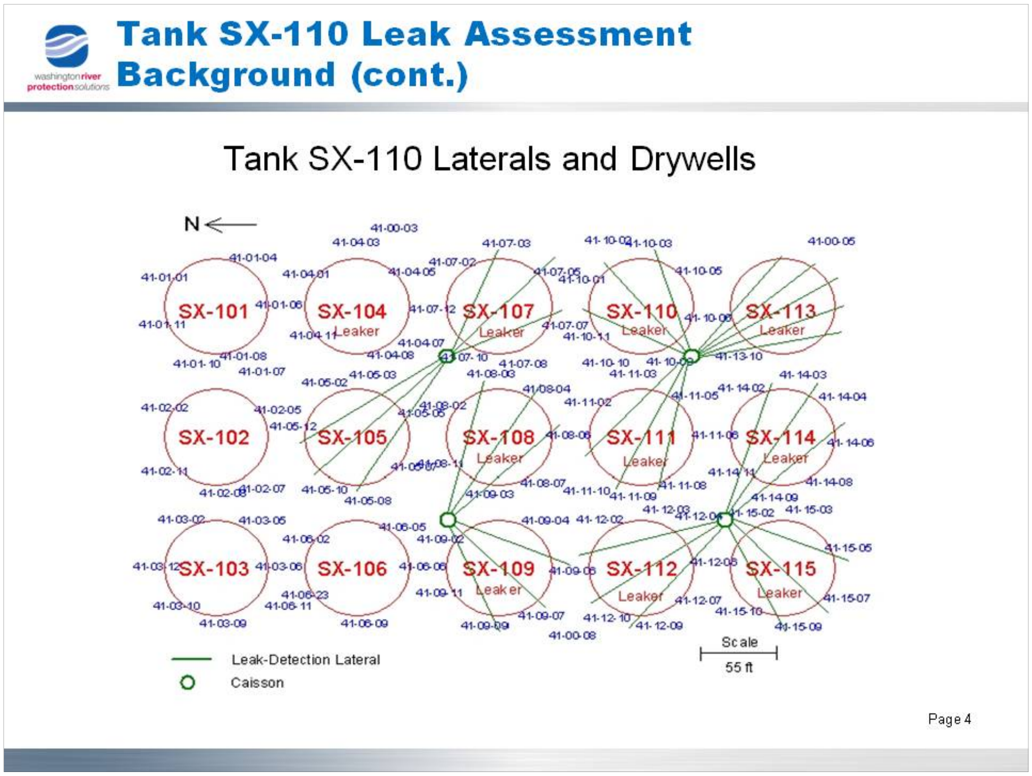
Purpose of this meeting

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



Tank SX-110 Leak Assessment Background

- 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 ^{239}Pu and 6g enriched Uranium



Tank SX-110 Leak Assessment Background (cont.)

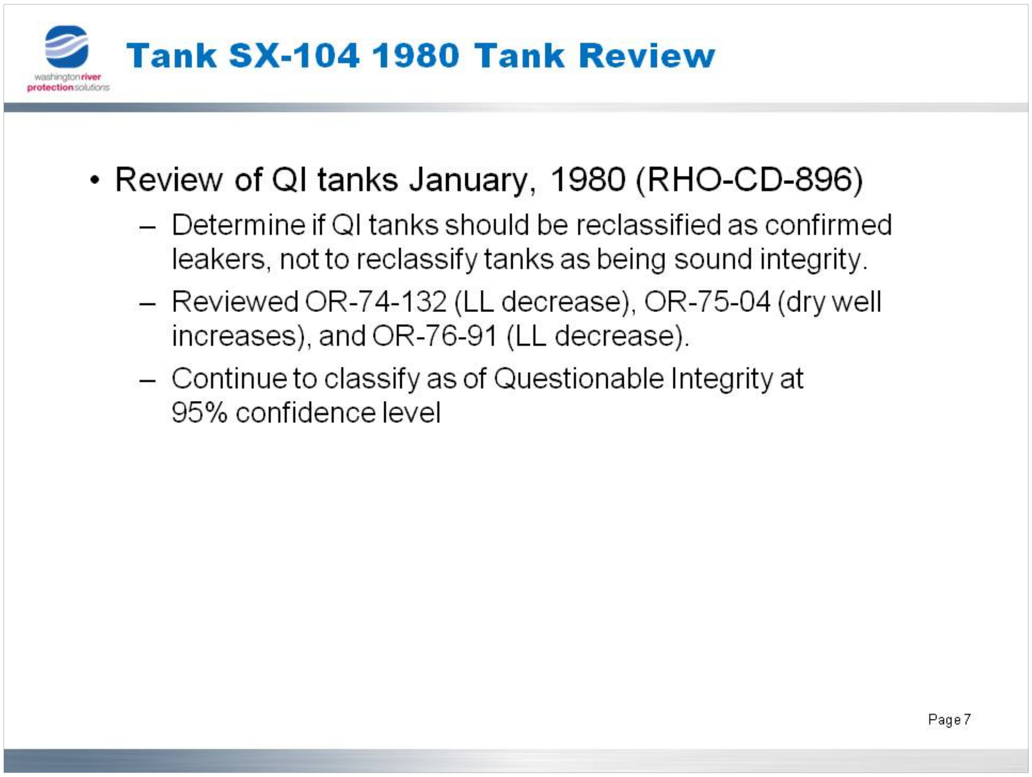
Tank SX-110 Laterals and Drywells

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**

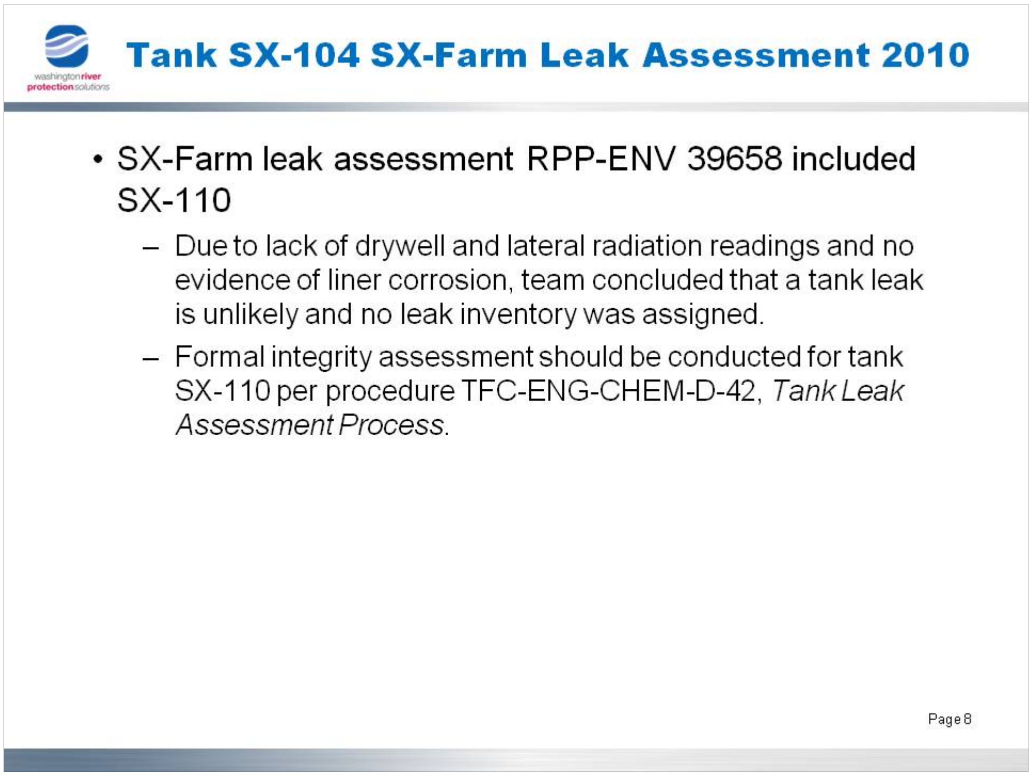
Tank SX-110 Occurrence Reports (cont.)

- 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,



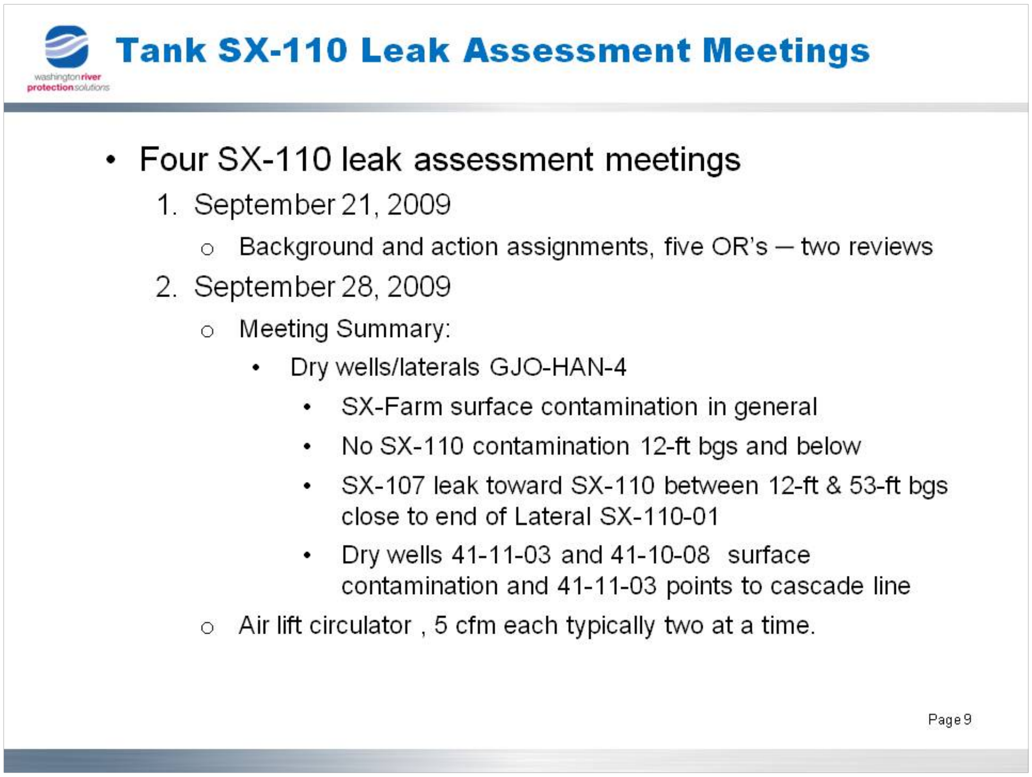
Tank SX-104 1980 Tank Review

- 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



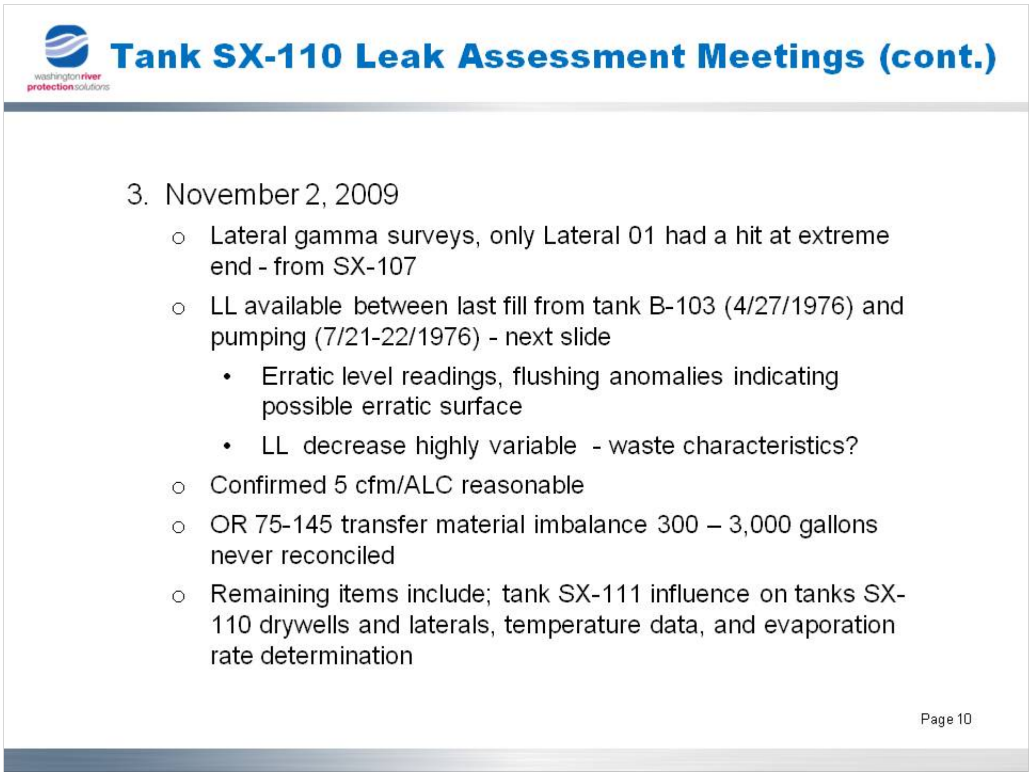
Tank SX-104 SX-Farm Leak Assessment 2010

- 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

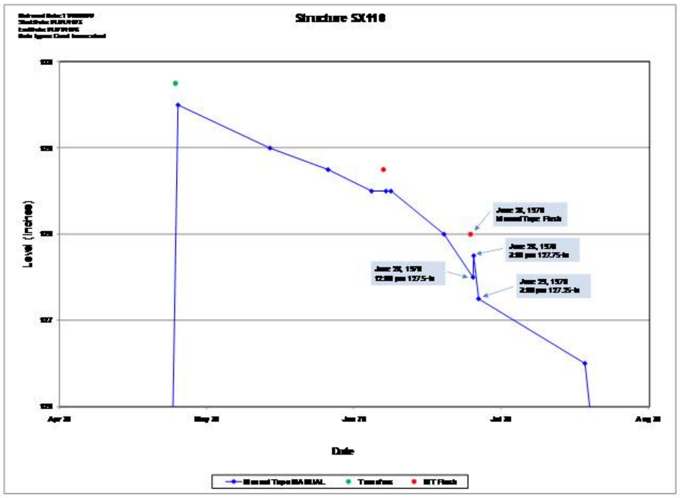
- Four SX-110 leak assessment meetings
  1. September 21, 2009
     - Background and action assignments, five OR's — two reviews
  2. September 28, 2009
     - Meeting Summary:
       - Dry wells/laterals GJO-HAN-4
         - SX-Farm surface contamination in general
         - No SX-110 contamination 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
     - Air lift circulator , 5 cfm each typically two at a time.



Tank SX-110 Leak Assessment Meetings (cont.)

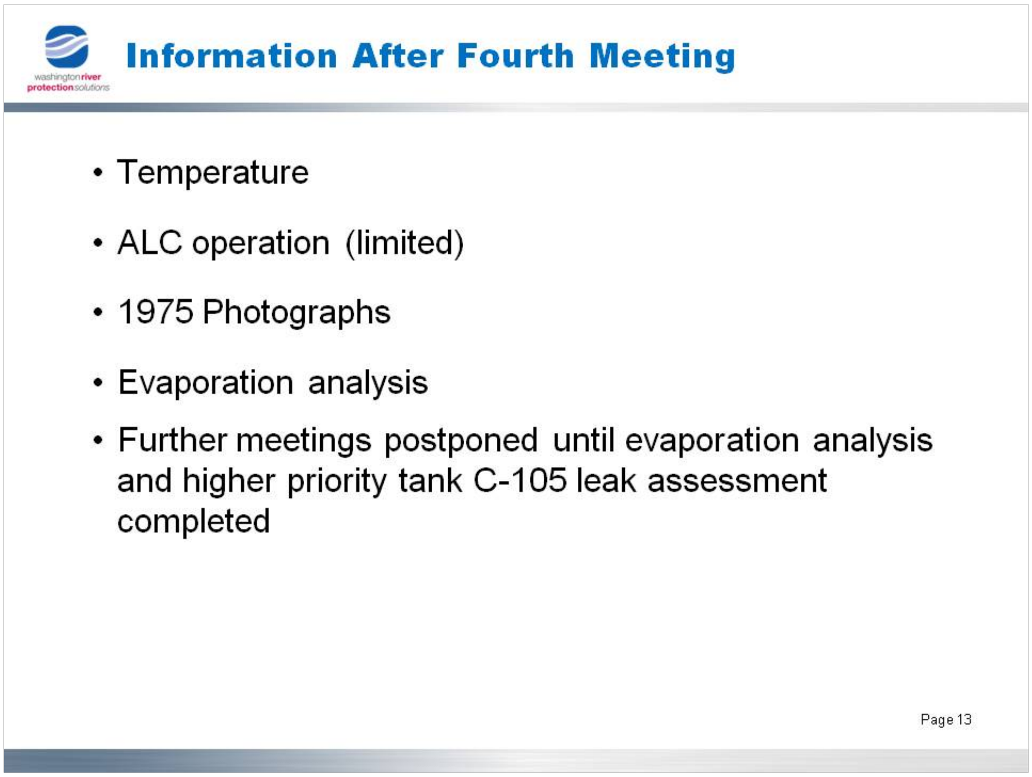
3. November 2, 2009
   - Lateral gamma surveys, only Lateral 01 had a hit at extreme end - from SX-107
   - LL available between last fill from tank B-103 (4/27/1976) and pumping (7/21-22/1976) - next slide
     - Erratic level readings, flushing anomalies indicating possible erratic surface
     - LL decrease highly variable - waste characteristics?
   - 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

Tank SX-110 Liquid Level



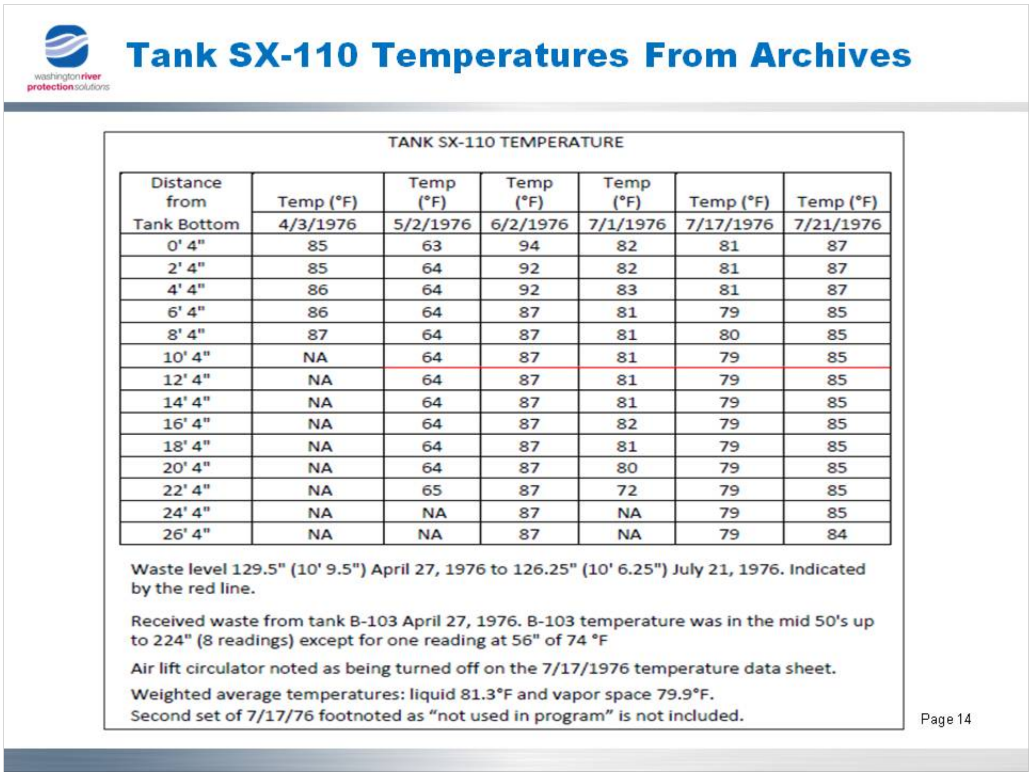
Tank SX-110 Leak Assessment Meetings (cont.)

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



Tank SX-110 Temperatures From Archives

TANK SX-110 TEMPERATURE

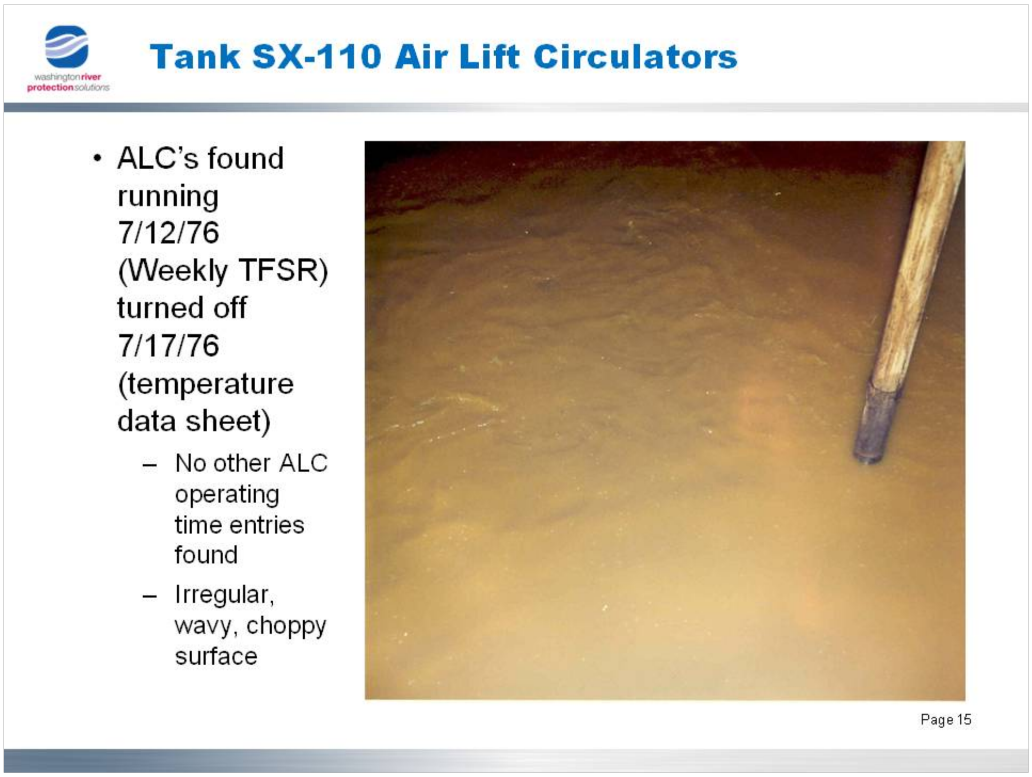
Distance from Tank Bottom	Temp (°F) 4/3/1976	Temp (°F) 5/2/1976	Temp (°F) 6/2/1976	Temp (°F) 7/1/1976	Temp (°F) 7/17/1976	Temp (°F) 7/21/1976
0' 4"	85	63	94	82	81	87
2' 4"	85	64	92	82	81	87
4' 4"	86	64	92	83	81	87
6' 4"	86	64	87	81	79	85
8' 4"	87	64	87	81	80	85
10' 4"	NA	64	87	81	79	85
12' 4"	NA	64	87	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 by the red line.

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

SX-110 1975 Photographs

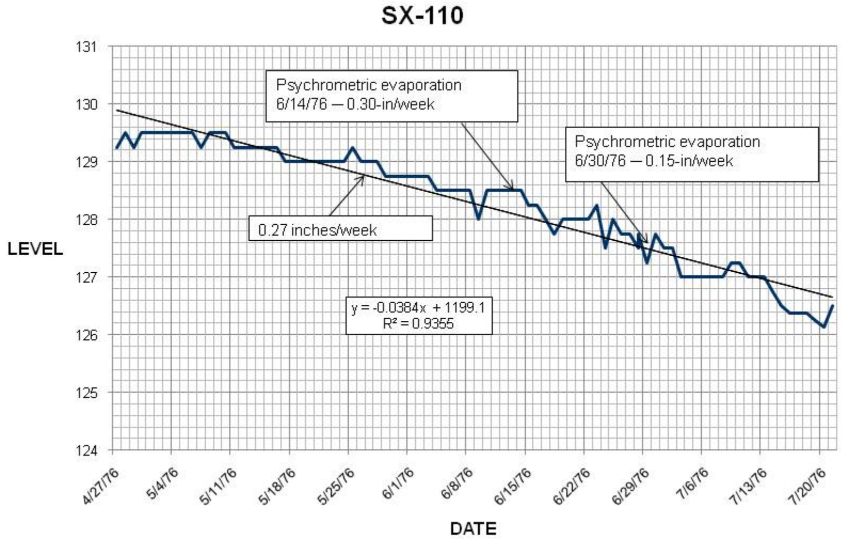
- 1975 photos found
  - Fairly clear- away from liquid surface
  - No anomalies evident
  - Supports observation in 2008 assessment
  - No obvious evidence of corrosion

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

Analysis of 1976 SX-110 Liquid Level Decrease

- 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 Linear Regression

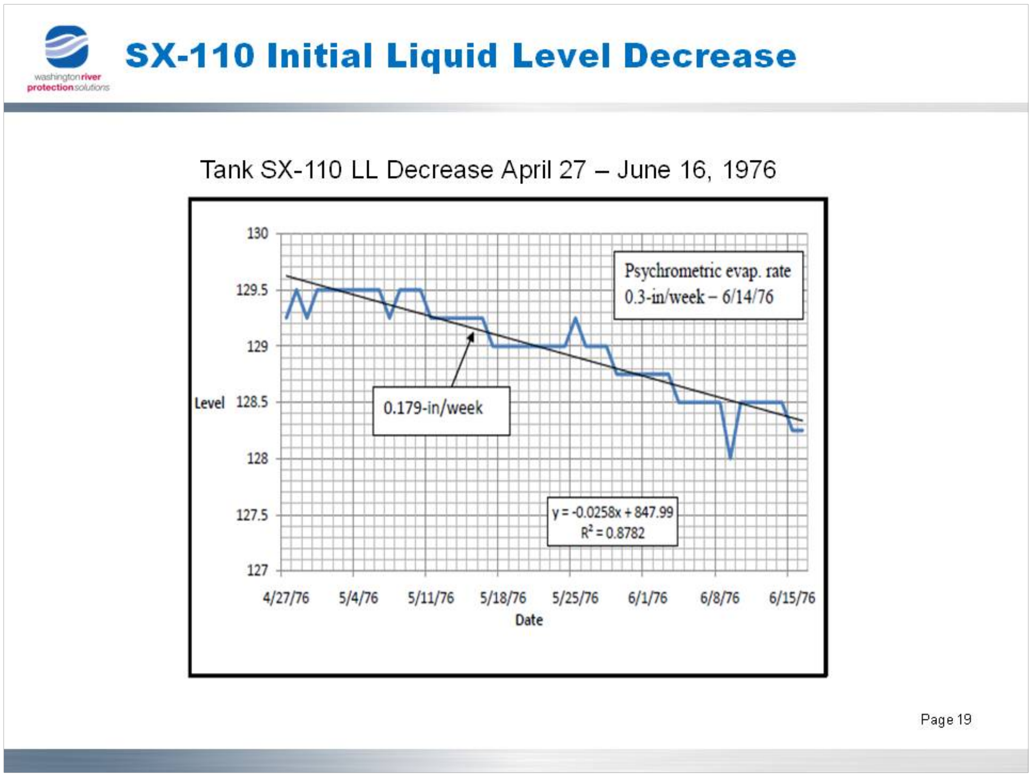


Psychrometric evaporation 6/14/76 — 0.30-in/week

Psychrometric evaporation 6/30/76 — 0.15-in/week

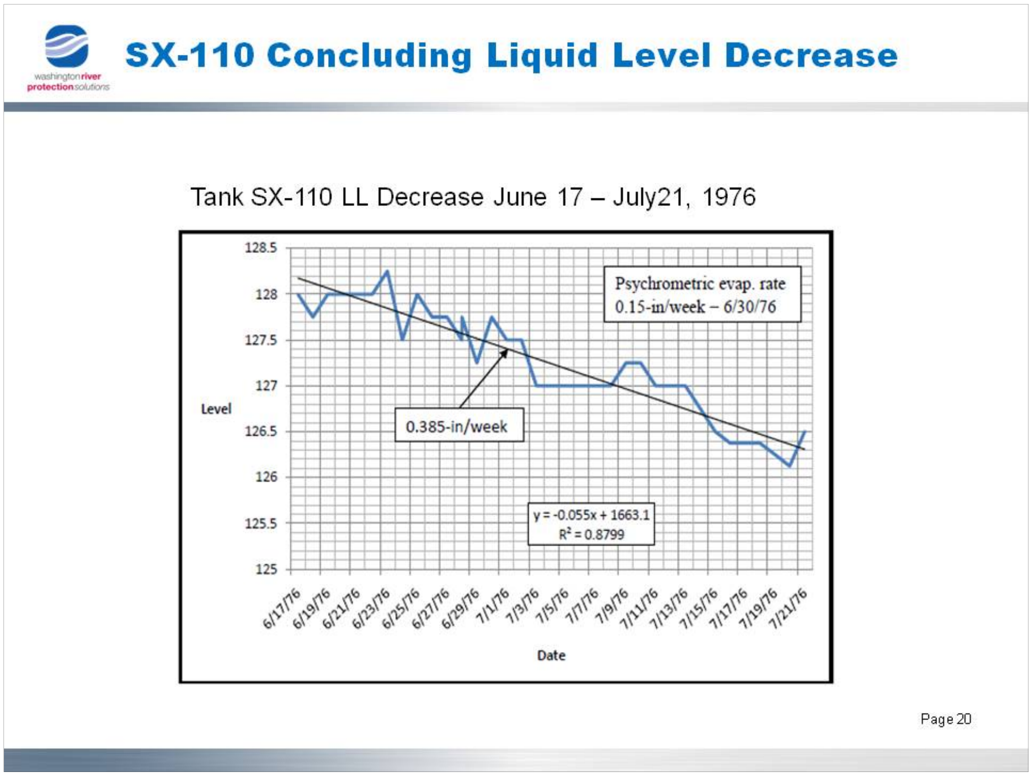
0.27 inches/week

$y = -0.0384x + 1199.1$
$R^2 = 0.9355$



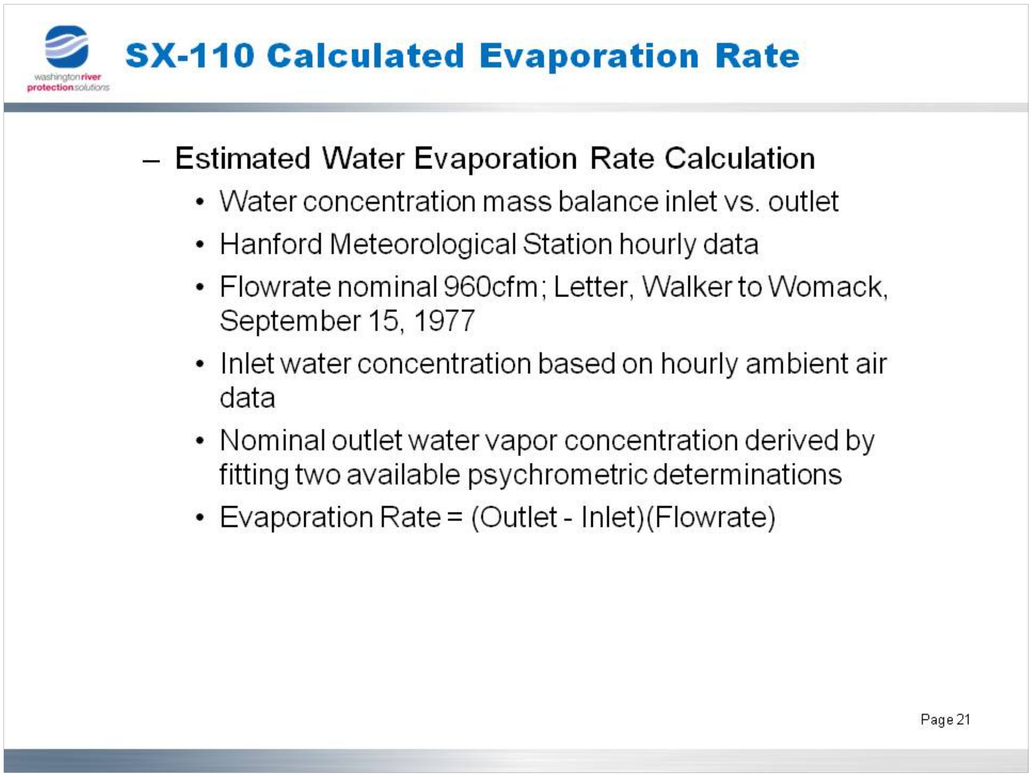
SX-110 Initial Liquid Level Decrease

Tank SX-110 LL Decrease April 27 – June 16, 1976



SX-110 Concluding Liquid Level Decrease

Tank SX-110 LL Decrease June 17 – July21, 1976



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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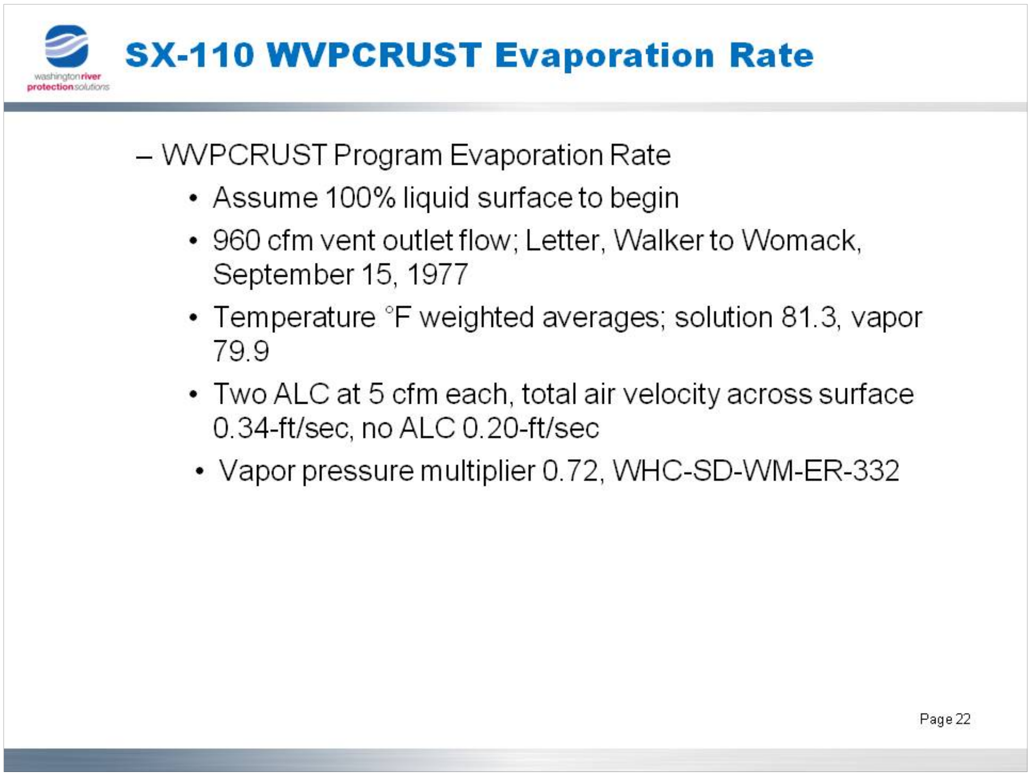

SX-110 WVPCRUST Evaporation Rate

- WVPCRUST 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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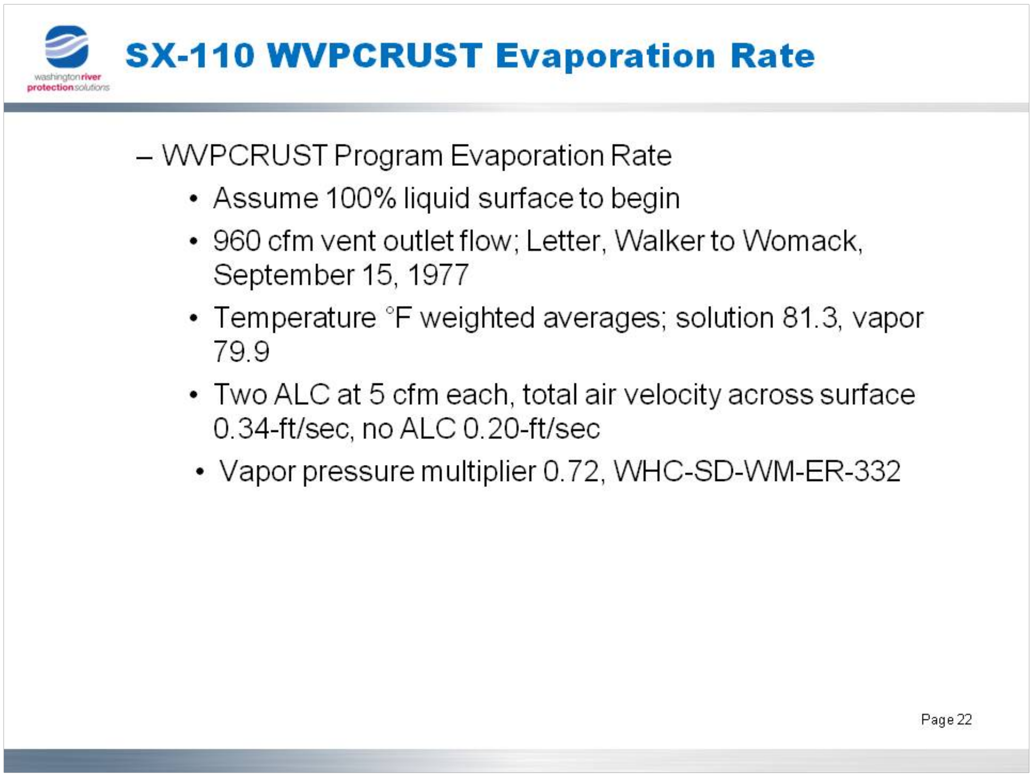
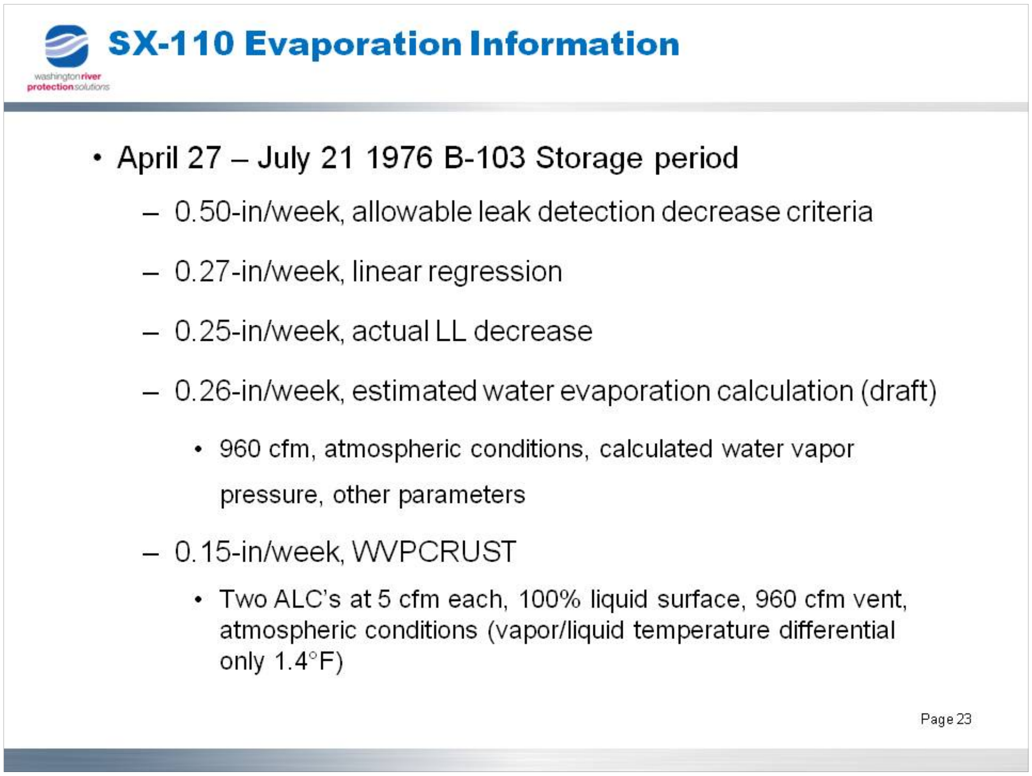


SX-110 WVPCRUST Evaporation Rate

- WVPCRUST 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



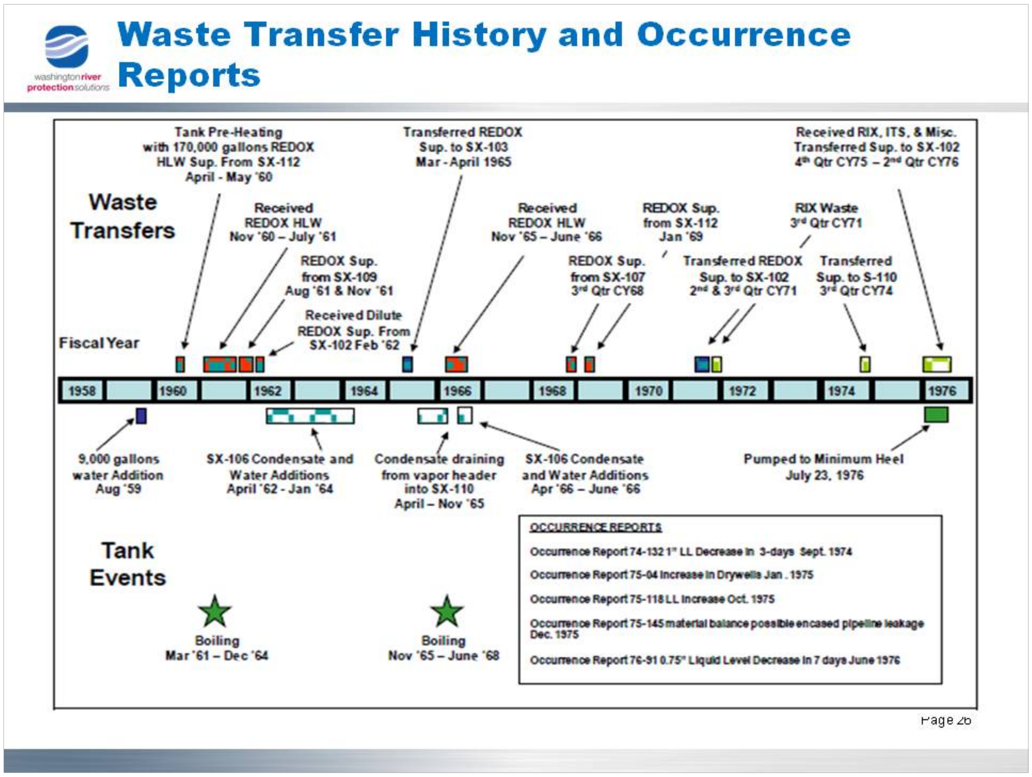
SX-110 Evaporation Information

- **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)

Path Forward

- Develop Leak Non-Leak Hypothesis
- Expert Elicitation Forms

Back Up Slides



Waste Transfer History and Occurrence Reports

Waste Transfers

Tank Pre-Heating with 170,000 gallons REDOX HLW Sup. From SX-112 April - May '60

Received REDOX HLW Nov '60 – July '61

REDOX Sup. from SX-109 Aug '61 & Nov '61

Received Dilute REDOX Sup. From SX-102 Feb '62

Transferred REDOX Sup. to SX-103 Mar - April 1965

Received REDOX HLW Nov '65 – June '66

REDOX Sup. from SX-107 3rd Qtr CY68

REDOX Sup. from SX-112 Jan '69

Transferred REDOX Sup. to SX-102 2nd & 3rd Qtr CY71

RIX Waste 3rd Qtr CY71

Transferred Sup. to S-110 3rd Qtr CY74

Received RIX, ITS, & Misc. Transferred Sup. to SX-102 4th Qtr CY75 – 2nd Qtr CY76

Fiscal Year

9,000 gallons water Addition Aug '59

SX-106 Condensate and Water Additions April '62 - Jan '64

Condensate draining from vapor header into SX-110 April – Nov '65

SX-106 Condensate and Water Additions Apr '66 – June '66

Pumped to Minimum Heel July 23, 1976

Tank Events

Boiling Mar '61 – Dec '64

Boiling Nov '65 – June '68

OCCURRENCE REPORTS

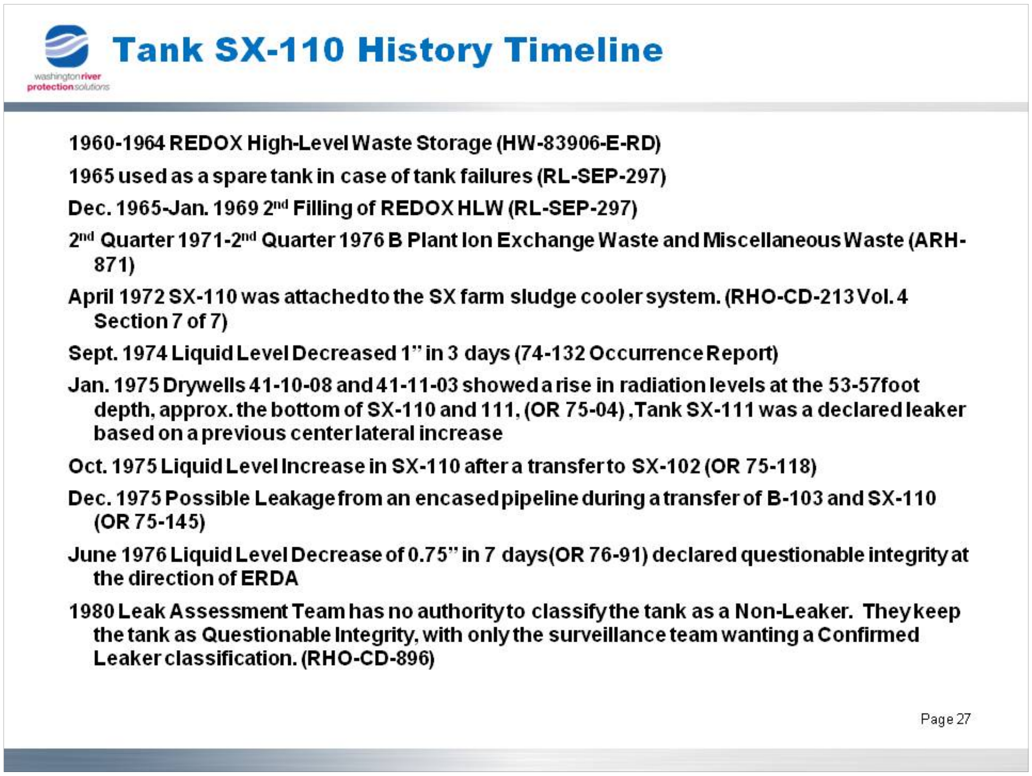
Occurrence Report 74-132 1" LL Decrease in 3-days Sept. 1974

Occurrence Report 75-04 Increase in Drywells Jan . 1975

Occurrence Report 75-118 LL Increase Oct. 1975

Occurrence Report 75-145 material balance possible encased pipeline leakage Dec. 1975

Occurrence Report 76-91 0.75" Liquid Level Decrease in 7 days June 1976



Tank SX-110 History Timeline

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 In-Tank Data (from HNF-3747, Rev. 0)			
SURFACE LEVEL MEASUREMENTS (SLM)	**Observation**		
ENRAF			
Unexplained, repeatable drop>tolerance	Yes	No	NA
Significant drop	Yes	No	NA
Significant trend change	Yes	No	NA
FIC			
Unexplained, repeatable drop>tolerance	Yes	No	NA
Significant drop	Yes	No	NA
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	NA
MANUAL GAUGE			
Unexplained, repeatable drop>tolerance	Yes	No	NA
Significant drop	Yes	No	NA
Significant trend change	Yes	No	NA
LIQUID OBSERVATION WELL (LOW) MEASUREMENTS	**Observation**		
Unexplained, repeatable drop>tolerance	Yes	No	NA
Significant drop	Yes	No	NA
Significant trend change	Yes	No	NA

CORROBORATING EVIDENCE	Corroborates SLM or LOW Data Given		
Thermocouple	Leak	Alt. Hypoth.	NA
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 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	Leak	Alt. Hypoth.	NA
RPP-ENV-39658 Rev. 0 (Draft): **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 over-concentration (HW-83906-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.			

	There was insufficient space available in other 241-SX tanks for storage of freshly 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-871 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, 663 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 Ion 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

	Interim Stabilization (1979) 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).	Leak	Alt. Hypoth.	NA
	Other (specify)	Leak	Alt. Hypoth.	NA
	Other (specify)	Leak	Alt. Hypoth.	NA

TABLE C-2. EX-TANK DATA

HISTORICAL GROSS GAMMA LOGS (GGL)	Observations		
Distribution			
Sign. peak at bottom of tank?	actual 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 76-91). 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.			
Sign. peak near surface?	actual data		No or NA
Sign. increased activity in between?	actual data		No or NA
Sign. increased activity below tank?	actual data		No or NA
Activity across boreholes			
Multiple boreholes?	Yes	No	NA
Consistent across boreholes?	Yes	No	NA
Activity 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
CORROBORATING EVIDENCE	**Corroborates SGL or GGL Data Given**		
Moisture Probe	Leak	Alt. Hypoth.	NA
Psychrometrics	Leak	Alt. Hypoth.	NA
Bore hole core sample	Leak	Alt. Hypoth.	NA
Laterals The activity detected at the extreme end (or bottom) of lateral 44-10-01 is thought to be associated with the loss of waste from tank SX-107.	Leak	Alt. Hypoth.	NA

Tank 241-SX-110 Leak Assessment Ex-Tank Data
(from HNF-3747, Rev. 0)

SPECTRAL GAMMA LOGS (SGL)	Observation		
Radionuclides			
Man-made?	Yes	No	NA
Multiple?	Yes	No	NA
Distribution			
Peak at bottom of tank?	actual data		No or NA
Peak near surface?	actual data		No or NA
Increased activity in between?	actual data		No or NA
Increased activity below tank? **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.	actual data		No or NA
Activity across boreholes			
Multiple boreholes?	Yes	No	NA
Activity over time			
Increased activity?	Yes	No	NA

Tank 241-SX-110 Leak Assessment Ex-Tank Data
(from HNF-3747, Rev. 0)

SPECTRAL GAMMA LOGS (SGL)	**Observation**		
Radionuclides			
Man-made?	Yes	No	NA
Multiple?	Yes	No	NA
Distribution			
Peak at bottom of tank?	actual data		No or NA
Peak near surface?	actual data		No or NA
Increased activity in between?	actual data		No or NA
Increased activity below tank?	actual 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

Weather conditions			
Barometric pressure	Leak	Alt. Hypoth.	NA
Precipitation	Leak	Alt. Hypoth.	NA
Temperature	Leak	Alt. Hypoth.	NA
Surface flooding	Leak	Alt. Hypoth.	NA
Process history	Leak	Alt. Hypoth.	NA
Drywell drilling logs	Leak	Alt. Hypoth.	NA
Occurrence reports	Leak	Alt. Hypoth.	NA
Occurrence Report 74-132, September 1974: The surface level decreased 1-in in three days, exceeding the decrease criterion of 0.5-in in seven days. None of the tank laterals or drywells showed any change. The tank contained 400 kgal of supernatant and 32 kgal of sludge, and had sufficient heat to evaporate ~ 0.25-in per week. Prior to the OR, there was a two week period when the MT did not indicate a decrease from evaporation. Following the decrease, the tank was switched from the SX ventilation system to the SX Farm sludge cooler, increasing the ventiilation rate from 60 cfm to ~1000 cfm. The surface level decreased -1-in during the next 3 days compared to actual psychrometric measurements indicating the tank should have lost -1.4-in per week. The tank was reconnected to the SX ventilation system. A note in the Preliminary OR indicates that this level behavior has been observed in other tanks with ALCs. The tank has four ALCs, with flowrates of ~ 5 cfm each. **Occurrence Report 75-04, January 1975**: Drywells 41-10-08 and 41-11-03, located between tanks SX-110 and SX-111 showed increased radiation at 53-ft - 57-ft. Tank SX-110 Contained ~ 393 kgal of supernatant and 32 kgal of sludgeg. Tank SX-111 was declared a leaker in May, 1974, and contained ~ 125 kgal of sludgeg Both tanks were ventilated at the time of occurrence. The surface level of SX-110 was decreasing due to evaporation, and was within leak detection criteria; SX-111 contained only sludge. Final OR noted that the radiation levels in the drywells had stabilized; and hints that once the SX-110 supernatant is transferred to the 242-S Evaporator/Crystallizer, it is unlikely that the tank would be used for storage of terminal liquor (i.e., 242-S concentrated product). **Occurrence Report 76-91, June 1976**: The surface level decreased -0.75-in in seven days, exceeding the -0.5-in in 7 days decrease criterion. Two psychrometric analyses completed during June reported evaporation losses of -0.3-in per week and -0.15-in per week. The June 30, 1976 MT surface level readings were erratic, with one of three readings - 127.25-in - exceeding the decrease criterion. Drywell and lateral readings were stable. No corrective action			
Letter July 21, 1976 (IDMS D196225037): Tank is being watched because of a surface level decrease of -3.5-in. with -1.5-in not explained by evaporation and cooling. The tank's 9 drywells and 3 laterals do not exhibit any evidence of a tank leak.			
Surface spills	Leak	Alt. Hypoth.	NA
Transfer line leaks	Leak	Alt. Hypoth.	NA

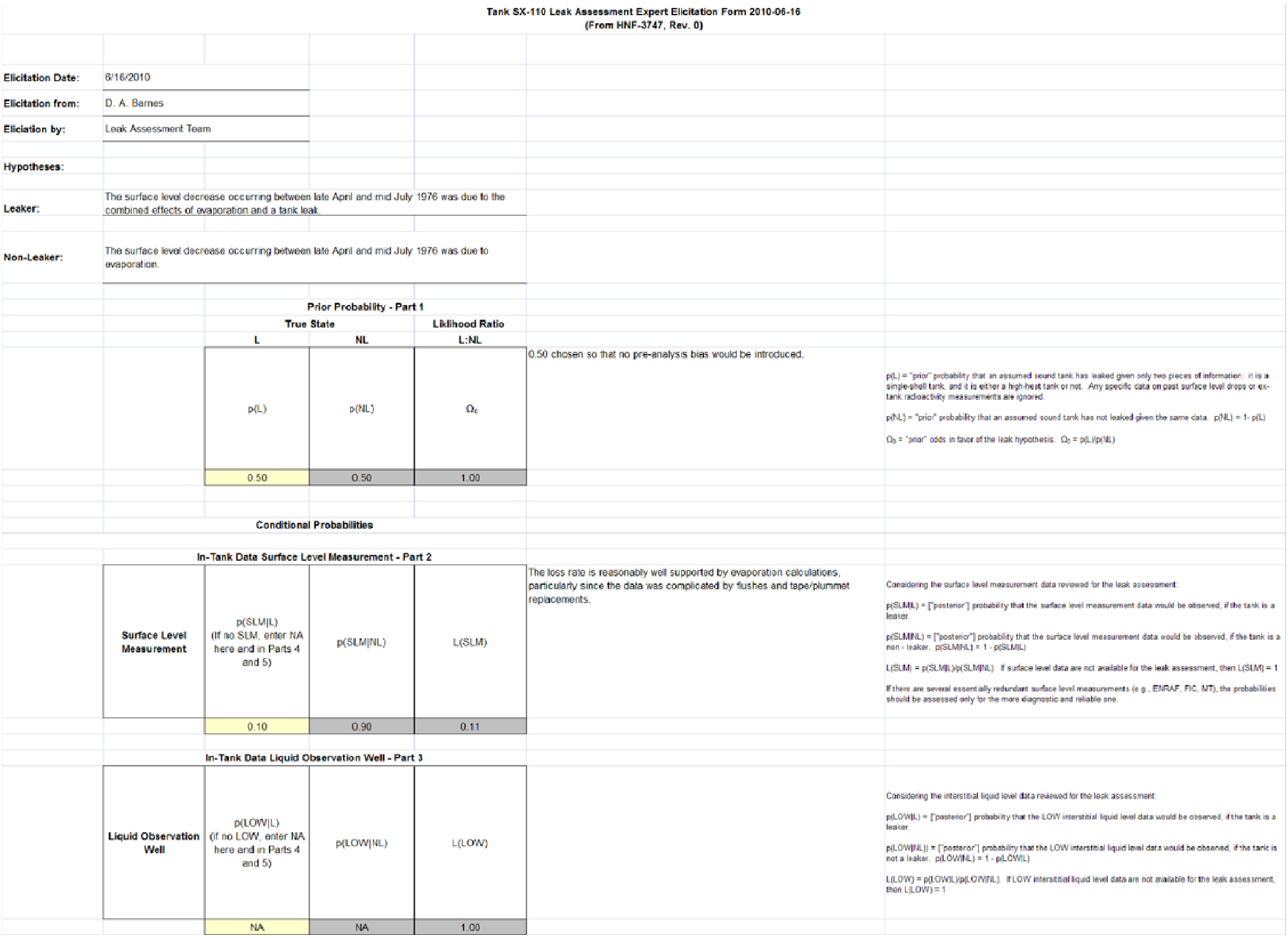
Construction history	Leak	Alt. Hypoth.	NA
Equipment maintenance calibration	Leak	Alt. Hypoth.	NA
Waste characteristics	Leak	Alt. Hypoth.	NA
In-tank operations	Leak	Alt. Hypoth.	NA
Leak Assessments	Leak	Alt. Hypoth.	NA
July 21, 1976 (D194023422): The Energy Research and Development Administration (ERDA) 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 [N2129097]) and February 20, 1987 (8701204-25cn [N2125781] thru 8701204-56cn [N2125935]) were located and reviewed. The July 23, 1976 photographs are black and white images whereas the February 20, 1987 photographs are color images. There is streaking on the steel liner walls, but the 1976 photographs do not show any evidence of corrosion of the steel tank liner. The February 20, 1987 color photographs show different coloration (i.e. shades of yellow, orange and red) along the steel tank liner walls, possibly due to residual red lead paint used to protect the steel liner (HW-4957 page 34).			
Other (specify)	Leak	Alt. Hypoth.	NA

APPENDIX D

Tank SX-110 Leak Assessment Team Expert Elicitation Forms

ELICITATION FORMS

Expert Opinion: Expert Opinion: D. A. Barnes



Tank SX-110 Leak Assessment Expert Elicitation Form 2010-06-16
(From HNF-3747, Rev. 0)

Elicitation Date: 6/16/2010

Elicitation from: D. A. Barnes

Eliciation by: Leak Assessment Team

Hypotheses:

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

Prior Probability - Part 1

True State		**Liklihood Ratio**
L	**NL**	**L:NL**
p(L)	p(NL)	Ω_0
0.50	0.50	1.00

0.50 chosen so that no pre-analysis bias would be introduced.

p(L) = "prior" probability that an assumed sound tank has leaked given only two pieces of information: it is a single-shell tank, and it is either a high-heat tank or not. Any specific data on past surface level drops or ex-tank radioactivity measurements are ignored.

p(NL) = "prior" probability that an assumed sound tank has not leaked given the same data. p(NL) = 1- p(L)

Ω_0 = "prior" odds in favor of the leak hypothesis. Ω_0 = p(L)/p(NL)

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)
	0.10	0.90	0.11

The loss rate is reasonably well supported by evaporation calculations, particularly since the data was complicated by flushes and tape/plummet replacements.

Considering the surface level measurement data reviewed for the leak assessment:

p(SLM|L) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a leaker.

p(SLM|NL) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a non - leaker. p(SLM|NL) = 1 - p(SLM|L)

L(SLM) = p(SLM|L)/p(SLM|NL). If surface level data are not available for the leak assessment, then L(SLM) = 1

If there are several essentially redundant surface level measurements (e.g., ENRAF, FIC, MT), the probabilities should be assessed only for the more diagnostic and reliable one.

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)
	NA	NA	1.00

Considering the interstitial liquid level data reviewed for the leak assessment:

p(LOW|L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is a leaker.

p(LOW|NL)) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is not a leaker. p(LOW|NL) = 1 - p(LOW|L)

L(LOW) = p(LOW|L)/p(LOW|NL). If LOW interstitial liquid level data are not available for the leak assessment, then L(LOW) = 1

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

Surface Level Measurement - Liquid Observation Well Interdependence	$p(SLM \mid LOW,L)$ (if no LOW, enter NA)	$p(SLM \mid LOW,NL)$	$L(SLM \mid LOW)$
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

$p(SLM \mid LOW,L)$ = ["posterior"] probability that the surface level measurement data would be observed if the LOW interstitial liquid level data are observed, and if the tank is a leaker.

$p(SLM \mid LOW,NL)$ = ["posterior"] probability that a surface level measurement data would be observed if the LOW interstitial liquid level measurement data are observed, and if the tank is a non-leaker. $p(SLM \mid LOW,NL) = 1 - p(SLM \mid LOW,L)$

$L(SLM \mid LOW) = p(SLM \mid LOW,L)/p(SLM \mid LOW,NL)$. If either surface level measurement data or LOW interstitial liquid level data are not available for the leak assessment, then $L(SLM \mid LOW) = 1$.

If there is no LOW, skip to the next part.

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

Liquid Observation Well - Surface Level Measurement Interdependence	$p(LOW \mid SLM,L)$ (if no SLM, enter NA)	$p(LOW \mid SLM,NL)$	$L(LOW \mid SLM)$
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

$p(LOW \mid SLM,L)$ = ["posterior"] probability that the LOW interstitial liquid level data would be observed if a surface level measurement decrease is observed, and if the tank is a leaker.

$p(LOW \mid SLM,NL)$ = ["posterior"] probability that a LOW interstitial liquid level measurement decrease would be observed if a surface level measurement decrease is observed, and if the tank is a non-leaker. $p(LOW \mid SLM,NL) = 1 - pp(LOW \mid SLM,L)$

$L(LOW \mid SLM) = p(LOW \mid SLM,L)/p(LOW \mid SLM,NL)$. If either surface level data or LOW interstitial liquid level data are not available for the leak assessment, then $L(LOW \mid SLM) = 1$.

Ex-Tank Data - Gross Gamma Drywell Logs - Part 6

Gross Gamma Drywell Logs	$p(GGL \mid L)$ (if no GGL, enter NA here and in Parts 8 and 9)	$p(GGL \mid NL)$	$L(GGL)$
	0.20	0.80	0.25

All drywells and/or lateral data was completely clean, except for some contamination near other known leaker tanks. There is no drywell or lateral evidence to support a leak from SX110.

Considering the historical gross gamma drywell logs reviewed for the leak assessment:

$p(GGL \mid L)$ = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a leaker.

$p(GGL \mid NL)$ = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a non - leaker. $p(GGL \mid NL) = 1 - p(GGL \mid L)$

$L(GGL) = p(GGL \mid L)/p(GGL \mid NL)$. If gross gamma logs are not available for the leak assessment, then $L(GGL) = 1$

Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7

Spectral Gamma Drywell Logs	$p(SGL \mid L)$ (if no SGL, enter NA here and in Parts 8 and 9)	$p(SGL \mid NL)$	$L(SGL)$
	0.20	0.80	0.25

The spectral gamma surveys confirm that the drywells surrounding SX110 are clean, and the equipment is much more sensitive than the gross gamma tools. This lends credibility to the non-leak hypothesis.

Considering the spectral gamma drywell logs reviewed for the leak assessment:

$p(SGL \mid L)$ = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a leaker.

$p(SGL \mid NL)$ = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a non - leaker. $p(SGL \mid NL) = 1 - p(SGL \mid L)$

$L(GGL) = p(SGL \mid L)/p(SGL \mid NL)$. If spectral gamma drywell logs are not available for the leak assessment, then $L(SGL) = 1$.

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

Gross Gamma Log - Spectral Gamma Log Interdependence	$p(GGL \mid SGL,L)$	$p(GGL \mid SGL,NL)$	$L(GGL \mid SGL)$
	NA	NA	1.00

Considering that ex-tank data sources may be interdependent:

$p(GGL \mid SGL,L)$ = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are are observed, and if the tank is a leaker.

$p(GGL \mid SGL,NL)$ = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are observed, and if the tank is a non-leaker. $p(GGL \mid SGL,NL) = 1 - p(GGL \mid SGL,L)$

$L(GGL \mid SGL) = p(GGL \mid SGL,L)/p(GGL \mid SGL,NL)$. If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then $L(GGL \mid SGL) = 1$.

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

Spectral Gamma Log - Gross Gamma Log Interdependence	$p(SGL \mid GGL,L)$	$p(SGL \mid GGL,NL)$	$L(SGL \mid GGL)$
	0.40	0.60	0.67

A value of 0.40 was chosen to give some weighting to the spectral gamma data, since it does support the same conclusion as the gross gamma data. A value of 0.50 would give 100% weight to the gross gamma and 0% to the spectral data.

Considering that ex-tank data sources may be interdependent:

$p(SGL|GGL,L)$ = ["posterior"] probability that the spectral gamma logs would be observed if the gross gamma logs are observed, and if the tank is a leaker.

$p(SGL|GGL,NL)$ = ["posterior"] 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. $p(GGL|SGL,NL) = 1 - p(SGL|GGL,L)$

$L(SGL|GGL) = p(SGL|GGL,L) / p(SGL|GGL,NL)$. If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then $L(SGL|GGL) = 1$.

Combined Liklihood Ratios

L(SLM)	L(LOW)	$L(SLM \mid LOW)$	$L(LOW \mid SLM)$
0.11	1.00	1.00	1.00

L(GGL)	L(SGL)	$L(GGL \mid SGL)$	$L(SGL \mid GGL)$
0.25	0.25	1.00	0.67

Which In-Tank Condition Applies? (Mark X in Box)

SLM & No LOW?	X
LOW & No SLM?	
SLM & LOW; SLM most important? (Mark Part 4 NA)	
SLM & LOW; LOW most important? (Mark Part 5 NA)	

In-Tank Liklihood Ratio	**L(SLM,LOW)**
	0.11

If SLM and no LOW: $L(SLM,LOW) = L(SLM)$
if LOW and no SLM: $L(SLM,LOW) = L(LOW)$
If SLM and LOW and SLM most important: $L(SLM,LOW) = L(LOW|SLM) \times L(SLM)$
If SLM and LOW and LOW most important: $L(SLM,LOW) = L(SLM|LOW) \times L(LOW)$

Which Ex-Tank Condition Applies? (Mark X in Box)

GGL & No SGL?	
SGL & No GGL?	
GGL & SGL; GGL most important? (Mark Part 8 NA)	X
GGL & SGL; SGL most important? (Mark Part 9 NA)	

Ex-Tank Liklihood Ratio	**L(SGL,GGL)**
	0.17

If GGL and no SGL: $L(SGL,GGL) = L(GGL)$
if SGL and no GGL: $L(SGL,GGL) = L(SGL)$
If GGL and SGL and GGL most important: $L(SGL, GGL) = L(SGL|GGL) \times L(GGL)$
If GGL and SGL and SGL most important: $L(SGL, GGL) = L(GGL|SGL) \times L(LSGL)$

Combined Likelihood Ratio for Leak Hypothesis	**L(in,ex)**
	0.02

This indicates that there is approximately a 2% chance that the tank leaked, but was not identified from either the surface level data or the drywell/lateral data. Given the strong support for the non-leak hypothesis, this value seems reasonable.

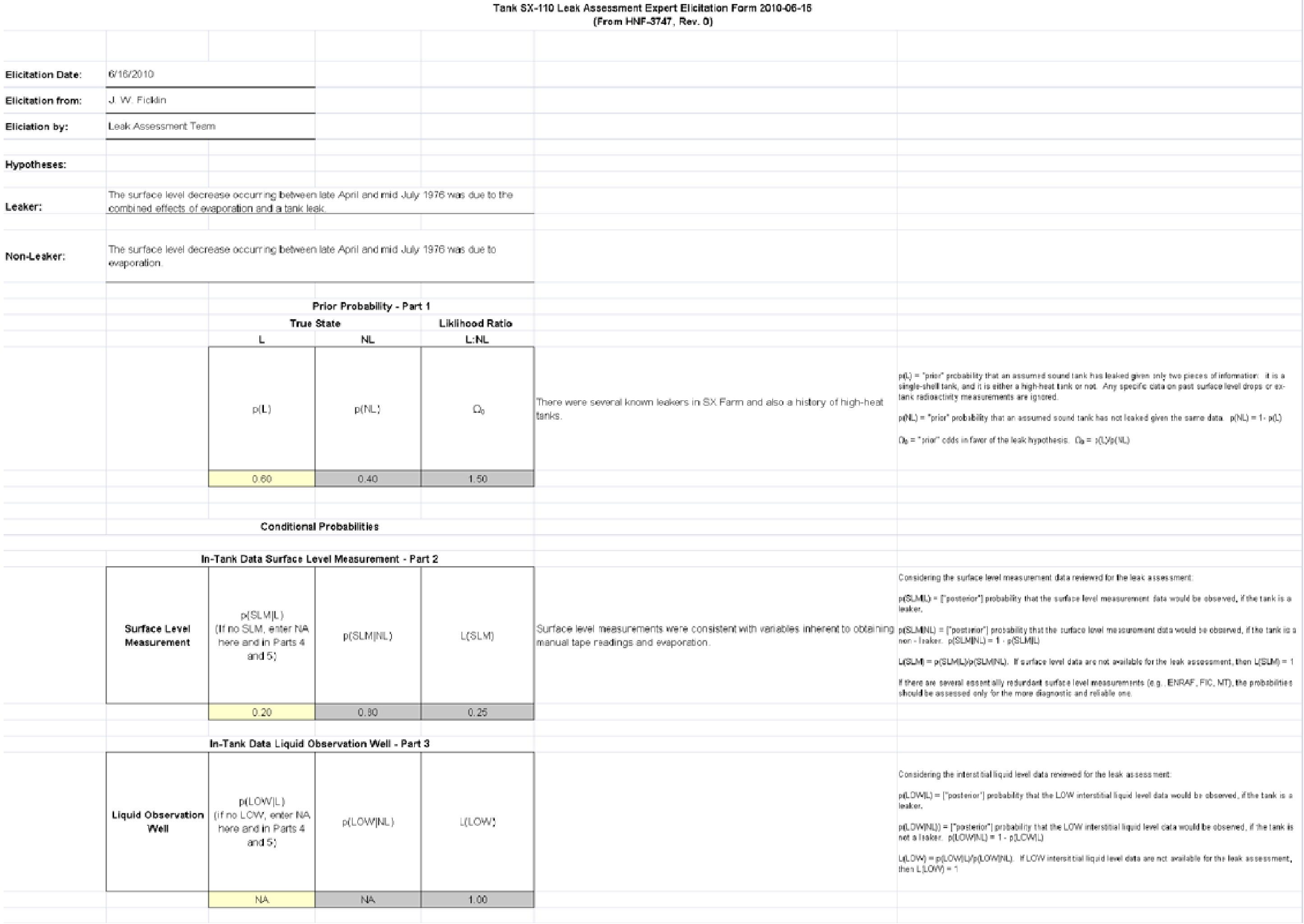
$L(in,ex) = L(SLM,LOW) \times L(SGL,GGL)$

Posterior Probability for Leak Hypothesis

$p(L \mid in,ex)$	$p(NL \mid in,ex)$	Ω_1
0.02	0.98	0.02

Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. $\Omega_1 = L(in,ex) \times \Omega_0$
$p(L|in,ex)$ = posterior probability (post-leak assessment) that the tank is a leaker. $(L|in,ex) = \Omega_1/(\Omega_1+1)$
$p(NL|in,ex)$ = posterior probability (post-leak assessment) that the tank is a leaker. $p(NL|in,ex) = 1 - p(L|in,ex)$

Expert Opinion: Expert Opinion: J. W. Ficklin



Tank SX-110 Leak Assessment Expert Elicitation Form 2010-06-16
(From HNF-3747, Rev. 0)

Elicitation Date: 6/16/2010

Elicitation from: J. W. Ficklin

Eliciation by: Leak Assessment Team

Hypotheses:

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

Prior Probability - Part 1

	True State		**Likilhood Ratio**		
	L	**NL**	**L:NL**		
	p(L)	p(NL)	Ω_0	There were several known leakers in SX Farm and also a history of high-heat tanks.	p(L) = "prior" probability that an assumed sound tank has leaked given only two pieces of information: it is a single-shell tank, and it is either a high-heat tank or not. Any specific data on past surface level drops or ex-tank radioactivity measurements are ignored. p(NL) = "prior" probability that an assumed sound tank has not leaked given the same data. p(NL) = 1 - p(L) Ω_0 = "prior" odds in favor of the leak hypothesis. Ω_0 = p(L)/p(NL)
	0.60	0.40	1.50		

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)	Surface level measurements were consistent with variables inherent to obtaining manual tape readings and evaporation.	Considering the surface level measurement data reviewed for the leak assessment: p(SLM|L) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a leaker. p(SLM|NL) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a non - leaker. p(SLM|NL) = 1 - p(SLM|L) L(SLM) = p(SLM|L)/p(SLM|NL). If surface level data are not available for the leak assessment, then L(SLM) = 1 If there are several essentially redundant surface level measurements (e.g., ENRAF, FIC, MT), the probabilities should be assessed only for the more diagnostic and reliable one.
	0.20	0.80	0.25		

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)		Considering the interstitial liquid level data reviewed for the leak assessment: p(LOW|L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is a leaker. p(LOW|NL) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is not a leaker. p(LOW|NL) = 1 - p(LOW|L) L(LOW) = p(LOW|L)/p(LOW|NL). If LOW interstitial liquid level data are not available for the leak assessment, then L(LOW) = 1
	NA	NA	1.00		

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

Surface Level Measurement - Liquid Observation Well Interdependence	p(SLM|LOW,L) (if no LOW, enter NA)	p(SLM|LOW,NL)	L(SLM|LOW)
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

p(SLM|LOW,L) = ["posterior"] probability that the surface level measurement data would be observed if the LOW interstitial liquid level data are observed, and if the tank is a leaker.

p(SLM|LOW,NL) = ["posterior"] probability that a surface level measurement data would be observed if the LOW interstitial liquid level measurement data are observed, and if the tank is a non-leaker. p(SLM|LOW,NL) = 1 - p(SLM|LOW,L)

L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL) . If either surface level measurement data or LOW interstitial liquid level data are not available for the leak assessment, then L(SLM|LOW) = 1.

If there is no LOW, skip to the next part.

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

Liquid Observation Well - Surface Level Measurement Interdependence	p(LOW|SLM,L) (if no SLM, enter NA)	p(LOW|SLM,NL)	L(LOW|SLM)
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

p(LOW|SLM,L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed if a surface level measurement decrease is observed, and if the tank is a leaker.

p(LOW|SLM,NL) = ["posterior"] probability that a LOW interstitial liquid level measurement decrease would be observed if a surface level measurement decrease is observed, and if the tank is a non-leaker. p(LOW|SLM,NL) = 1 - pp(LOW|SLM,L)

L(LOW|SLM) = p(LOW|SLM,L)/p(LOW|SLM,NL) . If either surface level data or LOW intersititial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1

If there is no surface

Ex-Tank Data - Gross Gamma Drywell Logs - Part 6

Gross Gamma Drywell Logs	p(GGL|L) (if no GGL, enter NA here and in Parts 8 and 9)	p(GGL|NL)	L(GGL)
	0.30	0.70	0.43

Considering the historical gross gamma drywell logs reviewed for the leak assessment:

p(GGL|L) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a leaker.

p(GGL|NL) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a non - leaker.
p(GGL|NL) = 1 - p(GGL|L)

L(GGL) = p(GGL|L)/p(GGL|NL) If gross gamma logs are not available for the leak assessment, then L(GGL) = 1

Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7

Spectral Gamma Drywell Logs	p(SGL|L) (if no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)	L(SGL)
	0.30	0.70	0.43

Review of drywell logs supports elevated readings influenced by adjacent leaking tanks SX-107 & 111.

Considering the spectral gamma drywell logs reviewed for the leak assessment:

p(SGL|L) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a leaker.

p(SGL|NL) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a non - leaker. p(SGL|NL) = 1 - p(SGL|L)

L(GGL) = p(SGL|L)/p(SGL|NL). If spectral gamma drywell logs are not available for the leak assessment, then L(SGL) = 1.

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

Gross Gamma Log - Spectral Gamma Log Interdependence	p(GGL|SGL,L)	p(GGL|SGL,NL)	L(GGL|SGL)
	NA	NA	1.00

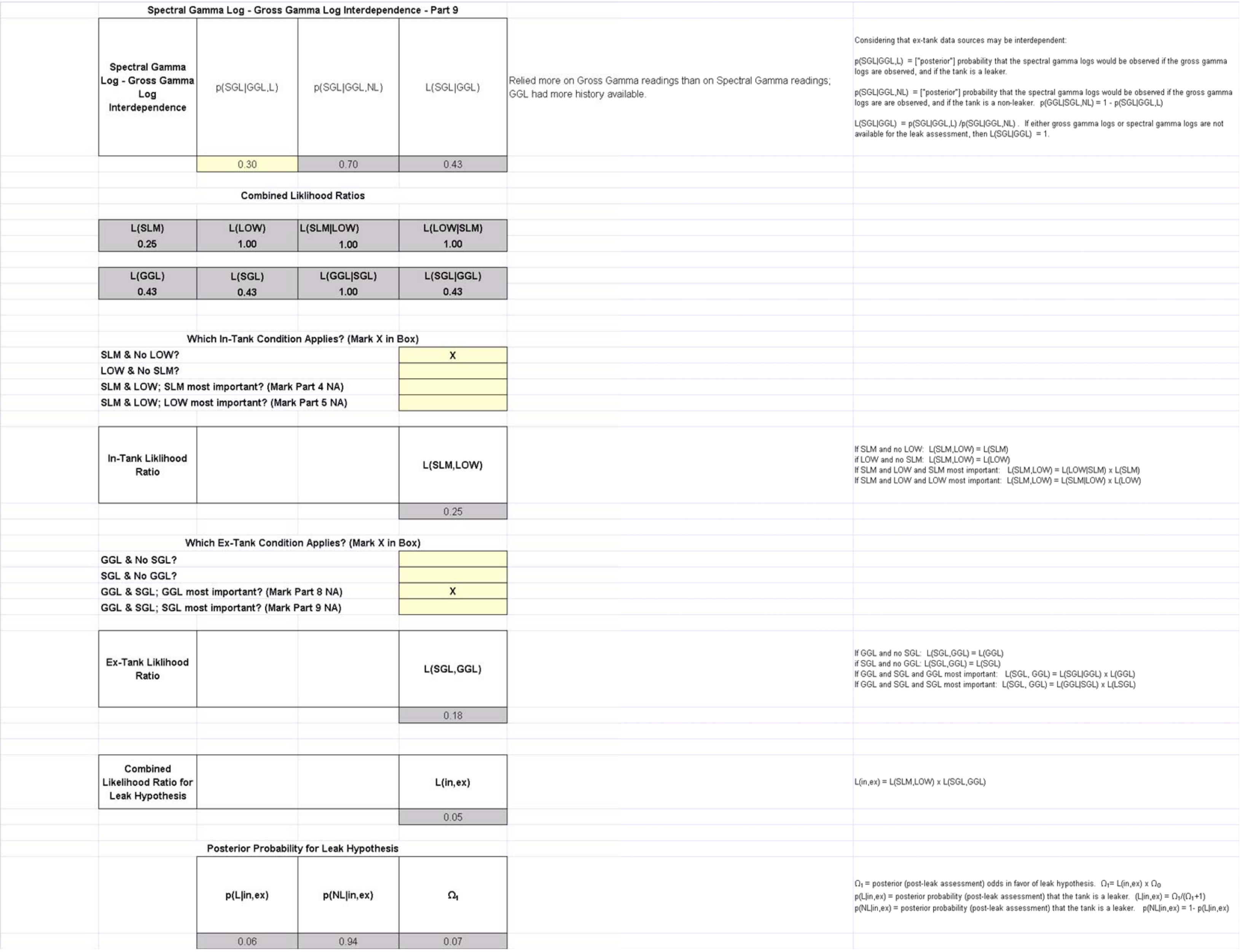
Spectral gamma readings observed were much lower than those levels that would be associated with a tank leak.

Considering that ex-tank data sources may be interdependent

p(GGL|SGL,L) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are are observed, and if the tank is a leaker.

p(GGL|SGL,NL) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are observed and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(GGL|SGL,L)

L(GGL|SGL) = p(GGL|SGL,L)/p(GGL|SGL,NL). If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(GGL|SGL) = 1.



Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

Spectral Gamma Log - Gross Gamma Log Interdependence	p(SGL|GGL,L)	p(SGL|GGL,NL)	L(SGL|GGL)
	0.30	0.70	0.43

Relied more on Gross Gamma readings than on Spectral Gamma readings; GGL had more history available.

Considering that ex-tank data sources may be interdependent:

p(SGL|GGL,L) = ["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(SGL|GGL,NL) = ["posterior"] 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(GGL|SGL,NL) = 1 - p(SGL|GGL,L)

L(SGL|GGL) = p(SGL|GGL,L) /p(SGL|GGL,NL) . If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(SGL|GGL) = 1.

Combined Liklihood Ratios

L(SLM)	L(LOW)	L(SLM|LOW)	L(LOW|SLM)
0.25	1.00	1.00	1.00

L(GGL)	L(SGL)	L(GGL|SGL)	L(SGL|GGL)
0.43	0.43	1.00	0.43

Which In-Tank Condition Applies? (Mark X in Box)

SLM & No LOW?	X
LOW & No SLM?	
SLM & LOW; SLM most important? (Mark Part 4 NA)	
SLM & LOW; LOW most important? (Mark Part 5 NA)	

In-Tank Liklihood Ratio	L(SLM,LOW)
	0.25

If SLM and no LOW: L(SLM,LOW) = L(SLM)
if LOW and no SLM: L(SLM,LOW) = L(LOW)
If SLM and LOW and SLM most important: L(SLM,LOW) = L(LOW|SLM) x L(SLM)
If SLM and LOW and LOW most important: L(SLM,LOW) = L(SLM|LOW) x L(LOW)

Which Ex-Tank Condition Applies? (Mark X in Box)

GGL & No SGL?	
SGL & No GGL?	
GGL & SGL; GGL most important? (Mark Part 8 NA)	X
GGL & SGL; SGL most important? (Mark Part 9 NA)	

Ex-Tank Liklihood Ratio	L(SGL,GGL)
	0.18

If GGL and no SGL: L(SGL,GGL) = L(GGL)
if SGL and no GGL: L(SGL,GGL) = L(SGL)
If GGL and SGL and GGL most important: L(SGL, GGL) = L(SGL|GGL) x L(GGL)
If GGL and SGL and SGL most important: L(SGL, GGL) = L(GGL|SGL) x L(LSGL)

Combined Likelihood Ratio for Leak Hypothesis	L(in,ex)
	0.05

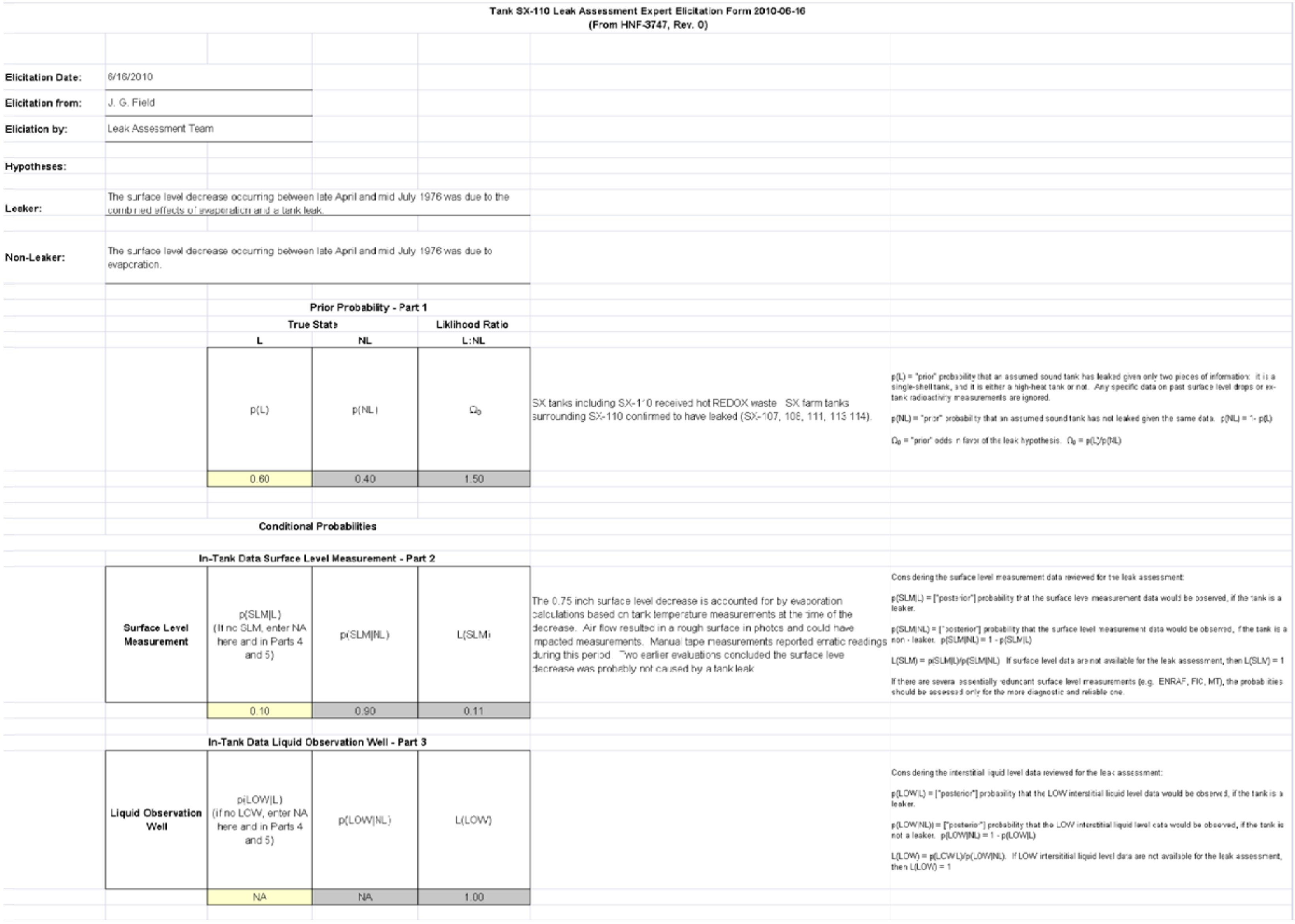
L(in,ex) = L(SLM,LOW) x L(SGL,GGL)

Posterior Probability for Leak Hypothesis

p(L|in,ex)	p(NL|in,ex)	Ω_1
0.06	0.94	0.07

Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. Ω_1= L(in,ex) x Ω_0
p(L|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. (L|in,ex) = $\Omega_1/(\Omega_1+1)$
p(NL|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. p(NL|in,ex) = 1- p(L|in,ex)

Expert Opinion: Expert Opinion: J. G. Field



Tank SX-110 Leak Assessment Expert Elicitation Form 2010-06-16
(From HNF-3747, Rev. 0)

Elicitation Date:	6/16/2010
Elicitation from:	J. G. Field
Eliciation by:	Leak Assessment Team
Hypotheses:	
Leaker:	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-Leaker:	The surface level decrease occurring between late April and mid July 1976 was due to evaporation.

Prior Probability - Part 1

True State		Liklihood Ratio		
L	NL	L:NL		
p(L)	p(NL)	Ω_0	SX tanks including SX-110 received hot REDOX waste SX farm tanks surrounding SX-110 confirmed to have leaked (SX-107, 108, 111, 113 114).	p(L) = "prior" probability that an assumed sound tank has leaked given only two pieces of information: it is a single-shell tank, and it is either a high-heat tank or not. Any specific data on past surface level drops or ex-tank radioactivity measurements are ignored. p(NL) = "prior" probability that an assumed sound tank has not leaked given the same data. p(NL) = 1 - p(L) Ω_0 = "prior" odds in favor of the leak hypothesis. Ω_0 = p(L)/p(NL)
0.60	0.40	1.50		

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)	The 0.75 inch surface level decrease is accounted for by evaporation calculations based on tank temperature measurements at the time of the decrease. Air flow resulted in a rough surface in photos and could have impacted measurements. Manual tape measurements reported erratic readings during this period. Two earlier evaluations concluded the surface level decrease was probably not caused by a tank leak	Considering the surface level measurement data reviewed for the leak assessment: p(SLM|L) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a leaker. p(SLM|NL) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a non - leaker. p(SLM|NL) = 1 - p(SLM|L) L(SLM) = p(SLM|L)/p(SLM|NL) If surface level data are not available for the leak assessment, then L(SLM) = 1 If there are several essentially redundant surface level measurements (e.g. ENRAF, FIC, MT), the probabilities should be assessed only for the more diagnostic and reliable one.
	0.10	0.90	0.11		

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)		Considering the interstitial liquid level data reviewed for the leak assessment: p(LOW|L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is a leaker. p(LOW|NL)) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is not a leaker. p(LOW|NL) = 1 - p(LOW|L) L(LOW) = p(LOW|L)/p(LOW|NL). If LOW intersititial liquid level data are not available for the leak assessment, then L(LOW) = 1
	NA	NA	1.00		

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

Surface Level Measurement - Liquid Observation Well Interdependence	p(SLM|LOW,L) (if no LOW, enter NA)	p(SLM|LOW,NL)	L(SLM|LOW)
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

p(SLM|LOW,L) = ["posterior"] probability that the surface level measurement data would be observed if the LOW interstitial liquid level data are observed, and if the tank is a leaker.

p(SLM|LOW,NL) = ["posterior"] probability that a surface level measurement data would be observed if the LOW interstitial liquid level measurement data are observed, and if the tank is a non-leaker. p(SLM|LOW,NL) = 1 - p(SLM|LOW,L)

L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL). If either surface level measurement data or LOW intersititial liquid level data are not available for the leak assessment, then L(SLM|LOW) = 1.

If there is no LOW, skip to the next part.

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

Liquid Observation Well - Surface Level Measurement Interdependence	p(LOW|SLM,L) (if no SLM, enter NA)	p(LOW|SLM,NL)	L(LOW|SLM)
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

p(LOW|SLM,L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed if a surface level measurement decrease is observed, and if the tank is a leaker.

p(LOW|SLM,NL) = ["posterior"] probability that a LOW interstitial liquid level measurement decrease would be observed if a surface level measurement decrease is observed, and if the tank is a non-leaker. p(LOW|SLM,NL) = 1 - pp(LOW|SLN,L)

L(LOW|SLM) = p(LOW|SLM,L)/p(LOW|SLM,NL). If either surface level data or LOW intersititial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1.

If there is no surface

Ex-Tank Data - Gross Gamma Drywell Logs - Part 6

Gross Gamma Drywell Logs	p(GGL|L) (if no GGL, enter NA here and in Parts 8 and 9)	p(GGL|NL)	L(GGL)
	0.20	0.80	0.25

No evidence of activity in drywells or laterals except low activity at the end of lateral #1 attributed to SX-111. Laterals under the tank should have shown higher levels of activity as was observed for other SX farm tanks if a leak occurred. However laterals could have missed a small leak.

Considering the historical gross gamma drywell logs reviewed for the leak assessment:

p(GGL|L) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a leaker.

p(GGL|NL) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a non - leaker. p(GGL|NL) = 1 - p(GGL|L)

L(GGL) = p(GGL|L)/p(GGL|NL). If gross gamma logs are not available for the leak assessment, then L(GGL) = 1

Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7

Spectral Gamma Drywell Logs	p(SGL|L) (if no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)	L(SGL)
	0.30	0.70	0.43

SGLS showed no drywell evidence of a leak, but drywells are limited and may have missed the plume.

Considering the spectral gamma drywell logs reviewed for the leak assessment:

p(SGL|L) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a leaker.

p(SGL|NL) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a non - leaker. p(SGL|NL) = 1 - p(SGL|L)

L(GGL) = p(SGL|L)/p(SGL|NL). If spectral gamma drywell logs are not available for the leak assessment, then L(SGL) = 1.

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

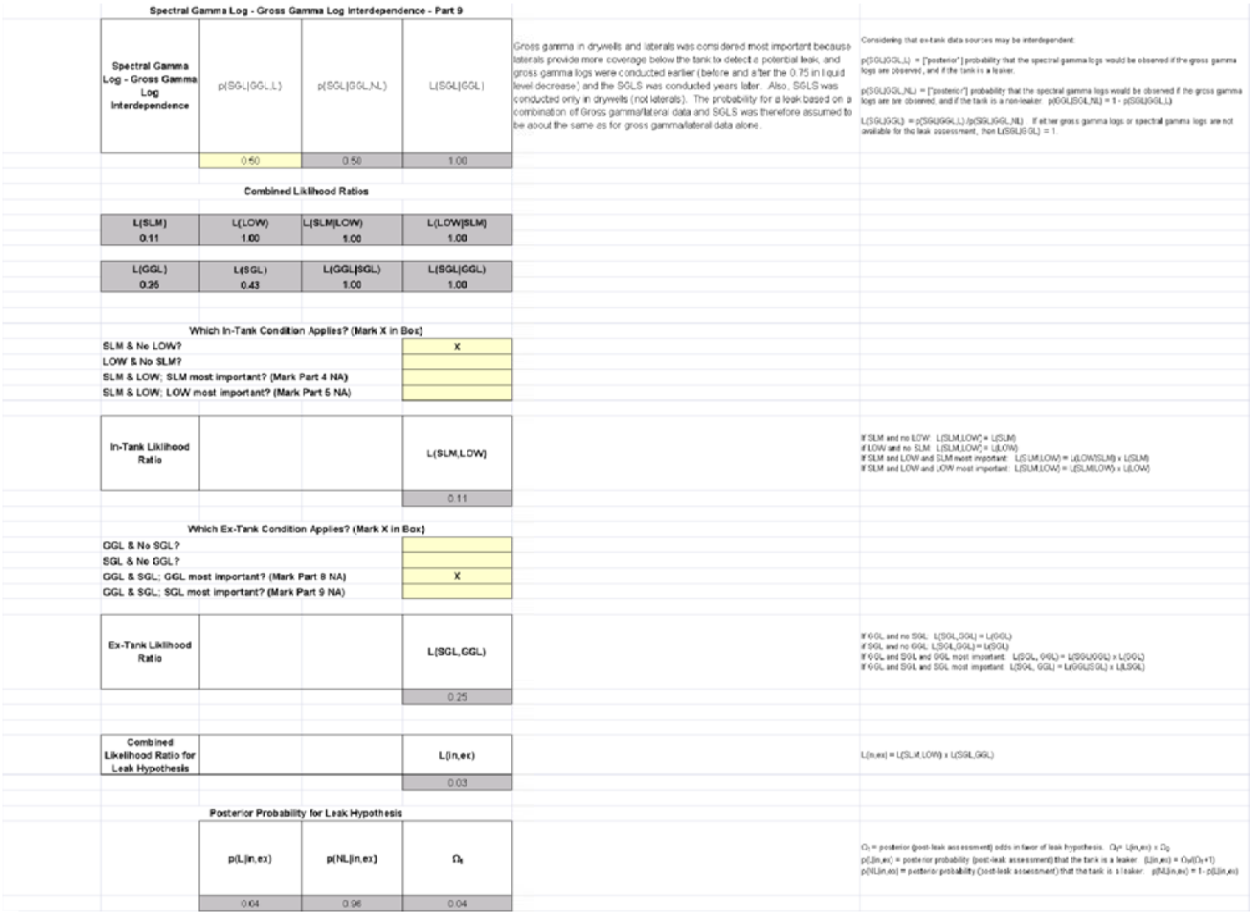
Gross Gamma Log - Spectral Gamma Log Interdependence	p(GGL|SGL,L)	p(GGL|SGL,NL)	L(GGL|SGL)
	NA	NA	1.00

Considering that ex-tank data sources may be interdepencent:

p(GGL|SGL,L) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are are observed, and if the tank is a leaker.

p(GGL|SGL,NL) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are observed, and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(GGL|SGL,L)

L(GGL|SGL) = p(GGL|SGL,L)/p(GGL|SGL,NL). If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(GGL|SGL) = 1.



Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

Spectral Gamma Log - Gross Gamma Log Interdependence	p(SGL|GGL,L)	p(SGL|GGL,NL)	L(SGL|GGL)
	0.50	0.50	1.00

Gross gamma in drywells and laterals was considered most important because laterals provide more coverage below the tank to detect a potential leak, and gross gamma logs were conducted earlier (before and after the 0.75 in liquid level decrease) and the SGLS was conducted years later. Also, SGLS was conducted only in drywells (not laterals). The probability for a leak based on a combination of Gross gamma/lateral data and SGLS was therefore assumed to be about the same as for gross gamma/lateral data alone.

Considering that ex-tank data sources may be interdependent:

p(SGL|GGL,L) = ["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(SGL|GGL,NL) = ["posterior"] 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(GGL|SGL,NL) = 1 - p(SGL|GGL,L)

L(SGL|GGL) = p(SGL|GGL,L)/p(SGL|GGL,NL). If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(SGL|GGL) = 1.

Combined Liklihood Ratios

L(SLM)	**L(LOW)**	**L(SLM|LOW)**	**L(LOW|SLM)**
0.11	**1.00**	**1.00**	**1.00**

L(GGL)	**L(SGL)**	**L(GGL|SGL)**	**L(SGL|GGL)**
0.25	**0.43**	**1.00**	**1.00**

Which In-Tank Condition Applies? (Mark X in Box)

SLM & No LOW?	X
LOW & No SLM?	
SLM & LOW; SLM most important? (Mark Part 4 NA)	
SLM & LOW; LOW most important? (Mark Part 5 NA)	

In-Tank Liklihood Ratio	**L(SLM,LOW)**
	0.11

If SLM and no LOW: L(SLM,LOW) = L(SLM)
If LOW and no SLM: L(SLM,LOW) = L(LOW)
If SLM and LOW and SLM most important: L(SLM,LOW) = L(LOW|SLM) x L(SLM)
If SLM and LOW and LOW most important: L(SLM,LOW) = L(SLM|LOW) x L(LOW)

Which Ex-Tank Condition Applies? (Mark X in Box)

GGL & No SGL?	
SGL & No GGL?	
GGL & SGL; GGL most important? (Mark Part 8 NA)	X
GGL & SGL; SGL most important? (Mark Part 9 NA)	

Ex-Tank Liklihood Ratio	**L(SGL,GGL)**
	0.25

If GGL and no SGL: L(SGL,GGL) = L(GGL)
If SGL and no GGL: L(SGL,GGL) = L(SGL)
If GGL and SGL and GGL most important: L(SGL, GGL) = L(SGL|GGL) x L(GGL)
If GGL and SGL and SGL most important: L(SGL, GGL) = L(GGL|SGL) x L(SGL)

Combined Likelihood Ratio for Leak Hypothesis	**L(in,ex)**
	0.03

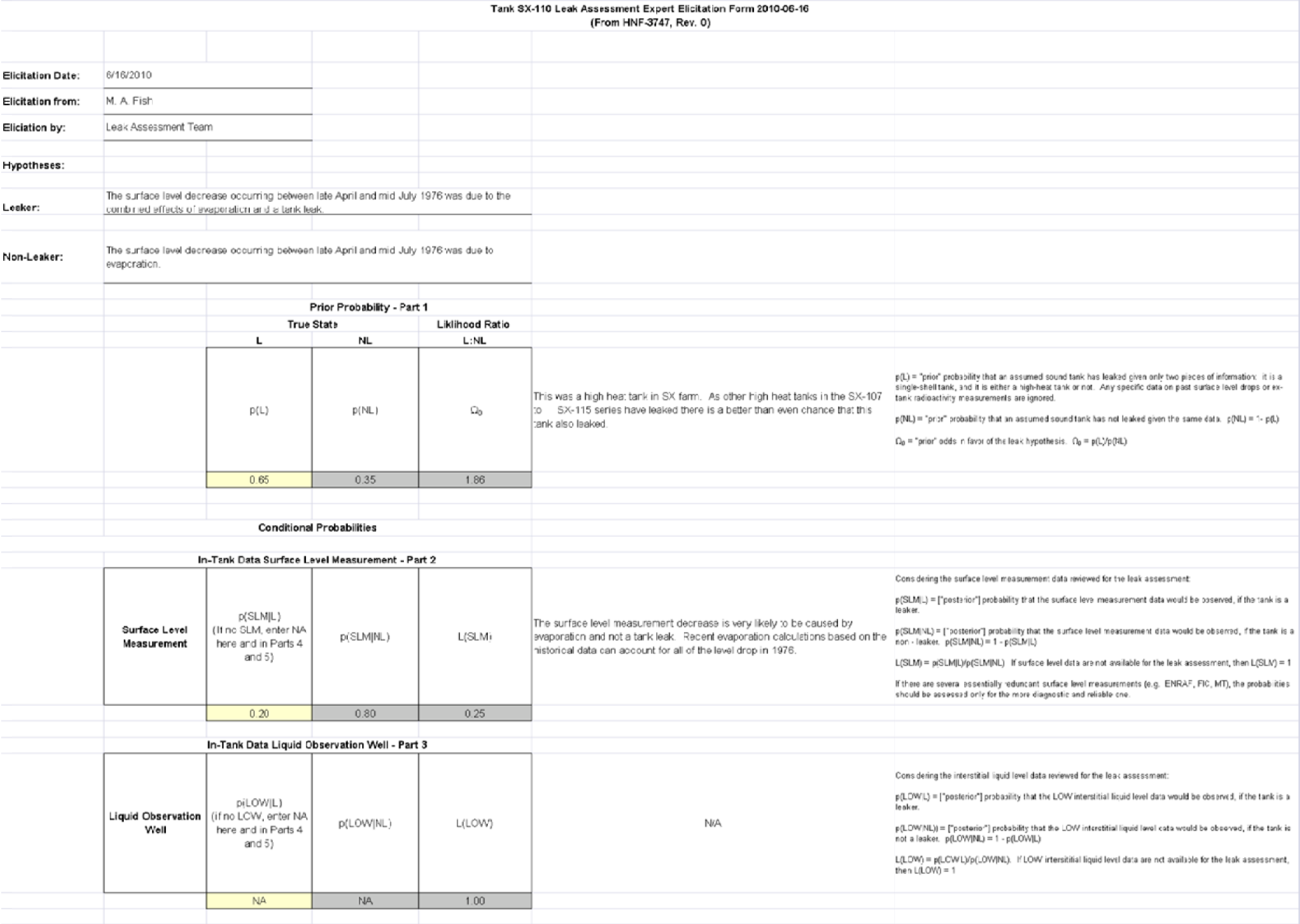
L(in,ex) = L(SLM,LOW) x L(SGL,GGL)

Posterior Probability for Leak Hypothesis

p(L|in,ex)	**p(NL|in,ex)**	**Ω_f**
0.04	0.96	0.04

Ω_f = posterior (post-leak assessment) odds in favor of leak hypothesis. Ω_f= L(in,ex) x Ω_0
p(L|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. (L|in,ex) = $\Omega_f/(\Omega_f+1)$
p(NL|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. p(NL|in,ex) = 1 - p(L|in,ex)

Expert Opinion: Expert Opinion: M. A. Fish



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

Hypotheses:

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

Prior Probability - Part 1

True State		Liklihood Ratio		
L	**NL**	**L:NL**		
p(L)	p(NL)	Ω_0	This was a high heat tank in SX farm. As other high heat tanks in the SX-107 to SX-115 series have leaked there is a better than even chance that this tank also leaked.	p(L) = "prior" probability that an assumed sound tank has leaked given only two pieces of information: it is a single-shell tank, and it is either a high-heat tank or not. Any specific data on past surface level drops or ex-tank radioactivity measurements are ignored. p(NL) = "prior" probability that an assumed sound tank has not leaked given the same data. p(NL) = 1 - p(L) Ω_0 = "prior" odds in favor of the leak hypothesis. Ω_0 = p(L)/p(NL)
0.65	0.35	1.86		

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)	The surface level measurement decrease is very likely to be caused by evaporation and not a tank leak. Recent evaporation calculations based on the historical data can account for all of the level drop in 1976.	Considering the surface level measurement data reviewed for the leak assessment: p(SLM|L) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a leaker. p(SLM|NL) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a non - leaker. p(SLM|NL) = 1 - p(SLM|L) L(SLM) = p(SLM|L)/p(SLM|NL) If surface level data are not available for the leak assessment, then L(SLM) = 1 If there are several essentially redundant surface level measurements (e.g. ENRAF, FIC, MT), the probabilities should be assessed only for the more diagnostic and reliable one.
	0.20	0.80	0.25		

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)	N/A	Considering the interstitial liquid level data reviewed for the leak assessment: p(LOW|L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is a leaker. p(LOW|NL)) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is not a leaker. p(LOW|NL) = 1 - p(LOW|L) L(LOW) = p(LOW|L)/p(LOW|NL). If LOW intersititial liquid level data are not available for the leak assessment, then L(LOW) = 1
	NA	NA	1.00		

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

Surface Level Measurement - Liquid Observation Well Interdependence	p(SLM|LOW,L) (if no LOW, enter NA)	p(SLM|LOW,NL)	L(SLM|LOW)	N/A	Considering that in-tank data sources may be interdependent: p(SLM|LOW,L) = ["posterior"] probability that the surface level measurement data would be observed if the LOW interstitial liquid level data are observed, and if the tank is a leaker. p(SLM|LOW,NL) = ["posterior"] probability that a surface level measurement data would be observed if the LOW interstitial liquid level measurement data are observed, and if the tank is a non-leaker. p(SLM|LOW,NL) = 1 - p(SLM|LOW,L) L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL) . If either surface level measurement data or LOW intersititial liquid level data are not available for the leak assessment, then L(SLM|LOW) = 1. **If there is no LOW, skip to the next part.**
	NA	NA	1.00		

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

Liquid Observation Well - Surface Level Measurement Interdependence	p(LOW|SLM,L) (if no SLM, enter NA)	p(LOW|SLM,NL)	L(LOW|SLM)	N/A	Considering that in-tank data sources may be interdependent: p(LOW|SLM,L) = ["posteriar"] probability that the LOW interstitial liquid level data would be observed if a surface level measurement decrease is observed, and if the tank is a leaker. p(LOW|SLM,NL) = ["posterior"] probability that a LOW interstitial liquid level measurement decrease would be observed if a surface level measurement decrease is observed, and if the tank is a non-leaker. p(LOW|SLM,NL) = 1 - pp(LOW|SLM,L) L(LOW|SLM) = p(LOW|SLM,L)/p(LOW|SLM,NL) . If either surface level data or LOW intersititial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1. **If there is no surface**
	NA	NA	1.00		

Ex-Tank Data - Gross Gamma Drywell Logs - Part 6

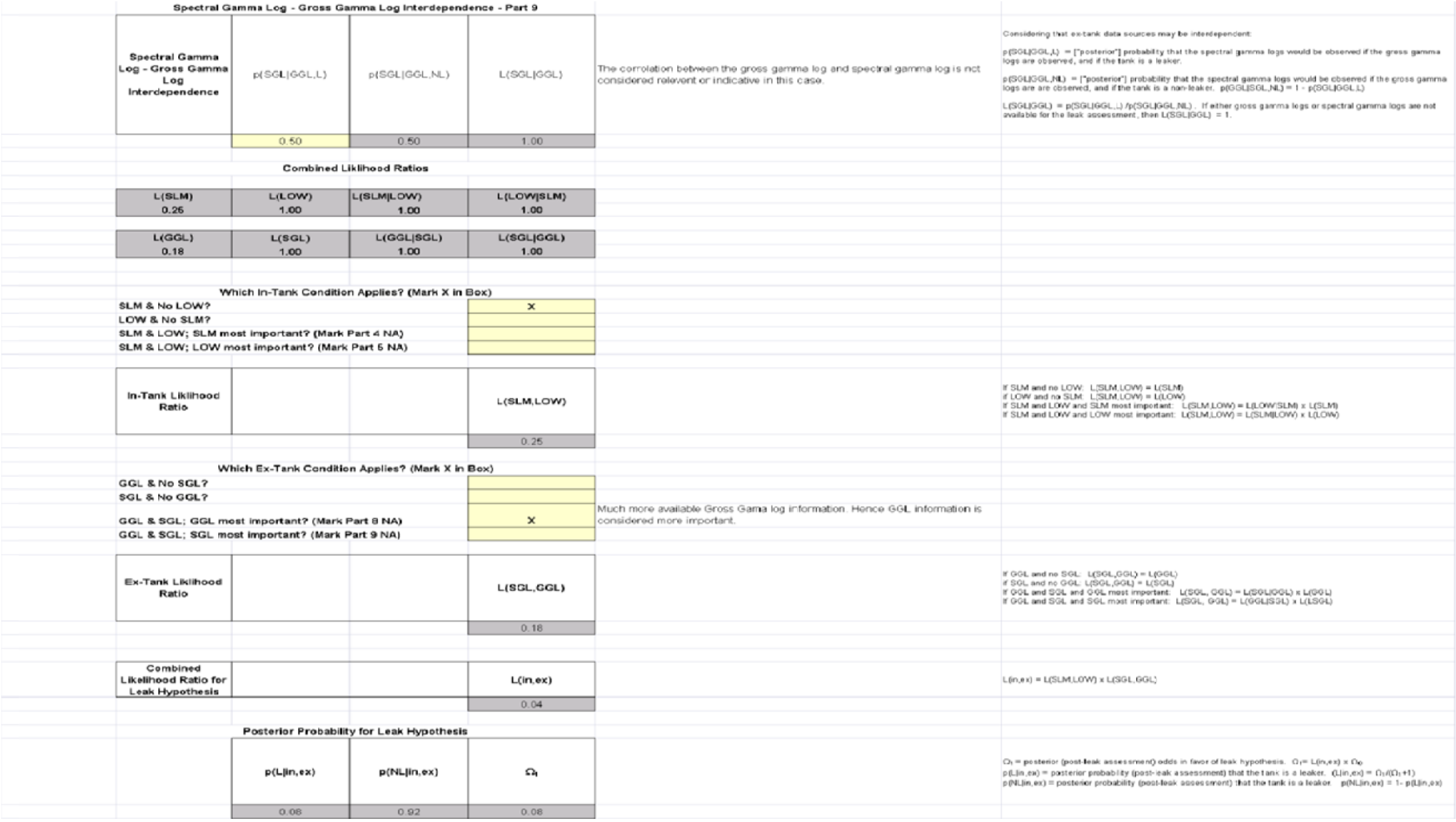
Gross Gamma Drywell Logs	p(GGL|L) (if no GGL, enter NA here and in Parts 8 and 9)	p(GGL|NL)	L(GGL)	The Gross Gamma logs and Lateral Logs provide little evidence of a tank waste leak. Contamination was identified but not in sufficient quantity to indicate a leaking tank. Low level gamma -ray activity found in one dry well (41-07-07) and at the end of one laterial (44-10-01) is likey to have come from SX-107 leak.	Considering the historical gross gamma drywell logs reviewed for the leak assessment: p(GGL|L) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a leaker. p(GGL|NL) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a non - leaker. p(GGL|NL) = 1 - p(GGL|L) L(GGL) = p(GGL|L)/p(GGL|NL). If gross gamma logs are not available for the leak assessment, then L(GGL) = 1
	0.15	0.85	0.18		

Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7

Spectral Gamma Drywell Logs	p(SGL|L) (if no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)	L(SGL)	As the Gross Gamma logs cover a much longer period than the Spectral Gamma Logs more credence is given to the Gross gamma log results. Hence score of 0.5. It is noted that in the spectral gamma log Cs-137 contamination is evident in in all of the bore holes surrounding SX-110 and is of uniform intensity. It is highly likely that this is the result of a surface leak not a leaking tank.	Considering the spectral gamma drywell logs reviewed for the leak assessment: p(SGL|L) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a leaker. p(SGL|NL) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a non - leaker. p(SGL|NL) = 1 - p(SGL|L) L(GGL) = p(SGL|L)/p(SGL|NL). If spectral gamma drywell logs are not available for the leak assessment, then L(SGL) = 1.
	0.50	0.50	1.00		

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

Gross Gamma Log - Spectral Gamma Log Interdependence	p(GGL|SGL,L)	p(GGL|SGL,NL)	L(GGL|SGL)	N/A	Considering that ex-tank data souces may be interdependent: p(GGL|SGL,L) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are are observed, and if the tank is a leaker. p(GGL|SGL,NL) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are observed, and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(GGL|SGL,L) L(GGL|SGL) = p(GGL|SGL,L)/p(GGL|SGL,NL). If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(GGL|SGL) = 1.
	NA	NA	1.00		



Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

Spectral Gamma Log - Gross Gamma Log Interdependence	p(SGL|GGL,L)	p(SGL|GGL,NL)	L(SGL|GGL)		
	0.50	0.50	1.00	The correlation between the gross gamma log and spectral gamma log is not considered relevent or indicative in this case.	Considering that ex-tank data sources may be interdependent: p(SGL|GGL,L) = ["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(SGL|GGL,NL) = ["posterior"] 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(GGL|SGL,NL) = 1 - p(SGL|GGL,L) L(SGL|GGL) = p(SGL|GGL,L) /p(SGL|GGL,NL) . If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(SGL|GGL) = 1.

Combined Liklihood Ratios

L(SLM)	L(LOW)	L(SLM|LOW)	L(LOW|SLM)
0.25	1.00	1.00	1.00

L(GGL)	L(SGL)	L(GGL|SGL)	L(SGL|GGL)
0.18	1.00	1.00	1.00

Which In-Tank Condition Applies? (Mark X in Box)

SLM & No LOW?	X
LOW & No SLM?	
SLM & LOW; SLM most important? (Mark Part 4 NA)	
SLM & LOW; LOW most important? (Mark Part 5 NA)	

In-Tank Liklihood Ratio	L(SLM,LOW)	
	0.25	If SLM and no LOW: L(SLM,LOW) = L(SLM) If LOW and no SLM: L(SLM,LOW) = L(LOW) If SLM and LOW and SLM most important: L(SLM,LOW) = L(LOW|SLM) x L(SLM) If SLM and LOW and LOW most important: L(SLM,LOW) = L(SLM|LOW) x L(LOW)

Which Ex-Tank Condition Applies? (Mark X in Box)

GGL & No SGL?		
SGL & No GGL?		
GGL & SGL; GGL most important? (Mark Part 8 NA)	X	Much more available Gross Gama log information. Hence GGL information is considered more important.
GGL & SGL; SGL most important? (Mark Part 9 NA)		

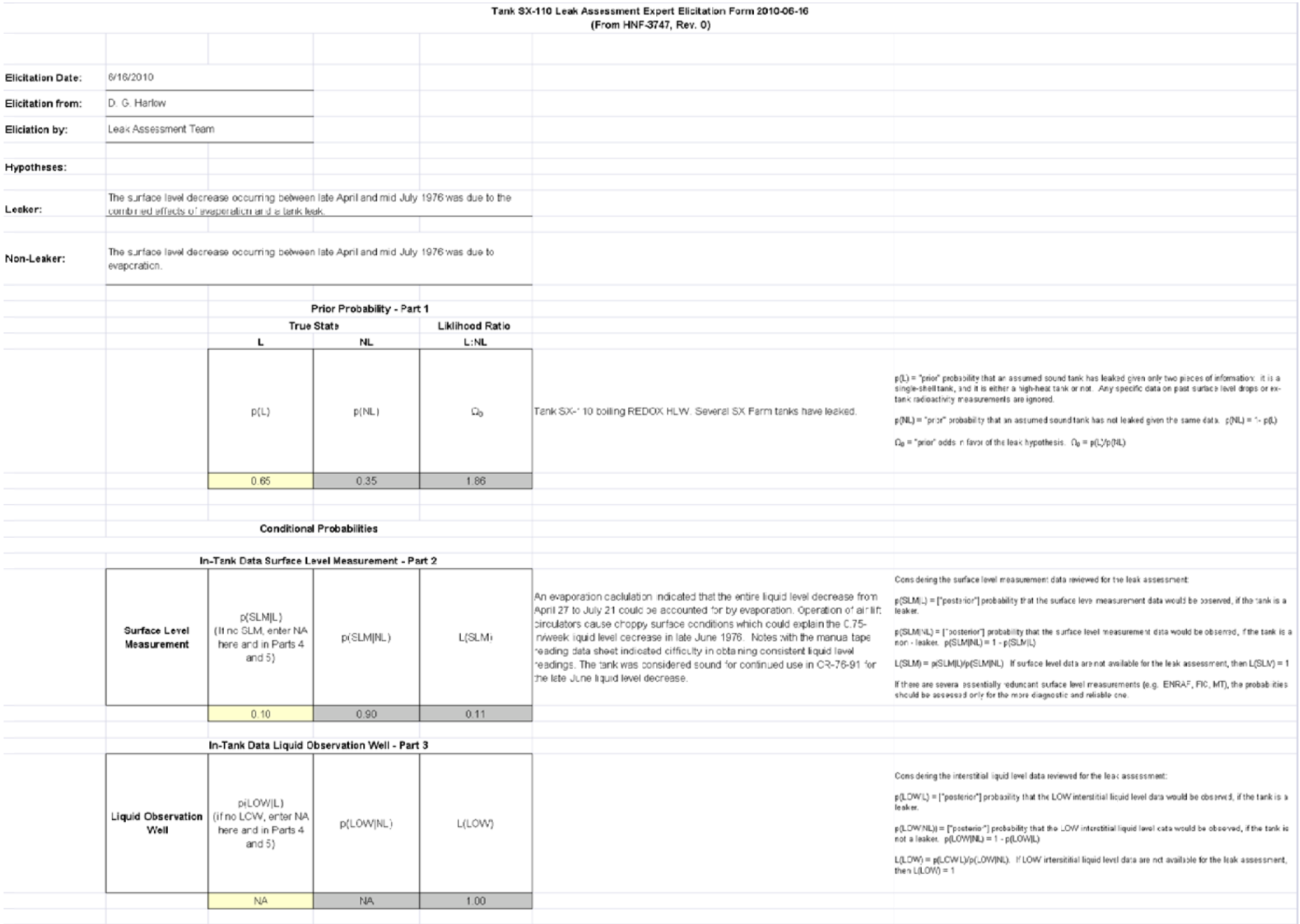
Ex-Tank Liklihood Ratio	L(SGL,GGL)	
	0.18	If GGL and no SGL: L(SGL,GGL) = L(GGL) If SGL and no GGL: L(SGL,GGL) = L(SGL) If GGL and SGL and GGL most important: L(SGL, GGL) = L(SGL|GGL) x L(GGL) If GGL and SGL and SGL most important: L(SGL, GGL) = L(GGL|SGL) x L(LSGL)

Combined Likelihood Ratio for Leak Hypothesis	L(in,ex)	
	0.04	L(in,ex) = L(SLM,LOW) x L(SGL,GGL)

Posterior Probability for Leak Hypothesis

p(L|in,ex)	p(NL|in,ex)	Ω_1	
0.08	0.92	0.08	Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. Ω_1= L(in,ex) x Ω_0 p(L|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. (L|in,ex) = $\Omega_1/(\Omega_1+1)$ p(NL|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. p(NL|in,ex) = 1- p(L|in,ex)

Expert Opinion: Expert Opinion: D. G. Harlow



Tank SX-110 Leak Assessment Expert Elicitation Form 2010-06-16
(From HNF-3747, Rev. 0)

Elicitation Date: 6/16/2010

Elicitation from: D. G. Harlow

Eliciation by: Leak Assessment Team

Hypotheses:

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

Prior Probability - Part 1

True State L	 NL	Liklihood Ratio L:NL		
p(L)	p(NL)	Ω_0	Tank SX-110 boiling REDOX HLW. Several SX Farm tanks have leaked.	p(L) = "prior" probability that an assumed sound tank has leaked given only two pieces of information: it is a single-shell tank, and it is either a high-heat tank or not. Any specific data on past surface level drops or ex-tank radioactivity measurements are ignored. p(NL) = "prior" probability that an assumed sound tank has not leaked given the same data. p(NL) = 1 - p(L) Ω_0 = "prior" odds in favor of the leak hypothesis. Ω_0 = p(L)/p(NL)
0.65	0.35	1.86		

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)	An evaporation caclulation indicated that the entire liquid level decrease from April 27 to July 21 could be accounted for by evaporation. Operation of air lift circulators cause choppy surface conditions which could explain the 0.75-in/week liquid level decrease in late June 1976. Notes with the manual tape reading data sheet indicated difficulty in obtaining consistent liquid level readings. The tank was considered sound for continued use in CR-76-91 for the late June liquid level decrease.	Considering the surface level measurement data reviewed for the leak assessment: p(SLM|L) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a leaker. p(SLM|NL) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a non - leaker. p(SLM|NL) = 1 - p(SLM|L) L(SLM) = p(SLM|L)/p(SLM|NL) If surface level data are not available for the leak assessment, then L(SLM) = 1 If there are several essentially redundant surface level measurements (e.g. ENRAF, FIC, MT), the probabilities should be assessed only for the more diagnostic and reliable one.
	0.10	0.90	0.11		

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)		Considering the interstitial liquid level data reviewed for the leak assessment: p(LOW|L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is a leaker. p(LOW|NL)) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is not a leaker. p(LOW|NL) = 1 - p(LOW|L) L(LOW) = p(LOW|L)/p(LOW|NL). If LOW intersititial liquid level data are not available for the leak assessment, then L(LOW) = 1
	NA	NA	1.00		

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

Surface Level Measurement - Liquid Observation Well Interdependence	p(SLM|LOW,L) (if no LOW, enter NA)	p(SLM|LOW,NL)	L(SLM|LOW)		Considering that in-tank data sources may be interdependent: p(SLM|LOW,L) = ["posterior"] probability that the surface level measurement data would be observed if the LOW interstitial liquid level data are observed, and if the tank is a leaker. p(SLM|LOW,NL) = ["posterior"] probability that a surface level measurement data would be observed if the LOW interstitial liquid level measurement data are observed, and if the tank is a non-leaker. p(SLM|LOW,NL) = 1 - p(SLM|LOW,L) L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL) . If either surface level measurement data or LOW intersititial liquid level data are not available for the leak assessment, then L(SLM|LOW) = 1. **If there is no LOW, skip to the next part.**
	NA	NA	1.00		

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

Liquid Observation Well - Surface Level Measurement Interdependence	p(LOW|SLM,L) (if no SLM, enter NA)	p(LOW|SLM,NL)	L(LOW|SLM)		Considering that in-tank data sources may be interdependent: p(LOW|SLM,L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed if a surface level measurement decrease is observed, and if the tank is a leaker. p(LOW|SLM,NL) = ["posterior"] probability that a LOW interstitial liquid level measurement decrease would be observed if a surface level measurement decrease is observed, and if the tank is a non-leaker. p(LOW|SLM,NL) = 1 - pp(LOW|SLM,L) L(LOW|SLM) = p(LOW|SLM,L)/p(LOW|SLM,NL) . If either surface level data or LOW intersititial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1. **If there is no surface**
	NA	NA	1.00		

Ex-Tank Data - Gross Gamma Drywell Logs - Part 6

Gross Gamma Drywell Logs	p(GGL|L) (if no GGL, enter NA here and in Parts 8 and 9)	p(GGL|NL)	L(GGL)	Tank SX-110 laterals and drywells did not have any indication that the tank was leaking. There was indication of surface leaks and contamination spread from tank SX-107 but all could be explained other than tank SX-110 sources.	Considering the historical gross gamma drywell logs reviewed for the leak assessment: p(GGL|L) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a leaker. p(GGL|NL) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a non - leaker. p(GGL|NL) = 1 - p(GGL|L) L(GGL) = p(GGL|L)/p(GGL|NL). If gross gamma logs are not available for the leak assessment, then L(GGL) = 1
	0.20	0.80	0.25		

Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7

Spectral Gamma Drywell Logs	p(SGL|L) (if no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)		Gross gamma logs of the laterals and drywells cover the period in question and are therefore more relavent than the SGLS which are performed later and only cover the drywells	Considering the spectral gamma drywell logs reviewed for the leak assessment: p(SGL|L) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a leaker. p(SGL|NL) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a non - leaker. p(SGL|NL) = 1 - p(SGL|L) L(GGL) = p(SGL|L)/p(SGL|NL). If spectral gamma drywell logs are not available for the leak assessment, then L(SGL) = 1.
	0.10	0.90	0.11		

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

Gross Gamma Log - Spectral Gamma Log Interdependence	p(GGL|SGL,L)	p(GGL|SGL,NL)	L(GGL|SGL)		Considering that ex-tank data sources may be interdependent: p(GGL|SGL,L) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are are observed, and if the tank is a leaker. p(GGL|SGL,NL) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are observed, and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(GGL|SGL,L) L(GGL|SGL) = p(GGL|SGL,L)/p(GGL|SGL,NL). If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(GGL|SGL) = 1.
	NA	NA	1.00		

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

Spectral Gamma Log - Gross Gamma Log Interdependence	p(SGL|GGL,L)	p(SGL|GGL,NL)	L(SGL|GGL)
	0.50	0.50	1.00

Gross gamm logs are considered more relavent to a tank SX-110 leak during the period in question than the SGLS.

Considering that ex-tank data sources may be interdependent:

p(SGL|GGL,L) = ["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(SGL|GGL,NL) = ["posterior"] 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(GGL|SGL,NL) = 1 - p(SGL|GGL,L)

L(SGL|GGL) = p(SGL|GGL,L) /p(SGL|GGL,NL). If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(SGL|GGL) = 1.

Combined Liklihood Ratios

L(SLM)	L(LOW)	L(SLM|LOW)	L(LOW|SLM)
0.11	1.00	1.00	1.00

L(GGL)	L(SGL)	L(GGL|SGL)	L(SGL|GGL)
0.25	0.11	1.00	1.00

Which In-Tank Condition Applies? (Mark X in Box)

SLM & No LOW?	X
LOW & No SLM?	
SLM & LOW; SLM most important? (Mark Part 4 NA)	
SLM & LOW; LOW most important? (Mark Part 5 NA)	

In-Tank Liklihood Ratio	L(SLM,LOW)
	0.11

If SLM and no LOW: L(SLM,LOW) = L(SLM)
If LOW and no SLM: L(SLM,LOW) = L(LOW)
If SLM and LOW and SLM most important: L(SLM,LOW) = L(LOW|SLM) x L(SLM)
If SLM and LOW and LOW most important: L(SLM,LOW) = L(SLM|LOW) x L(LOW)

Which Ex-Tank Condition Applies? (Mark X in Box)

GGL & No SGL?	
SGL & No GGL?	
GGL & SGL; GGL most important? (Mark Part 8 NA)	X
GGL & SGL; SGL most important? (Mark Part 9 NA)	

Gross gamma most important.

Ex-Tank Liklihood Ratio	L(SGL,GGL)
	0.25

If GGL and no SGL: L(SGL,GGL) = L(GGL)
If SGL and no GGL: L(SGL,GGL) = L(SGL)
If GGL and SGL and GGL most important: L(SGL, GGL) = L(SGL|GGL) x L(GGL)
If GGL and SGL and SGL most important: L(SGL, GGL) = L(GGL|SGL) x L(LSGL)

Combined Likelihood Ratio for Leak Hypothesis	L(in,ex)
	0.03

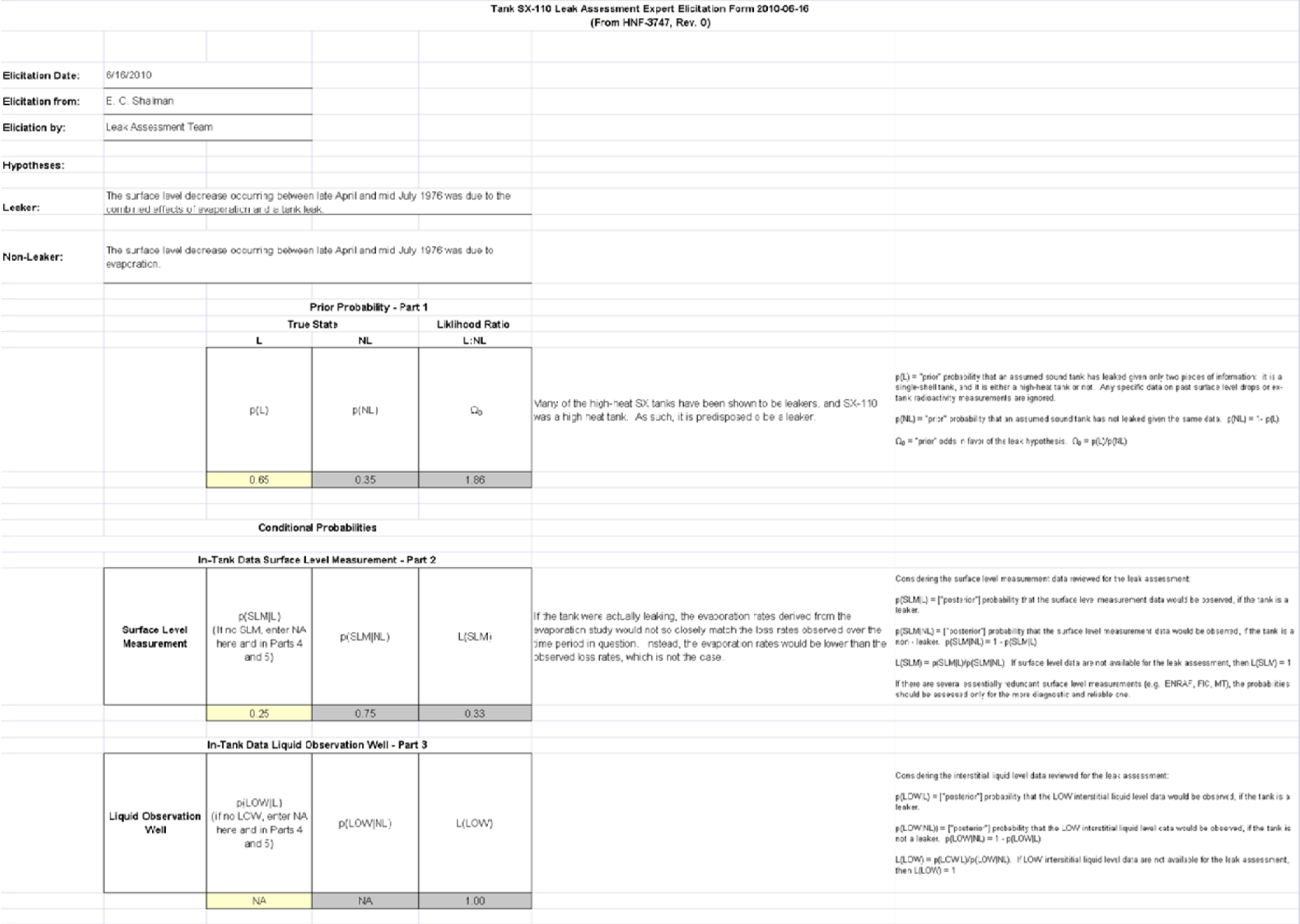
L(in,ex) = L(SLM,LOW) x L(SGL,GGL)

Posterior Probability for Leak Hypothesis

p(L|in,ex)	p(NL|in,ex)	Ω_1
0.05	0.95	0.05

Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. $\Omega_1 = L(in,ex) \times \Omega_0$
p(L|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. (L|in,ex) = $\Omega_1/(\Omega_1+1)$
p(NL|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. p(NL|in,ex) = 1- p(L|in,ex)

Expert Opinion: Expert Opinion: E. C. Shallman



Tank SX-110 Leak Assessment Expert Elicitation Form 2010-06-16
(From HNF-3747, Rev. 0)

Elicitation Date:	6/16/2010
Elicitation from:	E. C. Shallman
Eliciation by:	Leak Assessment Team
Hypotheses:	
Leaker:	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-Leaker:	The surface level decrease occurring between late April and mid July 1976 was due to evaporation.

Prior Probability - Part 1

True State		Liklihood Ratio		
L	**NL**	**L:NL**		
p(L)	p(NL)	Ω_0	Many of the high-heat 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(L) = "prior" probability that an assumed sound tank has leaked given only two pieces of information: it is a single-shell tank, and it is either a high-heat tank or not. Any specific data on past surface level drops or ex-tank radioactivity measurements are ignored. p(NL) = "prior" probability that an assumed sound tank has not leaked given the same data. p(NL) = 1 - p(L) Ω_0 = "prior" odds in favor of the leak hypothesis. Ω_0 = p(L)/p(NL)
0.65	0.35	1.86		

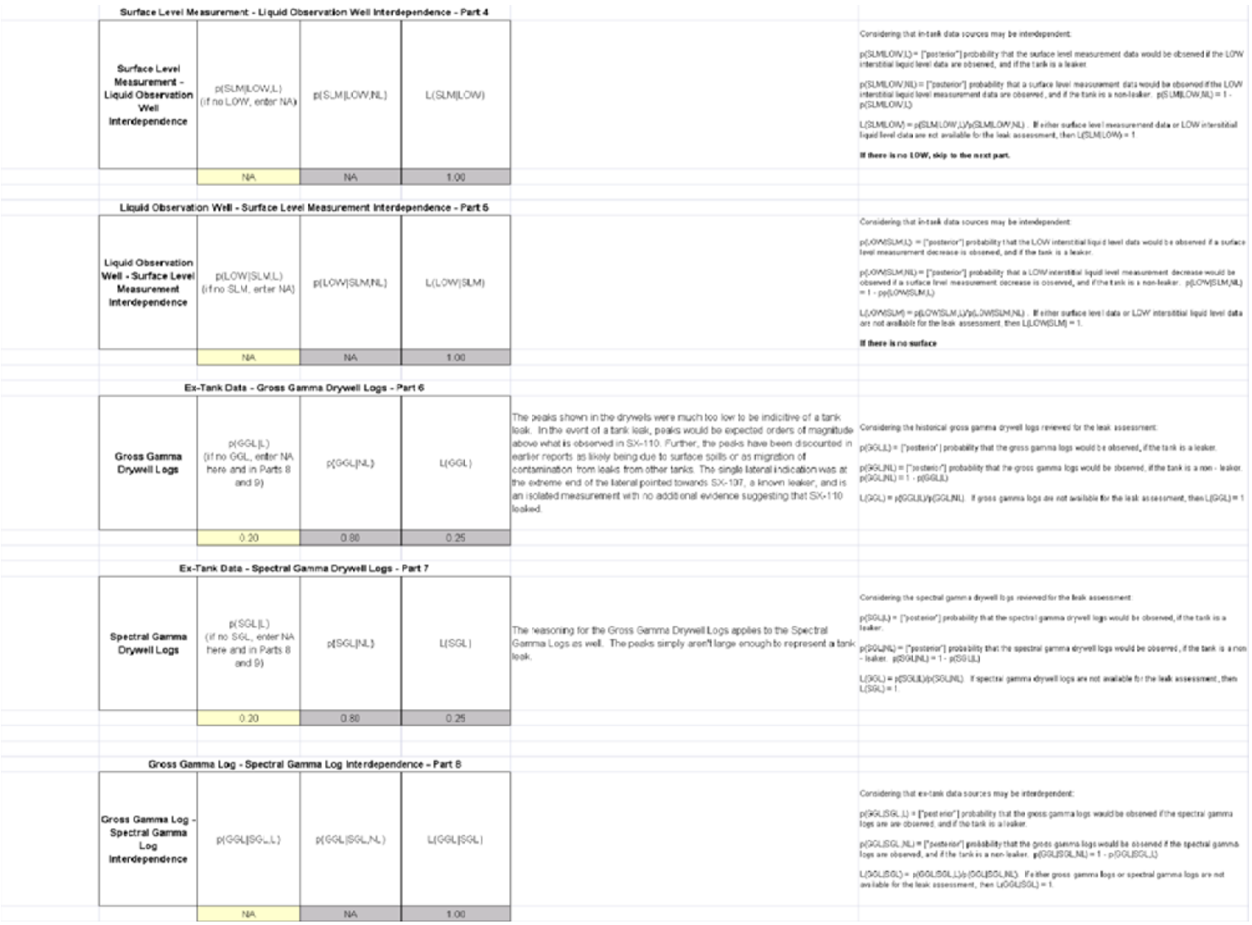
Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)	If the tank were actually leaking, the evaporation rates derived from the evaporation study would not so closely match the loss 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.	Considering the surface level measurement data reviewed for the leak assessment: p(SLM|L) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a leaker. p(SLM|NL) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a non - leaker. p(SLM|NL) = 1 - p(SLM|L) L(SLM) = p(SLM|L)/p(SLM|NL) If surface level data are not available for the leak assessment, then L(SLM) = 1 If there are several essentially redundant surface level measurements (e.g. ENRAF, FIC, MT), the probabilities should be assessed only for the more diagnostic and reliable one.
	0.25	0.75	0.33		

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)		Considering the interstitial liquid level data reviewed for the leak assessment: p(LOW|L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is a leaker. p(LOW|NL)) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is not a leaker. p(LOW|NL) = 1 - p(LOW|L) L(LOW) = p(LOW|L)/p(LOW|NL). If LOW intersititial liquid level data are not available for the leak assessment, then L(LOW) = 1
	NA	NA	1.00		



Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

Surface Level Measurement - Liquid Observation Well Interdependence	p(SLM|LOW,L) (if no LOW, enter NA)	p(SLM|LOW,NL)	L(SLM|LOW)		Considering that in-tank data sources may be interdependent: p(SLM|LOW,L) = ["posterior"] probability that the surface level measurement data would be observed if the LOW interstitial liquid level data are observed, and if the tank is a leaker. p(SLM|LOW,NL) = ["posterior"] probability that a surface level measurement data would be observed if the LOW interstitial liquid level measurement data are observed, and if the tank is a non-leaker. p(SLM|LOW,NL) = 1 - p(SLM|LOW,L) L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL). If either surface level measurement data or LOW interstitial liquid level data are not available for the leak assessment, then L(SLM|LOW) = 1. **If there is no LOW, skip to the next part.**
	NA	NA	1.00		

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

Liquid Observation Well - Surface Level Measurement Interdependence	p(LOW|SLM,L) (if no SLM, enter NA)	p(LOW|SLM,NL)	L(LOW|SLM)		Considering that in-tank data sources may be interdependent: p(LOW|SLM,L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed if a surface level measurement decrease is observed, and if the tank is a leaker. p(LOW|SLM,NL) = ["posterior"] probability that a LOW interstitial liquid level measurement decrease would be observed if a surface level measurement decrease is observed, and if the tank is a non-leaker. p(LOW|SLM,NL) = 1 - p(LOW|SLM,L) L(LOW|SLM) = p(LOW|SLM,L)/p(LOW|SLM,NL). If either surface level data or LOW interstitial liquid level data are not available for the leak assessment, then L(LOW|SLM) = 1. **If there is no surface**
	NA	NA	1.00		

Ex-Tank Data - Gross Gamma Drywell Logs - Part 6

Gross Gamma Drywell Logs	p(GGL|L) (if no GGL, enter NA here and in Parts 8 and 9)	p(GGL|NL)	L(GGL)	The peaks shown in the drywells were much too low to be indicitive of a tank leak. In the event of a tank leak, peaks would be expected orders of magnitude above what is observed in SX-110. Further, the peaks have been discounted in earlier reports as likely being due to surface spills or as migration of contamination from leaks from other tanks. The single lateral indication was at the extreme end of the lateral pointed towards SX-107, a known leaker, and is an isolated measurement with no additional evidence suggesting that SX-110 leaked.	Considering the historical gross gamma drywell logs reviewed for the leak assessment: p(GGL|L) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a leaker. p(GGL|NL) = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a non - leaker. p(GGL|NL) = 1 - p(GGL|L) L(GGL) = p(GGL|L)/p(GGL|NL). If gross gamma logs are not available for the leak assessment, then L(GGL) = 1
	0.20	0.80	0.25		

Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7

Spectral Gamma Drywell Logs	p(SGL|L) (if no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)	L(SGL)	The reasoning for the Gross Gamma Drywell Logs applies to the Spectral Gamma Logs as well. The peaks simply aren't large enough to represent a tank leak.	Considering the spectral gamma drywell logs reviewed for the leak assessment: p(SGL|L) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a leaker. p(SGL|NL) = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a non - leaker. p(SGL|NL) = 1 - p(SGL|L) L(SGL) = p(SGL|L)/p(SGL|NL). If spectral gamma drywell logs are not available for the leak assessment, then L(SGL) = 1.
	0.20	0.80	0.25		

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

Gross Gamma Log - Spectral Gamma Log Interdependence	p(GGL|SGL,L)	p(GGL|SGL,NL)	L(GGL|SGL)		Considering that ex-tank data sources may be interdependent: p(GGL|SGL,L) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are are observed, and if the tank is a leaker. p(GGL|SGL,NL) = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are observed, and if the tank is a non-leaker. p(GGL|SGL,NL) = 1 - p(GGL|SGL,L) L(GGL|SGL) = p(GGL|SGL,L)/p(GGL|SGL,NL). If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(GGL|SGL) = 1.
	NA	NA	1.00		

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

Spectral Gamma Log - Gross Gamma Log Interdependence	p(SGL|GGL,L)	p(SGL|GGL,NL)	L(SGL|GGL)
	0.25	0.75	0.33

If the assumption is that the tank is leaking, and the lateral data is indicitive of a tank leak, then we should be seeing corroboration from the spectral gamma logs, but we are not seeing any solid corroboration. There is a low chance of this if the tank were in fact a leaker.

Considering that ex-tank data sources may be interdependent:

p(SGL|GGL,L) = ["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(SGL|GGL,NL) = ["posterior"] 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(GGL|SGL,NL) = 1 - p(SGL|GGL,L)

L(SGL|GGL) = p(SGL|GGL,L) /p(SGL|GGL,NL) . If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(SGL|GGL) = 1.

Combined Liklihood Ratios

L(SLM)	L(LOW)	L(SLM|LOW)	L(LOW|SLM)
0.33	1.00	1.00	1.00

L(GGL)	L(SGL)	L(GGL|SGL)	L(SGL|GGL)
0.25	0.25	1.00	0.33

Which In-Tank Condition Applies? (Mark X in Box)

SLM & No LOW?	X
LOW & No SLM?	
SLM & LOW; SLM most important? (Mark Part 4 NA)	
SLM & LOW; LOW most important? (Mark Part 5 NA)	

In-Tank Liklihood Ratio	L(SLM,LOW)
	0.33

If SLM and no LOW: L(SLM,LOW) = L(SLM)
If LOW and no SLM: L(SLM,LOW) = L(LOW)
If SLM and LOW and SLM most important: L(SLM,LOW) = L(LOW|SLM) x L(SLM)
If SLM and LOW and LOW most important: L(SLM,LOW) = L(SLM|LOW) x L(LOW)

Which Ex-Tank Condition Applies? (Mark X in Box)

GGL & No SGL?	
SGL & No GGL?	
GGL & SGL; GGL most important? (Mark Part 8 NA)	X
GGL & SGL; SGL most important? (Mark Part 9 NA)	

Ex-Tank Liklihood Ratio	L(SGL,GGL)
	0.08

If GGL and no SGL: L(SGL,GGL) = L(GGL)
If SGL and no GGL: L(SGL,GGL) = L(SGL)
If GGL and SGL and GGL most important: L(SGL, GGL) = L(SGL|GGL) x L(GGL)
If GGL and SGL and SGL most important: L(SGL, GGL) = L(GGL|SGL) x L(LSGL)

Combined Likelihood Ratio for Leak Hypothesis	L(in,ex)
	0.03

L(in,ex) = L(SLM,LOW) x L(SGL,GGL)

Posterior Probability for Leak Hypothesis

p(L|in,ex)	p(NL|in,ex)	Ω_1
0.05	0.95	0.05

Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. $\Omega_1 = L(in,ex) \times \Omega_0$
p(L|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. (L|in,ex) = $\Omega_1/(\Omega_1+1)$
p(NL|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. p(NL|in,ex) = 1- p(L|in,ex)

Expert Opinion: Expert Opinion: D. J. Washenfelder

Tank SX-110 Leak Assessment Expert Elicitation Form 2010-06-16
(From HNF-3747, Rev. 0)

Elicitation Date: 6/10/2010

Elicitation from: D. J. Washenfelder

Eliciation by: Leak Assessment Team

Hypotheses:

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

Prior Probability - Part 1

True State		Liklihood Ratio		
L	NL	L:NL		
p(L)	p(NL)	Ω_0	This tank had been previously assessed and determined to be sound. The tank was administratively declared to be an 'Assumed Leaker' in compliance with direction from the Department of Energy. However, all of the other tanks in the south part of 241-SX tank farm - SX-107 - 109, and SX-111 - 115, are classified as leaking tanks, including several that suffered catastrophic leaks. Although tank SX-110 operating history was different from these other tanks, its association with this tank group makes it suspect without any further information being considered.	p(L) = "prior" probability that an assumed sound tank has leaked given only two pieces of information: it is a single shell tank, and it is either a high heat tank or not. Any specific data on past surface level drops or ex tank radioactivity measurements are ignored. p(NL) = "prior" probability that an assumed sound tank has not leaked given the same data. p(NL) = 1- p(L) Ω_0 = "prior" odds in favor of the leak hypothesis Ω_0 = p(L)/p(NL)
0.60	0.40	1.50		

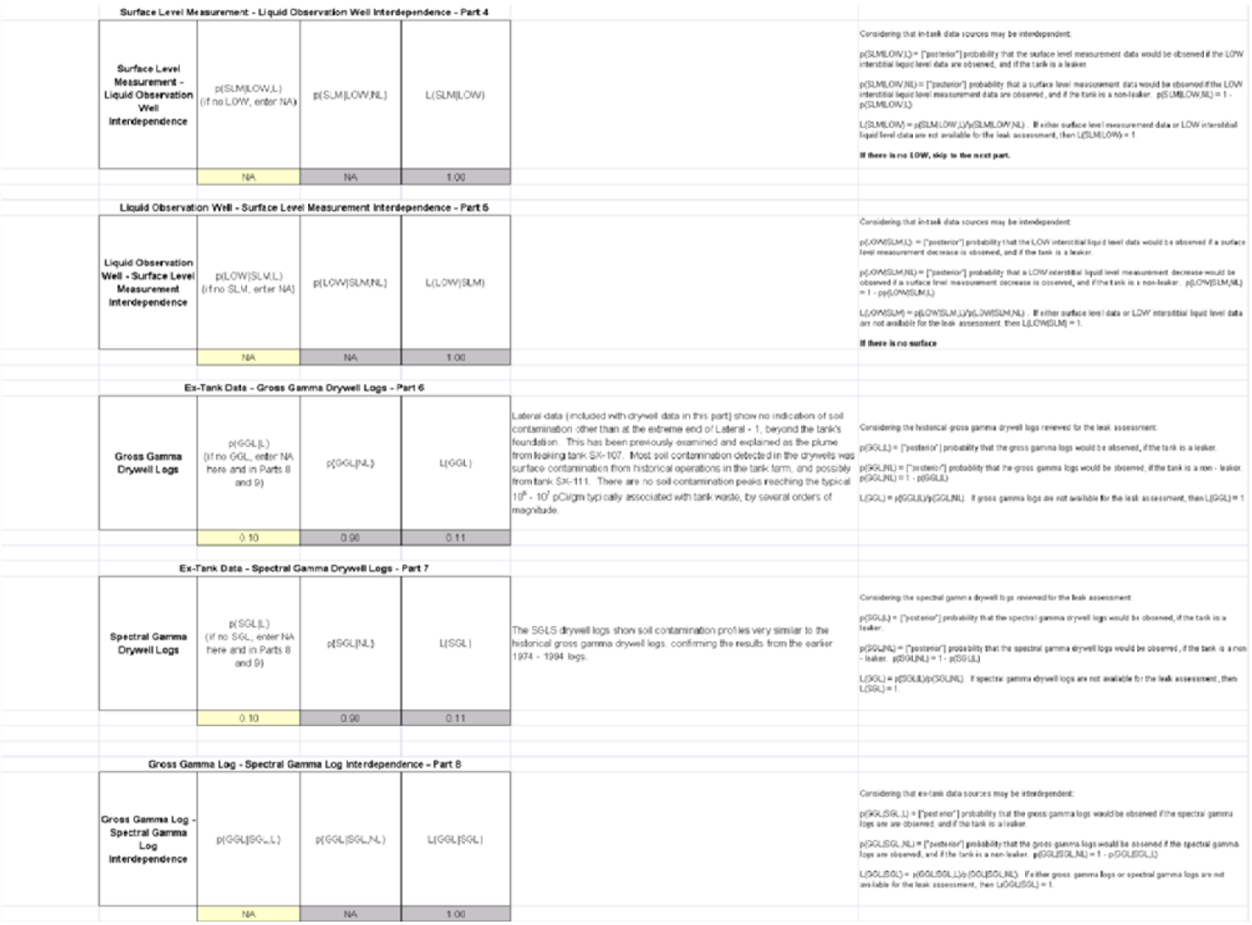
Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)	The evaporation analysis can account for most of the observed surface level decrease. However, temperature data available for the analysis do not seem consistent with field experience - for example, rapid changes in the bulk waste temperature, when typically observed changes are slow. Overall the analysis is probably conservative because of the low temperature difference betyween the waste temperature and the headspace temperature.	Considering the surface level measurement data reviewed for the leak assessment: p(SLM|L) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a leaker. p(SLM|NL) = ["posterior"] probability that the surface level measurement data would be observed, if the tank is a non - leaker. p(SLM|NL) = 1 - p(SLM|L) L(SLM) = p(SLM|L)/p(SLM|NL) If surface level data are not available for the leak assessment, then L(SLM) = 1 If there are several essentially redundant surface level measurements (e.g. ENRAF, FIC, MT), the probabilities should be assessed only for the more diagnostic and reliable one
	0.25	0.75	0.33		

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)	No LOW installed in the tank.	Considering the interstitial liquid level data reviewed for the leak assessment: p(LOW|L) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is a leaker. p(LOW|NL)) = ["posterior"] probability that the LOW interstitial liquid level data would be observed, if the tank is not a leaker. p(LOW|NL) = 1 - p(LOW|L) L(LOW) = p(LOW|L)/p(LOW|NL). If LOW intersitial liquid level data are not available for the leak assessment, then L(LOW) = 1
	NA	NA	1.00		



Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

Surface Level Measurement - Liquid Observation Well Interdependence	$p(SLM \mid LOW,L)$ (if no LOW, enter NA)	$p(SLM \mid LOW,NL)$	$L(SLM \mid LOW)$
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

$p(SLM|LOW,L)$ = ["posterior"] probability that the surface level measurement data would be observed if the LOW interstitial liquid level data are observed, and if the tank is a leaker.

$p(SLM|LOW,NL)$ = ["posterior"] probability that a surface level measurement data would be observed if the LOW interstitial liquid level measurement data are observed, and if the tank is a non-leaker. $p(SLM|LOW,NL) = 1 - p(SLM|LOW,L)$

$L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL)$. If either surface level measurement data or LOW intersititial liquid level data are not available for the leak assessment, then $L(SLM|LOW) = 1$.

If there is no LOW, skip to the next part.

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

Liquid Observation Well - Surface Level Measurement Interdependence	$p(LOW \mid SLM,L)$ (if no SLM, enter NA)	$p(LOW \mid SLM,NL)$	$L(LOW \mid SLM)$
	NA	NA	1.00

Considering that in-tank data sources may be interdependent:

$p(LOW|SLM,L)$ = ["posterior"] probability that the LOW interstitial liquid level data would be observed if a surface level measurement decrease is observed, and if the tank is a leaker.

$p(LOW|SLM,NL)$ = ["posterior"] probability that a LOW interstitial liquid level measurement decrease would be observed if a surface level measurement decrease is observed, and if the tank is a non-leaker. $p(LOW|SLM,NL) = 1 - pp(LOW|SLM,L)$

$L(LOW|SLM) = p(LOW|SLM,L)/p(LOW|SLM,NL)$. If either surface level data or LOW intersititial liquid level data are not available for the leak assessment, then $L(LOW|SLM) = 1$.

If there is no surface

Ex-Tank Data - Gross Gamma Drywell Logs - Part 6

Gross Gamma Drywell Logs	$p(GGL \mid L)$ (if no GGL, enter NA here and in Parts 8 and 9)	$p(GGL \mid NL)$	$L(GGL)$
	0.10	0.90	0.11

Lateral data (included with drywell data in this part) show no indication of soil contamination other than at the extreme end of Lateral - 1, beyond the tank's foundation. This has been previously examined and explained as the plume from leaking tank SX-107. Most soil contamination detected in the drywells was surface contamination from historical operations in the tank farm, and possibly from tank SX-111. There are no soil contamination peaks reaching the typical 10^6 - 10^7 pCi/gm typically associated with tank waste, by several orders of magnitude.

Considering the historical gross gamma drywell logs reviewed for the leak assessment:

$p(GGL|L)$ = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a leaker.

$p(GGL|NL)$ = ["posterior"] probability that the gross gamma logs would be observed, if the tank is a non - leaker. $p(GGL|NL) = 1 - p(GGL|L)$

$L(GGL) = p(GGL|L)/p(GGL|NL)$. If gross gamma logs are not available for the leak assessment, then $L(GGL) = 1$

Ex-Tank Data - Spectral Gamma Drywell Logs - Part 7

Spectral Gamma Drywell Logs	$p(SGL \mid L)$ (if no SGL, enter NA here and in Parts 8 and 9)	$p(SGL \mid NL)$	$L(SGL)$
	0.10	0.90	0.11

The SGLS drywell logs show soil contamination profiles very similar to the historical gross gamma drywell logs, confirming the results from the earlier 1974 - 1994 logs.

Considering the spectral gamma drywell logs reviewed for the leak assessment:

$p(SGL|L)$ = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a leaker.

$p(SGL|NL)$ = ["posterior"] probability that the spectral gamma drywell logs would be observed, if the tank is a non - leaker. $p(SGL|NL) = 1 - p(SGL|L)$

$L(SGL) = p(SGL|L)/p(SGL|NL)$. If spectral gamma drywell logs are not available for the leak assessment, then $L(SGL) = 1$.

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

Gross Gamma Log - Spectral Gamma Log Interdependence	$p(GGL \mid SGL,L)$	$p(GGL \mid SGL,NL)$	$L(GGL \mid SGL)$
	NA	NA	1.00

Considering that ex-tank data sources may be interdependent:

$p(GGL|SGL,L)$ = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are are observed, and if the tank is a leaker.

$p(GGL|SGL,NL)$ = ["posterior"] probability that the gross gamma logs would be observed if the spectral gamma logs are observed, and if the tank is a non-leaker. $p(GGL|SGL,NL) = 1 - p(GGL|SGL,L)$

$L(GGL|SGL) = p(GGL|SGL,L)/p(GGL|SGL,NL)$. If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then $L(GGL|SGL) = 1$.

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

Spectral Gamma Log - Gross Gamma Log Interdependence	$p(SGL \mid GGL,L)$	$p(SGL \mid GGL,NL)$	$L(SGL \mid GGL)$
	0.15	0.85	0.18

Gross gamma logs were considered more important than the SGLS logs because they were collected over a ~ 20 year period, making subtle trends in soil contamination evident. The SGLS baselining in the 1990's was a single-sample determination.

Considering that ex-tank data sources may be interdependent:

p(SGL|GGL,L) = ["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(SGL|GGL,NL) = ["posterior"] 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(GGL|SGL,NL) = 1 - p(SGL|GGL,L)

L(SGL|GGL) = p(SGL|GGL,L) /p(SGL|GGL,NL) . If either gross gamma logs or spectral gamma logs are not available for the leak assessment, then L(SGL|GGL) = 1.

Combined Liklihood Ratios

L(SLM)	L(LOW)	$L(SLM \mid LOW)$	$L(LOW \mid SLM)$
0.33	1.00	1.00	1.00

L(GGL)	L(SGL)	$L(GGL \mid SGL)$	$L(SGL \mid GGL)$
0.11	0.11	1.00	0.18

Which In-Tank Condition Applies? (Mark X in Box)

SLM & No LOW?	X
LOW & No SLM?	
SLM & LOW; SLM most important? (Mark Part 4 NA)	
SLM & LOW; LOW most important? (Mark Part 5 NA)	

In-Tank Liklihood Ratio	L(SLM,LOW)
	0.33

If SLM and no LOW: L(SLM,LOW) = L(SLM)
If LOW and no SLM: L(SLM,LOW) = L(LOW)
If SLM and LOW and SLM most important: L(SLM,LOW) = L(LOW|SLM) x L(SLM)
If SLM and LOW and LOW most important: L(SLM,LOW) = L(SLM|LOW) x L(LOW)

Which Ex-Tank Condition Applies? (Mark X in Box)

GGL & No SGL?	
SGL & No GGL?	
GGL & SGL; GGL most important? (Mark Part 8 NA)	X
GGL & SGL; SGL most important? (Mark Part 9 NA)	

Ex-Tank Liklihood Ratio	L(SGL,GGL)
	0.02

If GGL and no SGL: L(SGL,GGL) = L(GGL)
If SGL and no GGL: L(SGL,GGL) = L(SGL)
If GGL and SGL and GGL most important: L(SGL, GGL) = L(SGL|GGL) x L(GGL)
If GGL and SGL and SGL most important: L(SGL, GGL) = L(GGL|SGL) x L(LSGL)

Combined Likelihood Ratio for Leak Hypothesis	L(in,ex)
	0.01

L(in,ex) = L(SLM,LOW) x L(SGL,GGL)

Posterior Probability for Leak Hypothesis

$p(L \mid in,ex)$	$p(NL \mid in,ex)$	Ω_1
0.01	0.99	0.01

Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. $\Omega_1 = L(in,ex) \times \Omega_0$
p(L|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. (L|in,ex) = $\Omega_1/(\Omega_1+1)$
p(NL|in,ex) = posterior probability (post-leak assessment) that the tank is a leaker. p(NL|in,ex) = 1- p(L|in,ex)

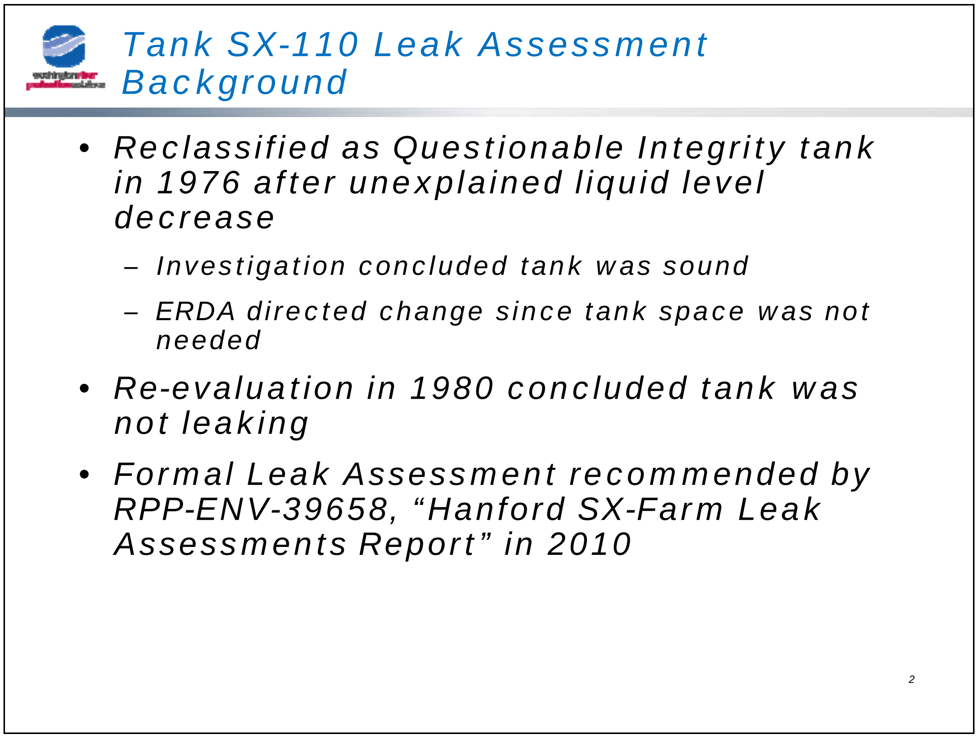
APPENDIX E

Executive Safety Review Board Briefing

241-SX-110 Leak Assessment

D. J. Washenfelder

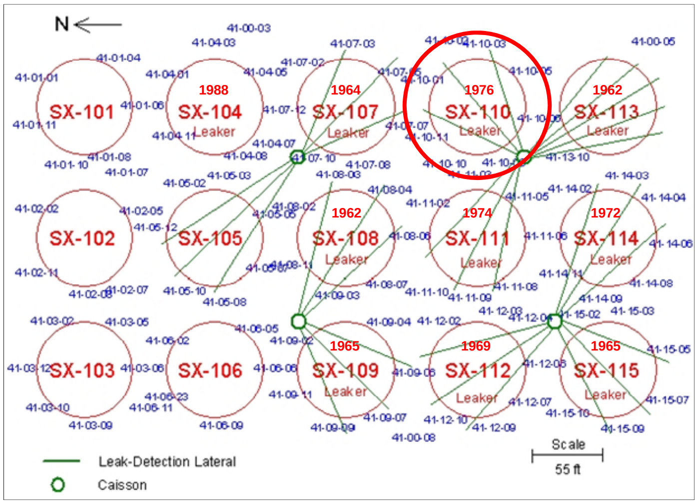
October 22, 2010



Tank SX-110 Leak Assessment Background

- 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

241-SX Tank Farm Leak Integrity Status



From GJ-HAN-4, Vadose Zone Characterization Project and the Hanford Tank Farms, SX Tank Farm Report

Tank SX-110 History

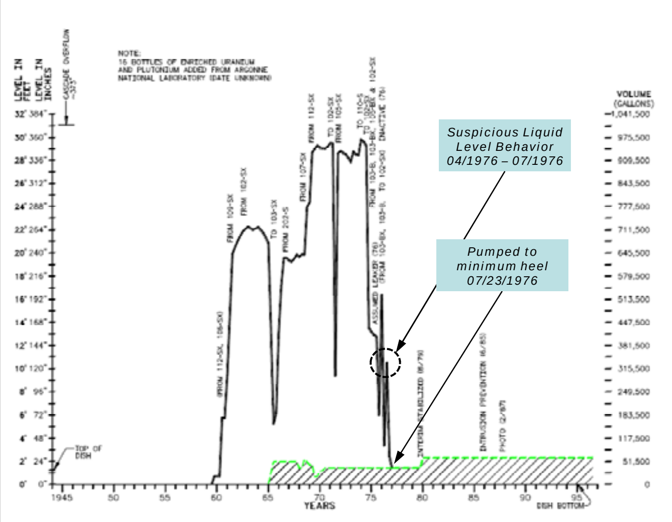
- *1 Mgal single-shell tank in operation 1959 – 1976*
- *Pumped to minimum heel in July, 1976 after OR 76-91 and ERDA directive*
- *Administratively stabilized in 1979*
- *External leak detection via 3 laterals and 8 drywells*
- *Contains ~49 kgal sludge and 7 kgal saltcake high temperature solids*

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



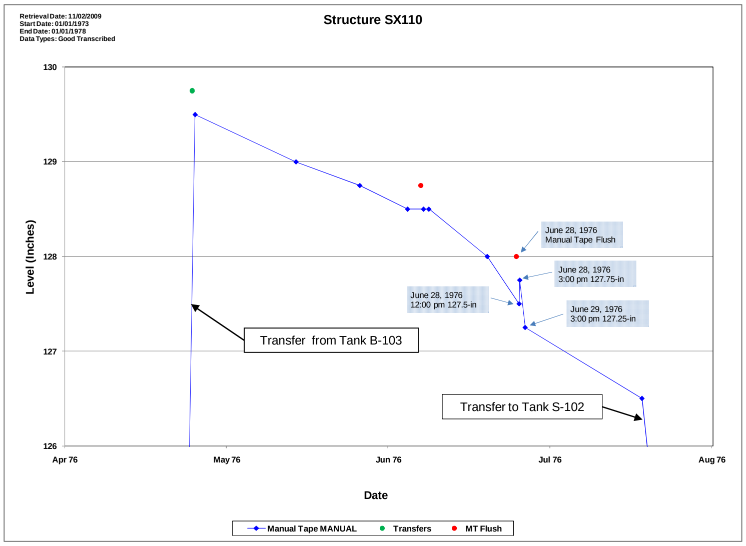
Suspicious Liquid Level Behavior 04/1976 – 07/1976

Pumped to minimum heel 07/23/1976

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

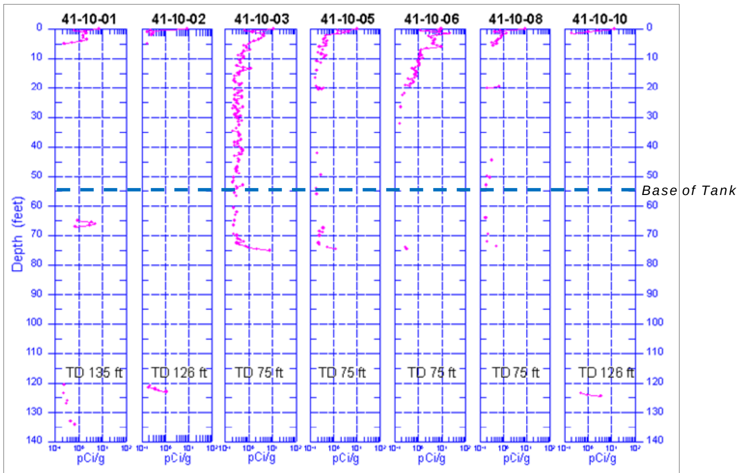


Figure C-10. Correlation Plot of Cs-137 Concentrations in Boreholes Surrounding Tank SX-110

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

Tank SX-110 Drywell Radiation Behavior (cont.)

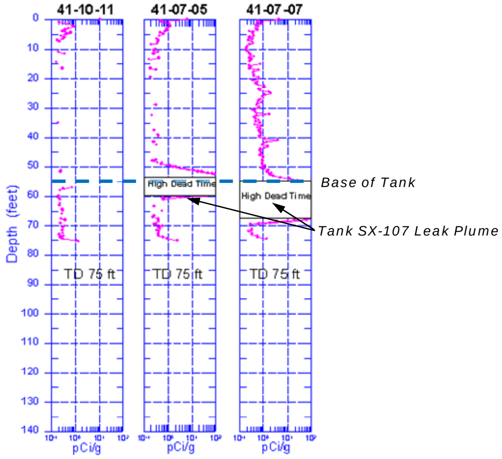
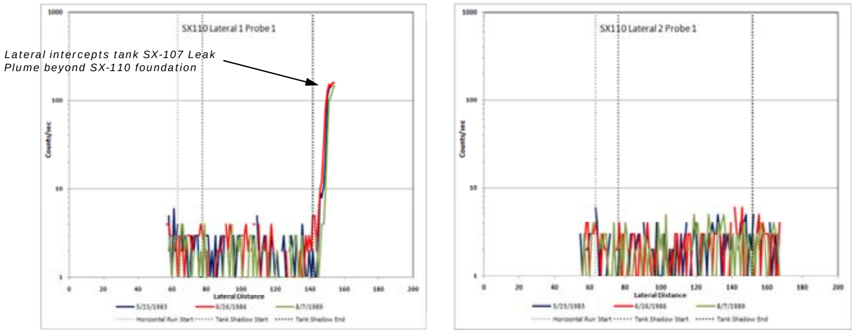


Figure C-10 (continued). Correlation Plot of Cs-137 Concentrations in Boreholes Surrounding Tank SX-110

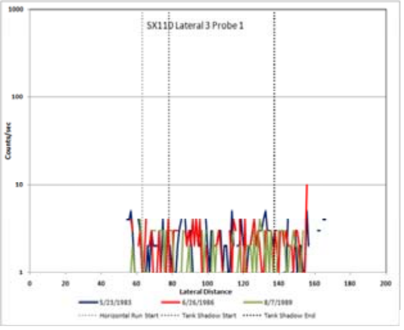
GJPO-HAN-4 Vadose Zone Characterization Project at the Hanford Tank Farms: SX Tank Farm Report, Appendix C. SX Tank Farm Correlation Plots, September, 1996

Tank SX-110 Lateral Radiation Behavior



Plotted from archived raw data by J. M. Reynolds

Tank SX-110 Lateral Radiation Behavior (cont.)



Plotted from archived raw data by J. M. Reynolds

SX-107 Soil Contamination Plume – NE View

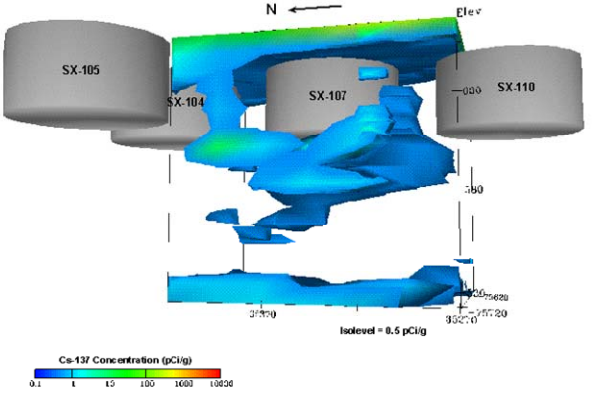


Figure 26. Visualization of Tank SX-107 Cs-137 Plume Viewed From the Southwest

GJPO-HAN-4 Vadose Zone Characterization Project at the Hanford Tank Farms: SX Tank Farm Report, 16.0 Figures

SX-107 Soil Contamination Plume – NW View

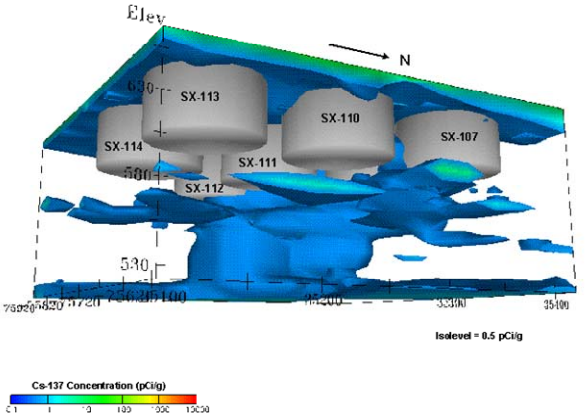


Figure 31. Visualization of Tank SX-110 Cs-137 Plume Viewed From the Southeast

GJPO-HAN-4 Vadose Zone Characterization Project at the Hanford Tank Farms: SX Tank Farm Report, 16.0 Figures

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

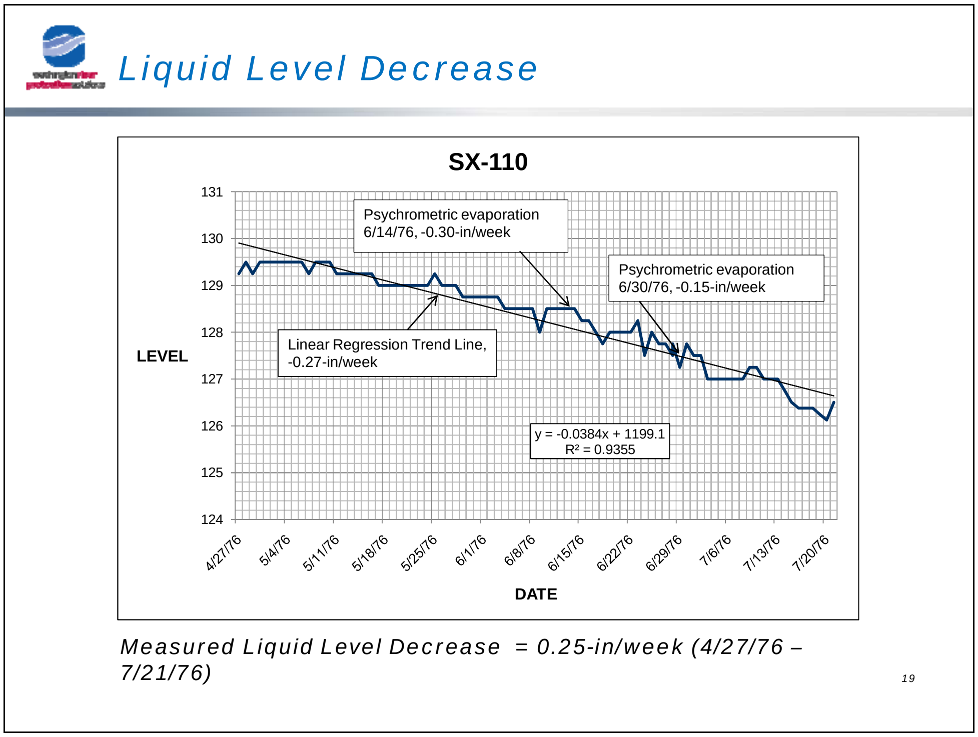
Surface chop resulting from airlift circulator operation.

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

Erratic Liquid Level Measurements - Summary

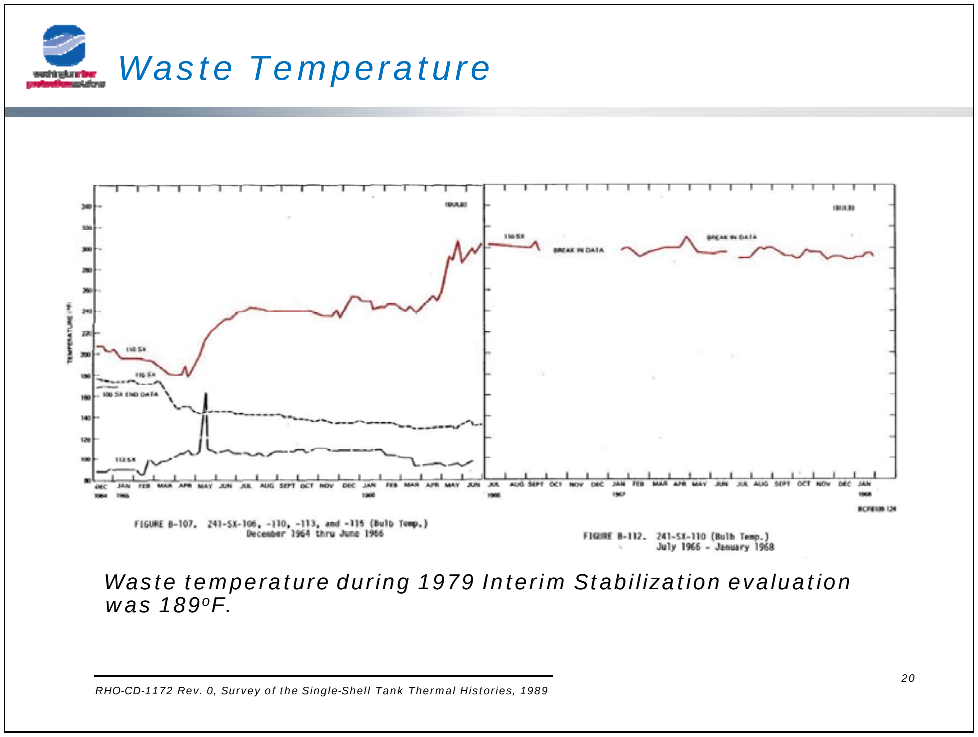
- *Airlift circulator (ALC) operation results in wavy - choppy surface*
- *ALCs noted as “found operating” in July 12, 1976 Tank Farm Surveillance Weekly Report**
- *Manual tape located close to an ALC*

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



Liquid Level Decrease

Measured Liquid Level Decrease = 0.25-in/week (4/27/76 – 7/21/76)



Waste Temperature

FIGURE B-107. 241-SX-106, -110, -113, and -115 (Bulb Temp.)
December 1964 thru June 1966

FIGURE B-112. 241-SX-110 (Bulb Temp.)
July 1966 - January 1968

Waste temperature during 1979 Interim Stabilization evaluation was 189°F.

RHO-CD-1172 Rev. 0, Survey of the Single-Shell Tank Thermal Histories, 1989

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

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*

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*

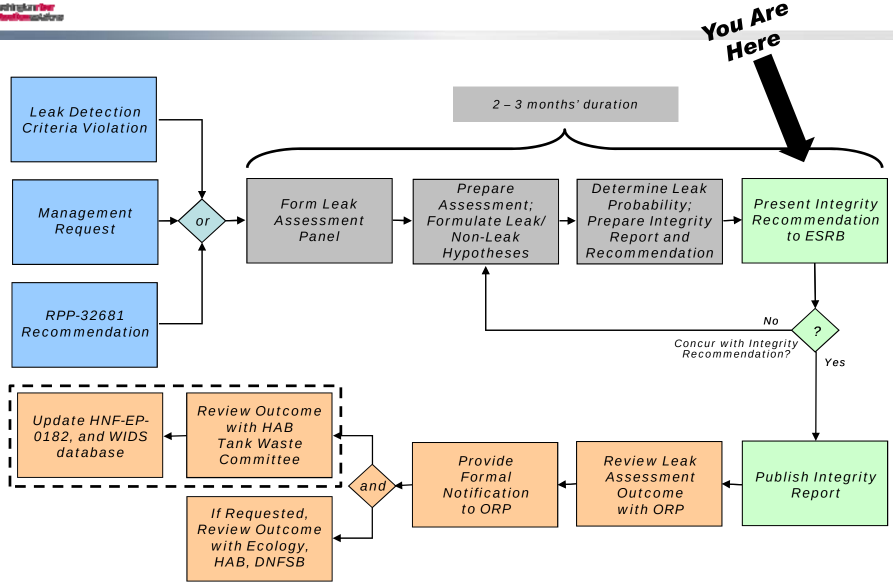
Leak Assessment Recommendation

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*

Other Tank SX-110 Leak Assessment Information

Tank Leak Assessment Process



You Are Here

2 – 3 months' duration

Leak Detection Criteria Violation

Management Request

RPP-32681 Recommendation

or

Form Leak Assessment Panel

Prepare Assessment; Formulate Leak/ Non-Leak Hypotheses

Determine Leak Probability; Prepare Integrity Report and Recommendation

Present Integrity Recommendation to ESRB

?

Concur with Integrity Recommendation?

No

Yes

Publish Integrity Report

Review Leak Assessment Outcome with ORP

Provide Formal Notification to ORP

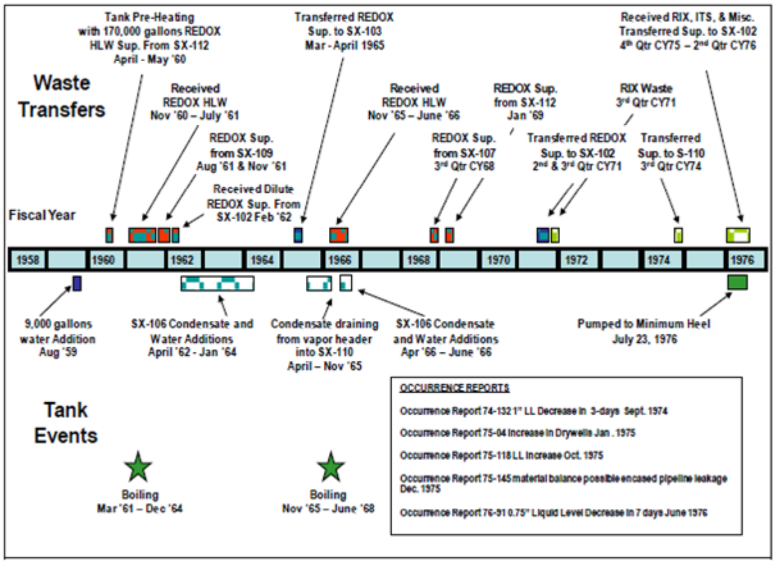
and

Review Outcome with HAB Tank Waste Committee

Update HNF-EP-0182, and WIDS database

If Requested, Review Outcome with Ecology, HAB, DNFSB

Tank SX-110 Operational Timeline


Waste Transfers

Tank Pre-Heating with 170,000 gallons REDOX HLW Sup. From SX-112 April - May '60

Received REDOX HLW Nov '60 – July '61

REDOX Sup. from SX-109 Aug '61 & Nov '61

Received Dilute REDOX Sup. From SX-102 Feb '62

Transferred REDOX Sup. to SX-103 Mar - April 1965

Received REDOX HLW Nov '65 – June '66

REDOX Sup. from SX-107 3rd Qtr CY68

REDOX Sup. from SX-112 Jan '69

Transferred REDOX Sup. to SX-102 2nd & 3rd Qtr CY71

RIX Waste 3rd Qtr CY71

Transferred Sup. to S-110 3rd Qtr CY74

Received RIX, ITS, & Misc. Transferred Sup. to SX-102 4th Qtr CY75 – 2nd Qtr CY76

9,000 gallons water Addition Aug '59

SX-106 Condensate and Water Additions April '62 - Jan '64

Condensate draining from vapor header into SX-110 April – Nov '65

SX-106 Condensate and Water Additions Apr '66 – June '66

Pumped to Minimum Heel July 23, 1976

Tank Events

Boiling Mar '61 – Dec '64

Boiling Nov '65 – June '68

OCCURRENCE REPORTS

Occurrence Report 74-132 1" LL Decrease in 3-days Sept. 1974

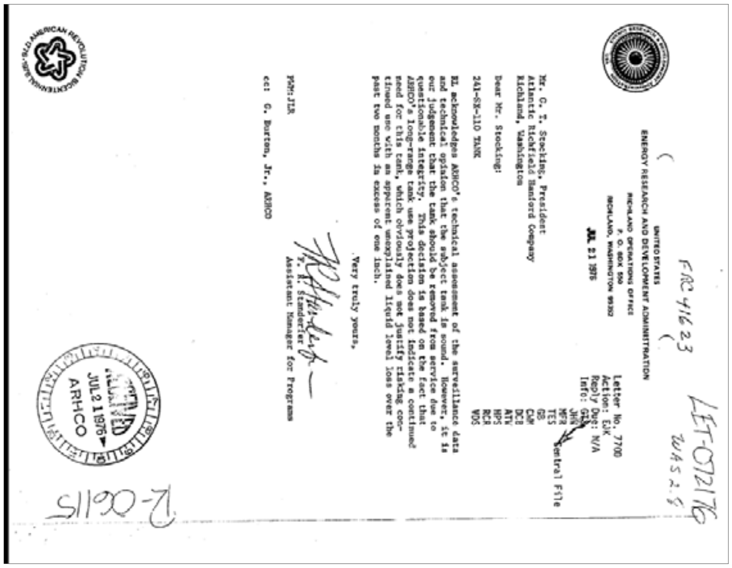
Occurrence Report 75-04 Increase in Drywells Jan . 1975

Occurrence Report 75-118 LL Increase Oct. 1975

Occurrence Report 75-145 material balance possible encased pipeline leakage Dec. 1975

Occurrence Report 76-31 0.75" Liquid Level Decrease in 7 days June 1976

ERDA Letter of Direction


LET-072176
WAS 2.8

FRC 41623

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
RICHLAND OPERATIONS OFFICE
P. O. BOX 550
RICHLAND, WASHINGTON 99352

JUL 21 1976

Letter No. 7700
Action: EJK
Reply Due: N/A
Info: GIL
JHW
MFR
TES
GB
CWM
DCB
ATW
HPS
RCR
VDS
Central File

Mr. G. T. Stocking, President
Atlantic Richfield Hanford Company
Richland, Washington

Dear Mr. Stocking:

241-SX-110 TANK

RL acknowledges ARHCO's technical assessment of the surveillance data and technical opinion that the subject tank is sound. However, it is our judgement 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.

Very truly yours,

F. R. Standerfer
Assistant Manager for Programs

PWM:JLR

cc: G. Burton, Jr., ARHCO

RECEIVED
JUL 21 1976
ARHCO

2-06115