RPP-ASMT-38219
Revision 0

Tank 241-C-110
Leak Assessment Report

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EXECUTIVE SUMMARY

Tank 241-C-110 is a 530,000 gallon capacity, 75-foot diameter, mild steel-lined concrete shell tank located at the west corner of the 16-tank C Tank Farm. The tank was placed in service in May, 1946, and continued to receive and store waste until early 1976 when the remaining supernatant was pumped to another C Farm tank. At that time, the tank was suspected of leaking and had been classified as a "Questionable Integrity" tank. The classification was based on gross gamma soil contamination readings detected at the 53' to 56' depth in drywell 30-10-09, located about 15 feet below the tank's foundation. The contamination was found in October, 1974, immediately after the drywell was drilled adjacent to the tank.

When the soil contamination was detected, tank 241-C-110 contained about 376,000 gallons of waste, including 165,000 gallons of supernatant. The liquid surface was being monitored with a manual tape, and showed no detectable decrease in level for the 1972 - mid-1975 period. By 1982 the gross gamma peak in the drywell had decayed to background.

In 1984 the "Questionable Integrity" and "Confirmed Leaker" tank classifications were combined and changed to "Assumed Leaker". A leak volume estimate was not made until 1989, when a 2,000 gallon volume was assigned based on the tank 241-C-110 manual tape sensitivity of +/- 0.75".

Document RPP-ENV-33418 Rev. 1, "Hanford C-Farm Leak Assessments Report: 241-C-101, 241-C-110, 241-C-111, 241-C-105, and Unplanned Waste Releases," published in February, 2008, reviewed the tank 241-C-110 leak history for purposes of retrieval technology selection. The report concluded that there was an alternative explanation for the contamination measured in the drywell, and that the tank may not have leaked.

The process for investigating potential tank leaks is described in Engineering procedure TFC-ENG-CHEM-D-42, "Tank Leak Assessment Process". The commitment for a formal tank 241-C-110 leak assessment was made by reference in Letter 08-TPD-015, S. J. Olinger, Office of River Protection to J. A. Hedges, State of Washington Department of Ecology, "Hanford C Farm Leak Assessments," April 9, 2008.

The leak assessment used a panel of experienced CH2M HILL Hanford Group, Inc. engineers and managers to review the tank 241-C-110 historical data and re-evaluate the basis for declaring the tank an "Assumed Leaker". The panel consisted of: Dennis J. Washenfelder, (Assessment Coordinator, Technical Integration Program Manager); Daniel G. Baide, (West Systems Engineering Manger); David A. Barnes, (Surveillance System Engineer, in-tank and ex-tank surveillance); David W. Brown (C Tank Farm Maintenance and Facility Operations Manager); Laroy S. Krogsrud (C Tank Farm Single-Shell Waste Tank System Engineer); and Phillip C. Miller (Environmental Support and Assessment Program Manager).

Based on review of the historical data, the panel developed plausible hypotheses for the observed tank behavior:

Leak Hypothesis:

> "A leak from tank 241-C-110 caused the elevated radiation reading in drywell 30-10-09."

Non-Leak Hypothesis:

> "An overflow from tank 241-C-110 via inlet or outlet line penetrations, a transfer line leak, or other unplanned release created the elevated radiation reading in drywell 30-10-09."

The consensus of the assessment team was that the available data indicate that the Non-Leaker hypothesis is the most likely explanation for the elevated radiation reading in the drywell. The tank's stable liquid level surface bracketing the period when the drywell gross gamma peak was discovered, the natural decay of the drywell gross gamma peak following discovery, and an interior tank photo showing evidence of waste in and above the tank inlet line penetrations indicate that tank overfilling is the most likely cause of the observed radiation in the drywell.

The recommendation of the assessment team was that the integrity status of tank 241-C-110 be changed from "Assumed Leaker" to "Sound".

The results of this assessment were presented to the Executive Safety Review Board on June 26, 2008. The Board concurred with the recommendation of the assessment team.

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Abbreviations and Acronyms

DOE-GJO	DOE Grand Junction Office
DOE-RL	Department of Energy Richland Operations Office
SST	single-shell tank

Units

ft	foot
id	inside diameter
in	inch
kgal	kilogallon (1,000 gallons)

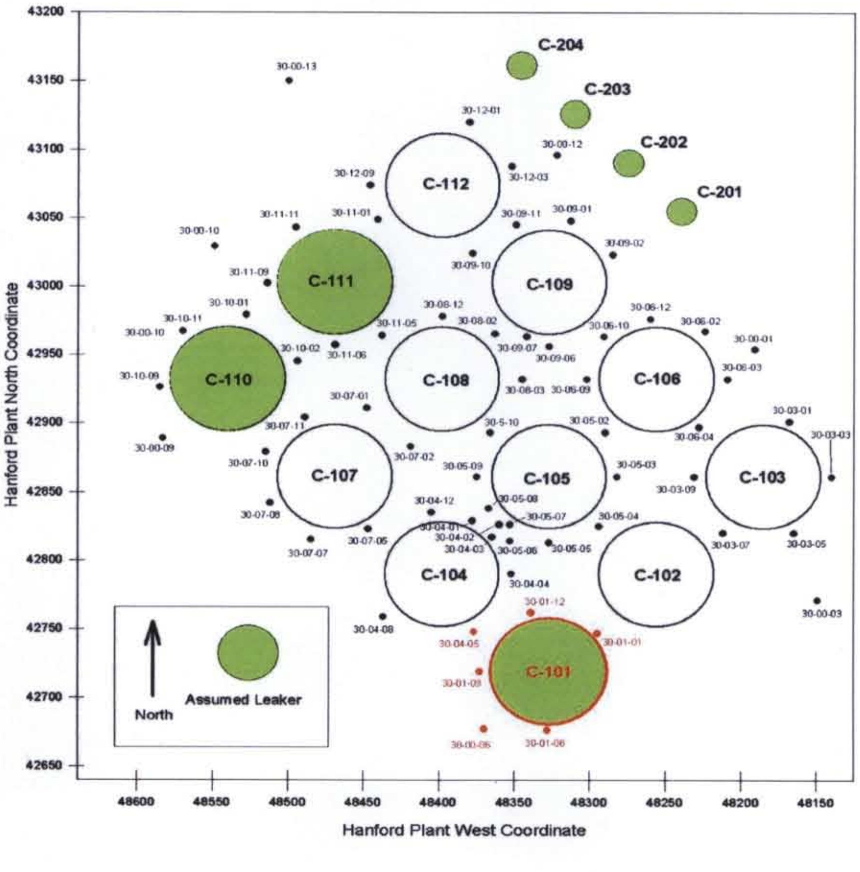
1.0 INTRODUCTION

This document provides the results of a formal leak assessment performed on tank 241-C-110 (tank C-110). The leak assessment process is described in Engineering procedure TFC-ENG-CHEM-D-42, Rev. A-1, *Tank Leak Assessment Process*. The commitment for a formal tank C-110 leak assessment was made by reference in Letter 08-TPD-015, S. J. Olinger, Office of River Protection to J. A. Hedges, State of Washington Department of Ecology, "Hanford C Farm Leak Assessments," April 9, 2008.

Tank C-110 is a 530,000 gallon capacity, 75-foot diameter, mild steel-lined concrete single-shell tank located at the west corner of the 16-tank C Tank Farm. The tank was placed in service in May, 1946, and continued to receive and store waste until early 1976 when the remaining supernatant was pumped to another C Farm tank. At that time, the tank was suspected of leaking and had been classified as a "Questionable Integrity" tank.

Figure 1-1. 241-C Farm Plot Plan.

Tank C-110 is located in the west corner of the tank farm, the first tank in the three-tank C-110, -111, and -112 Cascade. Drywells illustrated in the plan are identified by their associated tank number and clock position from North.



The classification was based on gross gamma soil contamination readings detected at the 53' to 56' depth in drywell 30-10-09, located about 15 feet below the tank's foundation. The contamination was found in October, 1974, immediately after the drywell was drilled adjacent to the tank.

When the soil contamination was detected, tank 241-C-110 contained about 376,000 gallons (kgal) of waste, including 165,000 kgal of supernatant. The liquid surface was being monitored with a manual tape, and showed no detectable decrease in level for the 1972 - mid-1975 period. By 1982 the gross gamma peak in the drywell had decayed to background.

In 1984 the "Questionable Integrity" and "Confirmed Leaker" tank classifications were combined and changed to "Assumed Leaker". A leak volume estimate was not made until 1989, when a 2,000 gallon volume was assigned based on the tank 241-C-110 manual tape sensitivity of +/- 0.75" (8901832B R1).

Document RPP-ENV-33418 Rev. 1, "Hanford C-Farm Leak Assessments Report: 241-C-101, 241-C-110, 241-C-111, 241-C-105, and Unplanned Waste Releases," published in February, 2008, reviewed the tank 241-C-110 history for purposes of retrieval technology selection. The report concluded that there was an alternative explanation for the contamination measured in the drywell, and that the tank may not have leaked.

2.0 METHOD OF ANALYSIS

The method of analysis used was Engineering Procedure TFC-ENG-CHEM-D-42, *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 *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 CH2M HILL Hanford Group, Inc. engineers and managers to review the tank C-110 historical data and re-evaluate the basis for declaring the tank an "Assumed Leaker". The panel consisted of: Dennis J. Washenfelder, (Assessment Coordinator, Technical Integration Program Manager); Daniel G. Baide, (West Systems Engineering Manger); David A. Barnes, (Surveillance System Engineer, in-tank and ex-tank surveillance); David W. Brown (C Tank Farm Maintenance and Facility Operations Manager); Laroy S. Krogsrud (C Tank Farm Single-Shell Waste Tank System Engineer); and Phillip C. Miller (Environment Support and Assessment Program Manager). The team met between April 29, 2008 and June 18, 2008 to gather and review information, develop the Leak and Non-Leak Hypotheses, and reach a consensus recommendation for tank C-110.

3.0 SUMMARY OF TANK HISTORY

Tank C-110 is a 530,000 gallon capacity, 75-foot diameter, mild steel-lined concrete single-shell tank located at the west corner of the 16-tank C Tank Farm. The tank was placed in service in May, 1946, and continued to receive and store waste until early 1976 when the remaining supernatant was pumped to another C Farm tank. At that time, the tank was suspected of leaking and had been classified as a "Questionable Integrity" tank. Of the twelve 100-Series C Farm tanks, three – C-101, C-110, and C-111 - are classified as an "Assumed Leaker".

Tank C-110 did not see severe service based on the process history records that are available. It did not store high-heat waste. It is unlikely that it was exposed to repeated, rapid heating and cooling cycles, based on the wastes stored in the tank, although actual temperature records have not been located.

Discussions with the authors of RPP-ENV-33418 Rev. 1 indicate that waste stored in the tank did not meet current AC 5.16 Corrosion Mitigation Controls for the period May, 1946 – March, 1947, when the tank was used as part of a cascade for B Plant 1st Cycle Decontamination Waste with a pH of ~8 (Current Administrative Control 5.16 requirements are pH $\geq$ 12).

During the 1970 - 1972 period about 1.4 million gallons of B Plant concentrator bottoms and IX waste were received and transferred through the tank, equivalent to several fills and empties. Available monthly and quarterly production records show the tank's liquid level at the end of each reporting period, which is not indicative of the maximum fill level the tank may have experienced during the period.

4.0 SUMMARY OF AVAILABLE DATA

4.1 TANK FEATURES AND CONFIGURATION

4.1.1 Features and Configuration

Tank 241-C-110 is a 530,000 gallon capacity, 75-foot diameter, mild steel-lined concrete single-shell tank located at the west corner of the 16-tank C Tank Farm. The tank has 4 side fill inlet nozzles: V-138, -139, and -140, connected to the 241-C-153 Diversion Box. The 4th inlet nozzle is a capped spare. Capping was accomplished in a variety of ways: friction fit, gasketed caps; plugged with wooden plugs; or plastic-bagged. The centerline of the inlet nozzles is at 17'-4", equivalent to ~ 547,500 gal of waste storage. A cascade overflow line to tank C-111 has a 16'-11.5" centerline, equal to ~535,000 gallons of waste storage. The steel liner extends to 19'.

During construction of the early tank farms, concrete viaducts were used to support the transfer pipeline runs from the edge of the construction excavation to the tanks. Figure 1 shows a portion of the pipeline viaducts being erected during the 241-BX Tank Farm construction.

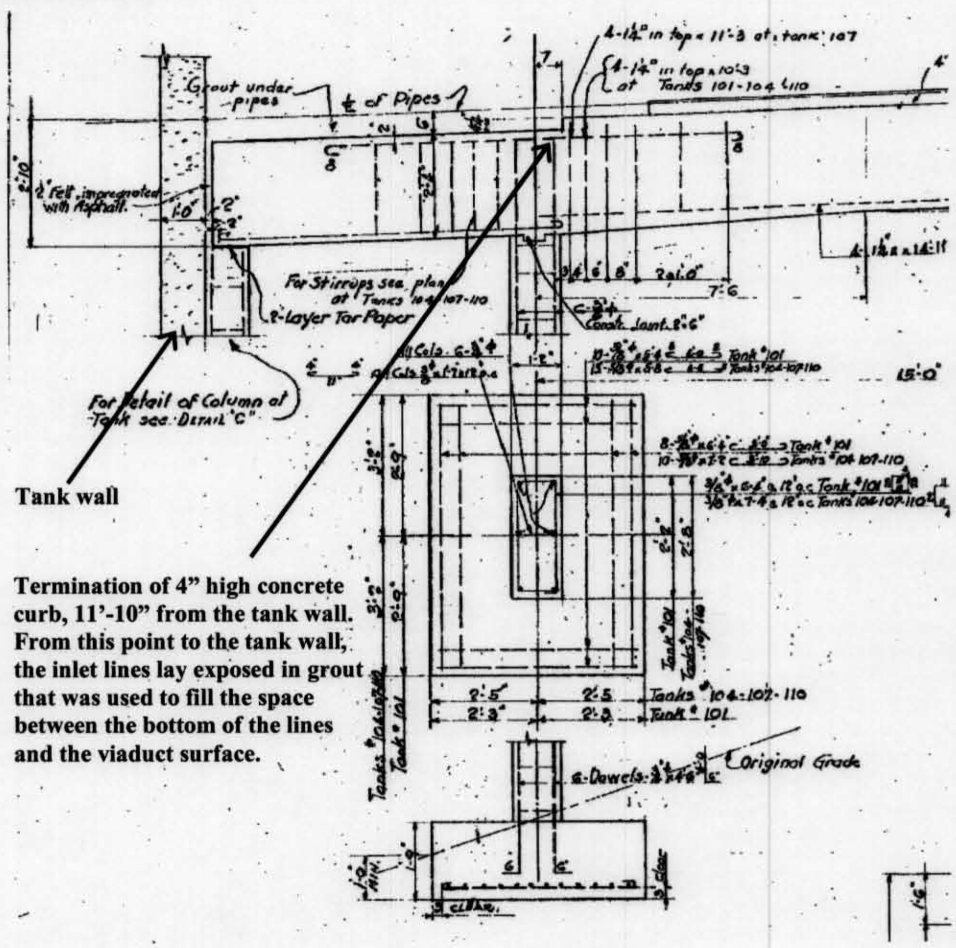
Figure 4-1. 241-BX Tank Farm Construction.

Forms for the concrete pillars that will support the pipeline viaduct have been erected in this 1947 photo. The earliest tank farms, including 241-B, -C, -T, and –U, used viaducts to support waste transfer pipelines between the edge of the tank farm excavation and the tanks. (N1D0001281 1375-NEG 241-BX 8-15-1947)

Drawing W-74108 "Hanford Engineer Works Building No. 241-T-U-B & C Concrete Details of Pipe Supports" shows that the viaduct has a 4" high curb running along both edges. The curbing stops about 11'-10" from the tank wall. At about 9'-10" from the tank wall the viaduct surface steps down and the void space between the pipes and the viaduct surface is grouted. At this point the viaduct begins fanning out from 2'-8" wide to 7'-4" wide to support the spread placement of the fill lines through the tank wall. The concrete viaduct terminates 2" from the tank wall; the void space is filled with 2" asphalt-impregnated felt.

Figure 4-2. Pipeline Concrete Viaduct Details.

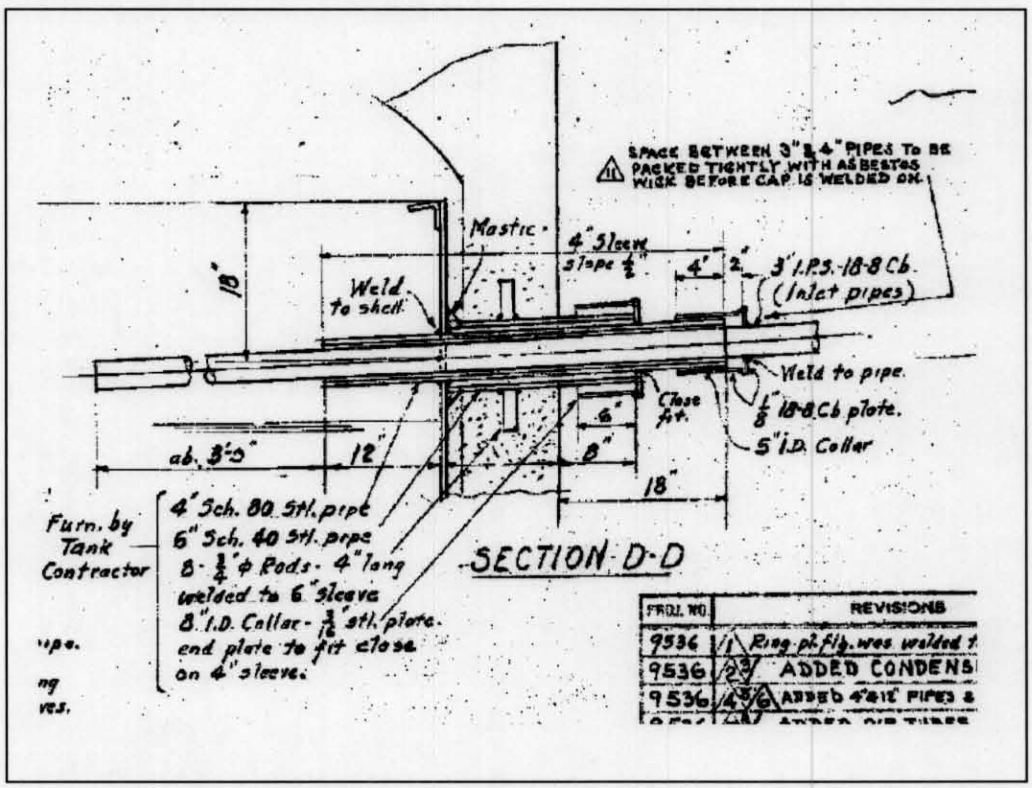
The viaduct has a 4" high curb running along both edges. The curbing stops about 11'-10" from the tank wall. At about 9'-10" from the tank wall the viaduct surface steps down and the void space between the pipes and the viaduct surface is grouted. At this point the viaduct begins fanning out from 2'-8" wide to 7'-4" wide to support the spread placement of the fill lines through the tank wall. The concrete viaduct terminates 2" from the tank wall; the void space is filled with 2" asphalt-impregnated felt. If the tank was overfilled, the waste could have backed-up through the spare inlet line and escaped from around the loose-fit end cap. The uncurbed portion of the viaduct would not have contained the waste, and it would easily spread immediately adjacent to the tank wall. (Drawing W-74108 Hanford Engineer Works Building No. 241-T-U-B & C Concrete Details of Pipe Supports)



The inlet lines pass through the tank wall via a 4' long 4" Schedule 80 pipe sleeve. A 5" id cap shrouds the 4" sleeve at the entry point of the 3" line, and was welded to the 3" line, allowing the 3" line to float in the ~ 1/4" annular void space inside the sleeve. Before welding the cap, the void space between the 3" line and the 4" sleeve was packed with asbestos wick (Drawing H-W-72743 "Hanford Engineer Works - BLD. #241 75'0" Dia. Storage Tanks T-U-B & C Arrangement").

Figure 4-3. Inlet Line Tank Wall Penetration Detail.

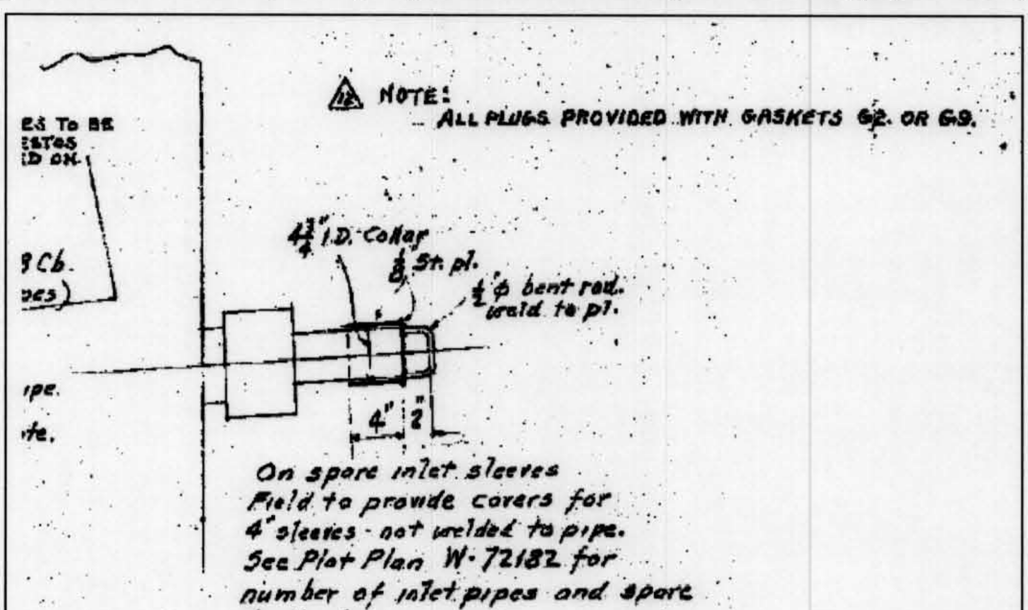
The inlet lines pass through the tank wall via a ~4' long 4" Sch. 80 pipe sleeve. A 5" id cap shrouds the 4" sleeve at the entry point of the 3" line (3" SST 18-8 tubing, and is welded to the 3" line, allowing the 3" line to float in the ~ 1/4" annular void space inside the sleeve. Before welding the cap, the void space between the 3" line and the 4" sleeve is packed with asbestos wick. It seems unlikely that the flexible asbestos wick packing could have placed very far into the 4' long ¼" annular space. (Drawing H-W-72743 Hanford Engineer Works - BLD.#241 75'0" Dia. Storage Tanks T-U-B & C Arrangement).



Drawing H-W-72743 also shows the detail for the spare inlet nozzle cover. The 4-3/4" ID x 4" cover was fit over the 4" pipe sleeve and not welded in place. The OD of 4" Schedule 80 pipe is 4-1/2", so the clearance between the nozzle cover and the pipe sleeve would be about 1/8" all around. However, based on a 1951 investigation, the drawing may not represent actual as-built conditions. The 1951 field installation of some of the spare inlet nozzles on single-shell tanks (SSTs) was conducted after waste had been discharged through a spare inlet from tank BX-102 (HW-20742, Loss of Depleted Metal Waste Supernate to Soil). This investigation of the covers on spare inlet nozzles revealed "... some have blanks which are welded tight, some have tapered wooden plugs driven in the spare nozzle covered by a cap and sealed with waterproofing, and some have caps covered with a waterproofing membrane and then sealed in cement" (HW-20742 page 5 item 2).

Figure 4-4. Spare Inlet Line Cover Detail.

The 4-3/4" ID x 4" cover is fit over the 4" pipe sleeve and not welded in place. The OD of 4" Sch. 80 pipe is 4-1/2", so the clearance between the nozzle cover and the pipe sleeve would be about 1/8" all around. However, based on a 1951 investigation, the drawing may not represent as-built conditions. The 1951 field installation of some of the spare inlet nozzles on SSTs was conducted after waste had been discharged through a spare inlet from tank BX-102. This investigation of the covers on spare inlet nozzles revealed "... some have blanks which are welded tight, some have tapered wooden plugs driven in the spare nozzle covered by a cap and sealed with waterproofing, and some have caps covered with a waterproofing membrane and then sealed in cement". (Drawing H-W-72743 Hanford Engineer Works - BLD.#241 75'0" Dia. Storage Tanks T-U-B & C Arrangement and HW-20742, Loss of Depleted Metal Waste Supernate to Soil, page 5 item 2)



4.2 IN-TANK DATA

4.2.1 Surface Level Behavior

Tank C-110 was placed in service in May, 1946, and continued to receive and store waste until early 1976 when the remaining supernatant was pumped to another C Farm tank. At that time, the tank was suspected of leaking and had been classified as a "Questionable Integrity" tank based on gross gamma soil contamination readings found at the 53' to 56' depth in drywell 30-10-09, about 15 feet below the tank's foundation. The contamination was detected in October, 1974, immediately after the drywell was drilled adjacent to the tank. When the soil contamination was detected, C-110 contained about 376 kgal of waste, including 165 kgal of supernatant. The liquid surface was being monitored with a manual tape, and showed no detectable decrease in level for the 1972 - mid-1975 period.

During the 1970 - 1972 period about 1.4 million gallons of B Plant concentrator bottoms and IX waste were received and transferred through the tank, equivalent to several fills and empties. Available monthly and quarterly production records show the tank's liquid level at the end of each reporting period, which is not indicative of the maximum fill level the tank may have experienced during the period.

An observation reported in HW-20742 page 4 (regarding tanks in BX and BY farms, and discussed in RPP-ENV-33418 is "...The depth of liquid in these tanks is determined by subtracting the elevation of the bottom of the tank from the elevation of the flange on top of a tank riser, and then subtracting from this difference the distance from the flange to the liquid as measured by foot markers placed along the electrode wires. Some electrodes were calibrated to read the liquid depth directly - others were calibrated so that the reading must be subtracted from the overall height as explained in the foregoing. Considerable confusion exists as to the true elevation for the tank bottom and flanges on tank risers. Recent investigations of the elevations have shown that one of the bench marks is off by over a foot; that the S Division [200 Areas processing plants and tank farms] Manual, the blue prints, and the surveyors do not agree on the elevations; that some blue prints use the center of the tank bottom for the tank elevation whereas other places use the side of the tank bottom, which could cause as much as [illegible] foot error; and that recent changes in elevations on the blue prints have not been recorded on the S Division records. Some direct reading electrodes were made according to the manual elevations and some were made according to the blue print elevations."

4.2.2 In-Tank Photographs

A 1986 photograph of the side fill inlet nozzles seems to show solidified material in the mouth of the spare inlet nozzle. The same photo shows that the reddish-color paint on the interior has been lost from above the inlet nozzles, which indicates the waste level inside this tank exceeded the height of the inlet nozzles.

Figure 4-5 1986 photo of Tank 241-C-110 Interior.

Missing paint above the inlet nozzles indicates that tank must have been filled above the inlets at one time. There appears to be solidified material in the mouths of the inlet lines, including the capped spare. The cascade overflow (outlet) line to tank 241-C-111 became plugged in November, 1952; there is no information that the line was ever unplugged. During the 1970 - 1972 period about 1.4 million gallons of B Plant concentrator bottoms and IX waste were received and transferred through the tank, equivalent to several fills and empties. Available monthly and quarterly production records show the tank's liquid level at the end of each reporting period, which is not indicative of the maximum fill level the tank may have experienced during the period. (8605264-4CN_[N2113041] C-110 Wall, Dome, Inlet Nozzles Aug 12 1986.jpg)

4.3 EX-TANK DATA

4.3.1 Tank C-110 Drywell 30-10-09

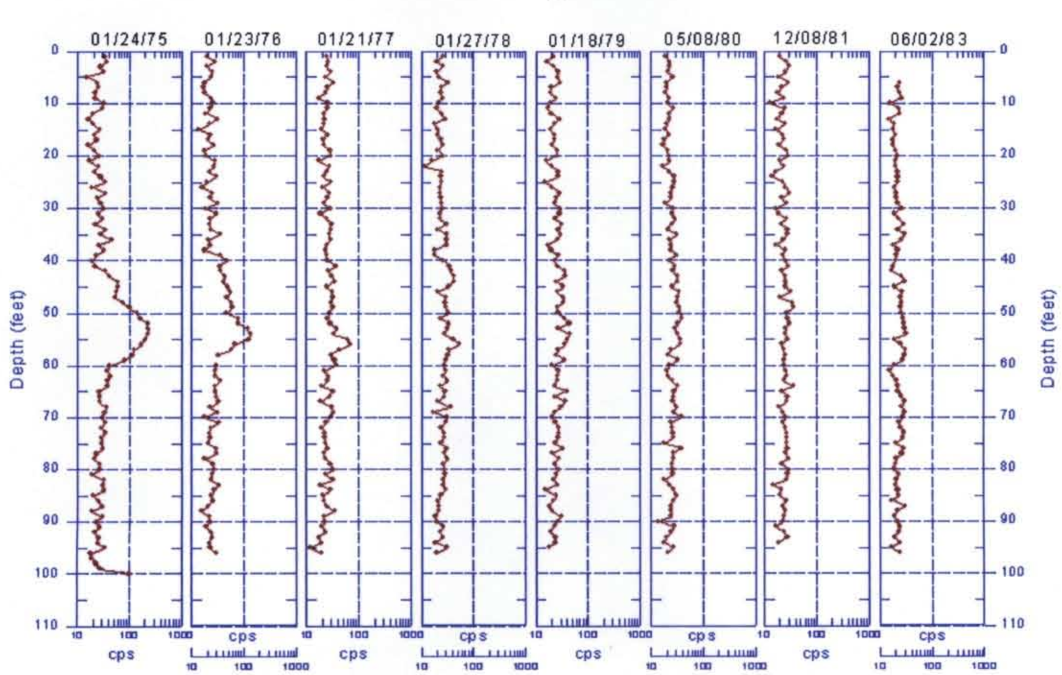
In October, 1974 gross gamma soil contamination readings were found at the 53' to 56' depth in drywell 30-10-09, about 15 feet below the tank's foundation. The contamination was detected immediately after the drywell was drilled adjacent to the tank.

By 1982 the gross gamma peak in the drywell had decayed to background at a half-life decay rate matching RuRh-106 (RPP-8321, 2001, Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-C Tank Farm – 200 West Area, page 351; and SD-WM-TI-356, Waste Storage Tank Status and Leak Detection Criteria, September 30, 1988). The presence of RuRh-106 with a half-life of 368 days suggests that the contamination might have been from relatively fresh waste (10 half-lives to complete decay is a rule-of-thumb.). No further changes in the drywell readings were noted.

Figure 4-6. Drywell 30-10-09 Historical Gross Gamma Logs.

Contamination was detected in Drywell 30-10-09 in October, 1974, immediately after the drywell was drilled adjacent to the tank. At that time tank C-110 contained about 376 kgal of waste, including 165 kgal of supernatant. The liquid surface was being monitored with a manual tape, and showed no detectable decrease in level for the 1972 - mid-1975 period. By 1982 the gross gamma peak in the drywell had decayed to background. (GJ-HAN-92 Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-110 Appendix A, Spectral Gamma-Ray Logs for Boreholes in the Vicinity of Tank C-110, November, 1997. \\hanford\data\Sitedata\HLANPlan\Geophysical_Logs\index.html)

Historical Gross Gamma Logs for Borehole 30-10-09



4.3.2 Other Tank C-110 Drywells

In 1994, the Department of Energy Richland Operations Office (DOE-RL) requested the DOE Grand Junction Office (DOE-GJO), Grand Junction, Colorado, to conduct a baseline characterization of gamma-emitting radionuclide contamination in the vadose zone at all of the Hanford Site single-shell tank farms. The baseline characterization of the C Tank Farm was accomplished by logging each of the drywells surrounding the tanks with spectral gamma logging systems.

The tank C-110 baseline report was issued in 1997. Data obtained from the drywells indicated that, "... the source of the Cs-137 contamination around this tank is a combination of surface spills and pipeline and tank leaks. On the basis of a review of historical gross gamma-ray logs for borehole 30-10-09, a tank leak may have occurred before 1975. The source of the tank leak is probably closest to borehole 30-10-09, on the west side of tank C-110." (GJ-HAN-92)

The inlet lines, including the spare inlet line, are located on the west side of tank C-110, nearest to drywell 30-10-09.

5.0 HYPOTHESES

The hypothesis posed by the assessment team was: "Does the 1974 evidence from drywell 30-10-09 provide a basis for concluding that tank C-110 had leaked?" Based on review of the historical data, the panel developed plausible hypotheses for the observed tank behavior:

1. Leak Hypothesis: "A leak from tank 241-C-110 caused the elevated radiation reading in drywell 30-10-09."
2. Non-Leak Hypothesis: "An overflow from tank 241-C-110 via inlet or outlet line penetrations, a transfer line leak, or other unplanned release created the elevated radiation reading in drywell 30-10-09."

6.0 SUMMARY OF ANALYSTS ASSESSMENT

Expert Opinion: D. G. Baide

Estimated Probability of Observed In-Tank and Ex-Tank Data if Tank had Leaked = 0.20

Basis for Opinion:

- C-110 was a low heat tank with a non-aggressive process history; only 2 C-100 tanks had leaked by 1974 when drywell 30-10-09 was drilled.
- Possible manual tape reference elevation errors combined with repeated tank fills and empties could have resulted in an overflow.
- Drywell spectral gamma scans are inconclusive, mostly showing evidence of surface spills.

Expert Opinion: D. A. Barnes

Estimated Probability of Observed In-Tank and Ex-Tank Data if Tank had Leaked = 0.10

Basis for Opinion:

- The tank showed no measurable change in level for about three years around the time the drywell was drilled and the contamination initially detected. It is very unlikely that the tank would maintain constant level if it were leaking.
- In-tank photos showed a high waste level beachline at the same level as the inlet nozzles, including the capped spare. From the photos the chances of an overfill appears very likely.
- When the drywell was drilled in 1974 a contamination spike was identified about 15 feet below the tank. The depth indicates it may have been there for a while, (long enough to migrate downwards at least 15 feet), but not too long since the ruthenium had not decayed away yet. Over the next 30 years the spike decayed away at the expected ruthenium decay rate, but no new contaminants were ever added at that location. This is further evidence that the deposit was a one-time event, and not a continuing tank leak. Also, the tank was relatively full on several occasions after that, and if it leaked the contamination spike would be expected to expand.
- The first full characterization spectral log was run in 1997. The contamination in 30-10-09 had decayed away, but two other drywells on the opposite side of the tank showed low levels of cesium and europium at the base. Both are directly under known piping and/or diversion boxes. Finding contamination near the base of the tank with no other history or data available does imply a tank leak. Because of the low levels identified and the presence of piping and pits that could contribute I assigned of 0.6 for the spectral gamma logs, slightly favoring a tank leak.

Expert Opinion: D. W. Brown

Estimated Probability of Observed In-Tank and Ex-Tank Data if Tank had Leaked = 0.20

Basis for Opinion:

- If tank C-110 was leaking, there should have been a manual tape indication of a leak, especially over the three year period that the liquid surface level was monitored and stable.
- The gross gamma drywell scan is more indicative of an external leak or an overflow from the tank since it never increased after initial monitoring.
- The interior tank photo shows that the tank was probably filled above the inlet lines at some time. The loose-fitting cap on the spare inlet line would have allowed waste leak out.
- The later spectral gamma drywell scans results are inconclusive for a tank leak; if the drywell was located in the leak plume, then the leak would go undetected. However, the gross gamma and spectral gamma scans are not inconsistent with each other.

Expert Opinion: L. S. Krogsrud

Estimated Probability of Observed In-Tank and Ex-Tank Data if Tank had Leaked = 0.22

Basis for Opinion:

- Based on the behavior of the manual tape on the liquid surface, a leak would not be suspected.
- The drywell 30-10-09 gamma peak was located below the tank foundation and did not increase over time. This behavior would be unlikely if the tank liner was leaking.

Expert Opinion: P. C. Miller

Estimated Probability of Observed In-Tank and Ex-Tank Data if Tank had Leaked = 0.05

Basis for Opinion:

- The manual tape was monitoring a liquid surface at the time of the 1974 drywell event. There was no detectable change in surface level measurement, so it is unlikely that the tank was leaking.
- The gross gamma peak in the 30-10-09 drywell decayed over time. If the tank was leaking and the drywell intercepted the plume, it is unlikely that the gamma peak would have behaved this way. However a plume from a leak could have missed all of the drywells. Probably not indicative of the tank leak status.

- The spectral gamma scan indicated that the radionuclides were mostly naturally-occurring isotopes. If the drywell intercepted a leak plume, manmade isotopes would have been present.

Expert Opinion: D. J. Washenfelder

Estimated Probability of Observed In-Tank and Ex-Tank Data if Tank had Leaked = 0.07

Basis for Opinion:

- When the soil contamination was detected, C-110 contained 165 kgal of supernatant. The liquid surface was being monitored with a manual tape, and showed no detectable decrease in level for the 1972 - mid-1975 period.
- The estimated loss was based on the +/- 0.75-inch accuracy of the manual tape measuring a liquid surface, ~ 2,000 gallons loss, rather than any field leak measurement.
- The interior tank photo of the inlet lines seems to show solidified material in the mouth of the spare inlet line. The same photo shows that the reddish-color paint on the interior has been lost from above the inlet lines, which indicates the waste level inside this tank exceeded the height of the inlet lines. Drawing H-W-72743 shows that the spare inlet cover was only loose fit over the open spare inlet line.
- By 1982 the gross gamma peak in the 30-10-09 drywell had decayed to background at a half-life decay rate matching RuRh-106. This is inconsistent with an active leak plume.
- RPP-ENV-33418 Rev. 1 Hanford C-Farm leak Assessments Report: 241-C-101, 241-C-110, 241-C-111, 241-C-105, and Unplanned Releases, February, 2008, reevaluated the decision to declare C-110 an assumed leaker based on data that were not available when original leak assessment was performed in 1974. The assessment concluded that, "The C-110 leak appears to be the result of a tank overflow 17 ft 4 in (208 in) above the tank bottom. As a worst case, the liquid level in SST was steady at 144 in from the tank center from 1971 to 1975, indicating that if there was a breach in the tank wall, it was above this level."

Summary:

The consensus of the assessment team is that the tank's stable liquid level surface bracketing the period when the 30-10-09 drywell gross gamma peak was discovered, the natural decay of the drywell gross gamma peak following discovery, and an interior tank photo showing evidence of waste in and above the tank inlet line penetrations indicate that tank overfilling was the most likely cause of the observed radiation in the drywell.

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 assessment team that the available in-tank and ex-tank data indicated that the no-leak hypothesis was more consistent with the data. The stable liquid surface level, the natural decay of the gross gamma peak in drywell 30-10-09 after its 1974 discovery, and the in-tank photo showing evidence of the tank possibly being overfilled reduce the estimated leak probability to about 0.12 (about one chance in nine) that the observed in-tank and ex-tank data would be present if the tank were leaking.

The most likely cause of the gross gamma peak in the drywell was overfilling of the tank resulting in loss of waste through the spare inlet line.

The recommendation of the assessment team is that the integrity status of tank 241-C-110 be changed from “Assumed Leaker” to “Sound”.

The results of this assessment were presented to the Executive Safety Review Board on June 26, 2008. The Board concurred with the recommendation of the assessment team.

8.0 REFERENCES

Documents:

GJ-HN-92, "Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-110 Appendix A Spectral Gamma-Ray Logs for Boreholes in the Vicinity of Tank C-110," November, 1997 \\hanford\data\Sitedata\HLANPlan\Geophysical_Logs\index.html

HNF-3747 Rev. 0, "Tank leak Assessment Process: Technical Background," December 30, 1998

HW-20742, "Loss of Depleted Metal Waste Supernate to Soil," April 5, 1951 [D8513094]

RPP-8321 Rev. 0, "Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-C Tank Farm – 200 West Area, June, 2001," page 351, June, 2001 [D6875724]

RPP-ENV-33418 Rev. 1, "Hanford C-Farm Leak Assessments Report: 241-C-101, 241-C-110, 241-C-111, 241-C-105, and Unplanned Waste Releases," February 26, 2008

SD-WM-TI-356 Rev. 0, "Waste Storage Tank Status and Leak Detection Criteria, September 30, 1988" [D197006832]

Correspondence:

08-TPD-015, Letter, S. J. Olinger, US Department of Energy, Office of River Protection, to J. A. Hedges, State of Washington Department of Ecology, "Hanford C Farm Leak Assessments," April 9, 2008 [0804160133]

8901832B R1, Letter, R. J. Baumhardt, Westinghouse Hanford Company, to R. E. Gerton U.S. Department of Energy, Richland Operations Office, "Single-Shell Tank Leak Volumes," May 17, 1989

Meeting Minutes:

241-C-110 Leak Assessment Meeting #1, April 29, 2008

241-C-110 Leak Assessment Meeting #2, May 8, 2008

241-C-110 Leak Assessment Meeting #3, May 22, 2008

Drawings and Sketches:

Drawing H-W-72743 "Hanford Engineer Works - BLD.#241 75'0" Dia. Storage Tanks T-U-B & C Arrangement"

Drawing W-71387 "Hanford Engineer Works 75 Ft. Diam. Building No. 241 "T" "U" "B" "C" Concrete Details of Tanks"

Drawing W-74108 "Hanford Engineer Works Building No. 241-T-U-B & C Concrete Details of Pipe Supports"

APPENDIX A
TANK C-110 LEAK ASSESSMENT TEAM MEETING MINUTES

A1 C-110 LEAK ASSESSMENT TEAM MEETING #1 MINUTES

MEETING MINUTES Page 1 of 4

SUBJECT: 241-C-110 Leak Assessment Meeting #1

TO:	BUILDING			
Distribution	2750-E/B-225			
FROM:	**CHAIRMAN**			
DJ Washenfelder	Same			
DEPARTMENT-OPERATION-COMPONENT	**AREA**	**SHIFT**	**DATE OF MEETING**	**NUMBER ATTENDING**
Process Analysis/Technical Integration	200-E		04/29/08	007

Distribution:
DG Baide*
DA Barnes*
DW Brown*
JG Field
ME Johnson
LS Krogsrud*
PC Miller*

*Leak Assessment Team Members

Need for Leak Assessment:

There is no known formal leak assessment for tank C-110. The tank was classified as "Questionable Integrity" in 1976 following the 1974 discovery of contamination in the soil around newly-drilled drywell 30-10-09 adjacent to the tank. Recently published RPPENV-33418 Rev. 1, "Hanford C-Farm Leak Assessments Report: 241-C-101, 241-C-110, 241-C-111, 241-C-105, and Unplanned Waste Releases," February 26, 2008, suggests that there is an alternative explanation for the contamination measured in the drywell, and that the tank may not have leaked.

The process for investigating potential tank leaks is described in TFC-ENG-CHEM-D-42, "Tank Leak Assessment Process". The commitment for a formal leak assessment was made by reference in Letter 08-TPD-015, S. J. Olinger, Office of River Protection to J. A. Hedges, State of Washington Department of Ecology, "Hanford C Farm Leak Assessments," April 9, 2008.

Tank 241-C-110 Characteristics and Operating History:

Tank 241-C-110 (C-110) is a 530 kgal 75' diameter mild steel single-shell tank located at the west corner of the 16-tank C Tank Farm. The tank was placed in service in May, 1946, and continued to receive and store waste until early 1976 when the remaining supernatant was pumped to another C Farm tank. At that time, the tank was suspected of leaking and had been classified as a "Questionable Integrity" tank based on gross gamma soil contamination readings found at the 53' to 56' depth in drywell 30-10-09, about 15 feet below the tank's foundation. The contamination was detected in October, 1974, immediately after the drywell was drilled adjacent to the tank.

There is no indication that an Unusual Occurrence report was filed when C-110 was designated as a Questionable Integrity tank. A leak volume estimate was not made until 1989, when a 2 kgal volume was assigned based on the C-110 manual tape sensitivity of +/- 0.75" (Since there was no detectable surface level decrease, the loss could be no greater than ~2 kgal [0.75" x 2,750 gal/" = ~ 2 kgal].)(8901832B R1, Single-Shell Tank Leak Volumes, March 17, 1989). In 1984 the "Questionable Integrity" and "Confirmed Leaker" tank classifications were combined and changed to "Assumed Leaker"(8901832B R1).

When the soil contamination was detected, C-110 contained about 376 kgal of waste,

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including 165 kgal of supernatant. The liquid surface was being monitored with a manual tape, and showed no detectable decrease in level for the 1972 - mid-1975 period. By 1982 the gross gamma peak in the drywell had decayed to background at a half-life decay rate matching RuRh-106 (RPP-8321, 2001, Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-C Tank Farm - 200 West Area, page 351; and SD-WM-TI-356, Waste Storage Tank Status and Leak Detection Criteria, September 30, 1988). The presence of RuRh-106 with a half-life of 368 days suggests that the contamination might have been from relatively fresh waste (10 half-lives to complete decay is a rule-of-thumb.).

The tank has 4 side fill inlet nozzles: V-138, -139, and -140, are connected to the 241-C-153 Diversion Box. The 4th is a capped spare. Capping was accomplished in a variety of ways: friction fit, gasketed caps; plugged with wooden plugs; or plastic-bagged. The centerline of the inlet nozzles is at 17'-4", equivalent to ~ 547,500 gal of waste storage. A cascade overflow line to tank C-111 has a 16'-11.5" centerline, equal to ~535,000 gallons of waste storage.

Subsequent to the meeting Drawing W-74108 "Hanford Engineer Works Building No. 241-T-U-B & C Concrete Details of Pipe Supports" was reviewed to obtain the viaduct details. The drawing shows that the viaduct has a 4" high curb running along both edges. The curbing stops about 11'-10" from the tank wall. At about 9'-10" from the tank wall the viaduct surface steps down and the void space between the pipes and the viaduct surface is grouted. At this point the viaduct begins fanning out from 2'-8" wide to 7'-4" wide to support the spread placement of the fill lines through the tank wall. The concrete viaduct terminates 2" from the tank wall; the void space is filled with 2" asphalt-impregnated felt.

The inlet lines pass through the tank wall via a 4' long 4" Sch. 80 pipe sleeve. A 5" id cap shrouds the 4" sleeve at the entry point of the 3" line, and is welded to the 3" line, allowing the 3" line to float in the ~ 1/4" annular void space inside the sleeve. Before welding the cap, the void space between the 3" line and the 4" sleeve is packed with asbestos wick (Drawing H-W-72743 "Hanford Engineer Works - BLD.#241 75'0" Dia. Storage Tanks T-U-B & C Arrangement").

Drawing H-W-72743 also shows the detail for the spare inlet nozzle cover. The 4-3/4" ID x 4" cover is fit over the 4" pipe sleeve and not welded in place. The OD of 4" Sch. 80 pipe is 4-1/2", so the the clearance between the nozzle cover and the pipe sleeve would be about 1/8" all around. However, based on a 1951 investigation, the drawing may not represent actual as-built conditions. The 1951 field installation of some of the spare inlet nozzles on SSTs was conducted after waste had been discharged through a spare inlet from tank BX-102 (HW-20742, Loss of Depleted Metal Waste Supernate to Soil). This investigation of the covers on spare inlet nozzles revealed "... some have blanks which are welded tight, some have tapered wooden plugs driven in the spare nozzle covered by a cap and sealed with waterproofing, and some have caps covered with a waterproofing membrane and then sealed in cement" (HW-20742 page 5 item 2).

Another observation reported in HW-20742 page 4 (regarding tanks in BX and BY farms is "... The depth of liquid in these tanks is determined by subtracting the elevation of the bottom of the tank from the elevation of the flange on top of a tank riser, and then subtracting from this difference the distance from the flange to the liquid as measured by foot markers placed along the electrode wires. Some electrodes were calibrated to read the liquid depth directly - others were calibrated so that the reading must be subtracted from the overall height as explained in the foregoing. Considerable confusion exists as to the true elevation for the tank bottom and flanges on tank risers. Recent investigations of the elevations have shown that one of the bench marks is off by over a foot; that the S Division [200 Areas processing plants and tank farms] Manual, the blue prints, and the surveyors do not agree on the elevations; that some blue prints use the center of the tank bottom for the tank elevation whereas other places use the side of the tank bottom, which

MEETING MINUTES (Continued) | Page 3 of 4

could cause as much as [illegible] foot error; and that recent changes in elevations on the blue prints have not been recorded on the S Division records. Some direct reading electrodes were made according to the manual elevations and some were made according to the blue print elevations."

During the 1970 - 1972 period about 1.4 mgal of B Plant concentrator bottoms and IX waste were received and transferred through the tank, equivalent to several fills and empties. Available monthly and quarterly production records show the tank's liquid level at the end of each reporting period, which is not indicative of the maximum fill level the tank may have experienced during the period. An interior tank photo of the side fill inlet nozzles discovered after the meeting seems to show solidified material in the mouth of the spare inlet nozzle (Photo 8605264-4CN_[N2113041] C-110 Wall, Dome, Inlet Nozzles Aug 12 1986.jpg [Email: RE: C-110 Leak Assessment Briefing - Photo showing Beach line inside SST C-110]).

Tank C-110 did not see severe service based on the process history records that are available. It did not store high-heat waste. It is unlikely that it was exposed to repeated, rapid heating and cooling cycles, based on the wastes stored in the tank, although actual temperature records have not been located.

Discussions with the authors of RPP-ENV-33418 Rev. 1 indicate that waste stored in the tank did not meet current AC 5.16 Corrosion Mitigation Controls for the period May, 1946 - March, 1947, when the tank was used as part of a cascade for B Plant 1st Cycle Decontamination Waste with a pH of ~8 (Current AC 5.16 requirements are pH >/= 12).

Of the 12 100-Series C Farm tanks, three - C-101, C-110, and C-111 - are classified as Assumed or Confirmed Leakers.

Team Member Actions for July 10 Meeting:

1. Team: Based on discussions of tank's process and thermal history, integrity status of other C-100's, and information received from following actions, determine "Prior Probability" of a C-110 leak using the process described in HNF-3747 Section 2.4. Prior Probability is the probability that C-110 has leaked given only that is an SST and either a high-heat tank or not, but adjusted for the information such as the integrity status of similar C-100s.

2. ME Johnson: Find C-110 thermal history, possibly located in RHO-CD-1172. If available, forward to team members to assist with CHEM-D-42 procedure Prior Probability determination. Previous Federal Repository searches for temperature records have not been successful. Status: Search turned up no additional temperature records.

3. ME Johnson: Forward C-110 drawing list to DG Baide for familiarization and review. Status: List provided.

4. LS Krogsrud: Locate and review any in-tank photos and in-tank videos of the tank's interior surfaces. Update team members before meeting. Status: ME Johnson provided in-tank still photos showing tank dome and inlet and spare inlet nozzles.

5. DA Barnes: Review tank drywell historic data and provide evaluation to team members by next meeting.

References:

Briefings:

SST C-110 Integrity Assessment Review, ME Johnson, April 29, 2008

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MEETING MINUTES (Continued)	Page 4 of 4

Correspondence - Emails:

C-110 Leak Assessment Briefing - FeCN Waste Valve Box nearby drwell [sic] 30-10-02, April 29, 2008

Emailing: 87661-8CN_[N1957355] C-110 Wall, Dome, Outlet Nozzle Aug 17 1979, April 30, 2008

RE: C-110 Leak Assessment Briefing - Concrete Support Bridges for Pipinelines [sic] to Furst [sic] Tank in Cascade, April 29, 2008

RE: C-110 Leak Assessment Briefing - Concrete Support Bridges for Pipinelines [sic] to Furst [sic] Tank in Cascade, April 29, 2008 [additional photographs attached)

RE: C-110 Leak Assessment Briefing - 1st Cycle Decontamination Waste Analyses 1951, April 29, 2008

RE: C-110 Leak Assessment Briefing - Photo showing Beach line inside SST C-110, April 30, 2008

SST C-110 Leak Assessment Team, April 9, 2008

Correspondence - Letters:

08-TPD-015, Hanford C Farm Leak Assessments, April 9, 2008

8901832B R1, Single-Shell Tank Leak Volumes, March 17, 1989 [D3688064]

Documents:

HW-20742, Loss of Depleted Metal Waste Supernate to Soil, April 5, 1951 [D8513094]

RPP-8321, 2001, Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-C Tank Farm - 200 West Area, June, 2001, page 351 [D6875724]

RPP-ENV-33418 Rev. 1, Hanford C-Farm Leak Assessments Report: 241-C-101, 241-C-110, 241-C-111, 241-C-105, and Unplanned Waste Releases, February 26, 2008

SD-WM-TI-356 Rev. 0, Waste Storage Tank Status and Leak Detection Criteria, September 30, 1988 [D197006832]

Drawings:

Drawing H-W-72743 "Hanford Engineer Works - BLD.#241 75'0" Dia. Storage Tanks T-U-B & C Arrangement"

Drawing W-71387 "Hanford Engineer Works 75 Ft. Diam. Building No. 241 "T" "U" "B" "C" Concrete Details of Tanks"

Drawing W-74108 "Hanford Engineer Works Building No. 241-T-U-B & C Concrete Details of Pipe Supports"

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A2 C-110 LEAK ASSESSMENT TEAM MEETING #2 MINUTES

MEETING MINUTES Page 1 of 6

SUBJECT: 241-C-110 Leak Assessment Meeting #2

TO:	BUILDING			
Distribution	2750-E/B-225			
FROM:	CHAIRMAN			
DJ Washenfelder	Same			
DEPARTMENT-OPERATION-COMPONENT	AREA	SHIFT	DATE OF MEETING	NUMBER ATTENDING
Process Analysis/Technical Integration	200-E		05/08/08	005

Distribution:
DG Baide*'
DA Barnes*'
DW Brown*'
JG Field'
ME Johnson
LS Krogsrud*'
PC Miller*

*Leak Assessment Team Members
'Attendees

Need for Leak Assessment:

There is no known formal leak assessment for tank C-110. The tank was classified as "Questionable Integrity" in 1976 following the 1974 discovery of contamination in the soil around newly-drilled drywell 30-10-09 adjacent to the tank. Recently published RPPENV-33418 Rev. 1, "Hanford C-Farm Leak Assessments Report: 241-C-101, 241-C-110, 241-C-111, 241-C-105, and Unplanned Waste Releases," February 26, 2008, suggests that there is an alternative explanation for the contamination measured in the drywell, and that the tank may not have leaked.

The process for investigating potential tank leaks is described in TFC-ENG-CHEM-D-42, "Tank Leak Assessment Process". The commitment for a formal leak assessment was made by reference in Letter 08-TPD-015, S. J. Olinger, Office of River Protection to J. A. Hedges, State of Washington Department of Ecology, "Hanford C Farm Leak Assessments," April 9, 2008.

Tank 241-C-110 Characteristics and Operating History:

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There is no indication that an Unusual Occurrence report was filed when C-110 was designated as a Questionable Integrity tank. A leak volume estimate was not made until 1989, when a 2 kgal volume was assigned based on the C-110 manual tape sensitivity of +/- 0.75" (Since there was no detectable surface level decrease, the loss could be no greater than ~2 kgal [0.75" x 2,750 gal/" = ~ 2 kgal].)(8901832B R1, Single-Shell Tank Leak Volumes, March 17, 1989). In 1984 the "Questionable Integrity" and "Confirmed Leaker" tank classifications were combined and changed to "Assumed Leaker"(8901832B R1).

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MEETING MINUTES (Continued)	Page 2 of 6

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MEETING MINUTES (Continued) | Page 3 of 6

spread placement of the fill lines through the tank wall. The concrete viaduct terminates 2" from the tank wall; the void space is filled with 2" asphalt-impregnated felt.

The inlet lines pass through the tank wall via a 4' long 4" Sch. 80 pipe sleeve. A 5" id cap shrouds the 4" sleeve at the entry point of the 3" line, and is welded to the 3" line, allowing the 3" line to float in the ~ 1/4" annular void space inside the sleeve. Before welding the cap, the void space between the 3" line and the 4" sleeve is packed with asbestos wick (Drawing H-W-72743 "Hanford Engineer Works - BLD.#241 75'0" Dia. Storage Tanks T-U-B & C Arrangement").

Drawing H-W-72743 also shows the detail for the spare inlet nozzle cover. The 4-3/4" ID x 4" cover is fit over the 4" pipe sleeve and not welded in place. The OD of 4" Sch. 80 pipe is 4-1/2", so the the clearance between the nozzle cover and the pipe sleeve would be about 1/8" all around. However, based on a 1951 investigation, the drawing may not represent actual as-built conditions. The 1951 field installation of some of the spare inlet nozzles on SSTs was conducted after waste had been discharged through a spare inlet from tank BX-102 (HW-20742, Loss of Depleted Metal Waste Supernate to Soil). This investigation of the covers on spare inlet nozzles revealed "... some have blanks which are welded tight, some have tapered wooden plugs driven in the spare nozzle covered by a cap and sealed with waterproofing, and some have caps covered with a waterproofing membrane and then sealed in cement" (HW-20742 page 5 item 2).

Another observation reported in HW-20742 page 4 (regarding tanks in BX and BY farms is "... The depth of liquid in these tanks is determined by subtracting the elevation of the bottom of the tank from the elevation of the flange on top of a tank riser, and then subtracting from this difference the distance from the flange to the liquid as measured by foot markers placed along the electrode wires. Some electrodes were calibrated to read the liquid depth directly - others were calibrated so that the reading must be subtracted from the overall height as explained in the foregoing. Considerable confusion exists as to the true elevation for the tank bottom and flanges on tank risers. Recent investigations of the elevations have shown that one of the bench marks is off by over a foot; that the S Division [200 Areas processing plants and tank farms] Manual, the blue prints, and the surveyors do not agree on the elevations; that some blue prints use the center of the tank bottom for the tank elevation whereas other places use the side of the tank bottom, which could cause as much as [illegible] foot error; and that recent changes in elevations on the blue prints have not been recorded on the S Division records. Some direct reading electrodes were made according to the manual elevations and some were made according to the blue print elevations."

During the 1970 - 1972 period about 1.4 mgal of B Plant concentrator bottoms and IX waste were received and transferred through the tank, equivalent to several fills and empties. Available monthly and quarterly production records show the tank's liquid level at the end of each reporting period, which is not indicative of the maximum fill level the tank may have experienced during the period. An interior tank photo of the side fill inlet nozzles discovered after the meeting seems to show solidified material in the mouth of the spare inlet nozzle. The same photo shows that the reddish-color paint on the interior has been lost from above the inlet nozzles, which indicates the waste level inside this tank exceeded the height of the inlet nozzles. (Photo 8605264-4CN_[N2113041] C-110 Wall, Dome, Inlet Nozzles Aug 12 1986.jpg [Email: RE: C-110 Leak Assessment Briefing - Photo showing Beach line inside SST C-110]).

Tank C-110 did not see severe service based on the process history records that are available. It did not store high-heat waste. It is unlikely that it was exposed to repeated, rapid heating and cooling cycles, based on the wastes stored in the tank, although actual temperature records have not been located.

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MEETING MINUTES (Continued)	Page 4 of 6

Discussions with the authors of RPP-ENV-33418 Rev. 1 indicate that waste stored in the tank did not meet current AC 5.16 Corrosion Mitigation Controls for the period May, 1946 - March, 1947, when the tank was used as part of a cascade for B Plant 1st Cycle Decontamination Waste with a pH of ~8 (Current AC 5.16 requirements are pH >/= 12).

Of the 12 100-Series C Farm tanks, three - C-101, C-110, and C-111 - are classified as Assumed or Confirmed Leakers.

Leak - Non-Leak Hypothesis:

Leak Hypothesis: "A leak from tank 241-C-110 caused the elevated radiation reading in drywell 30-10-09."

Non-Leak Hypothesis: "An overflow from tank 241-C-110 via inlet or outlet line penetrations, a transfer line leak, or other unplanned release created the elevated radiation reading in drywell 30-10-09."

Team Member Actions for April 29th Meeting:

1. Team: Based on discussions of tank's process and thermal history, integrity status of other C-100's, and information received from following actions, determine "Prior Probability" of a C-110 leak using the process described in HNF-3747 Section 2.4. Prior Probability is the probability that C-110 has leaked given only that is an SST and either a high-heat tank or not, but adjusted for the information such as the integrity status of similar C-100s. Status: 2 of 5 writeups received

2. ME Johnson: Find C-110 thermal history, possibly located in RHO-CD-1172. If available, forward to team members to assist with CHEM-D-42 procedure Prior Probability determination. Previous Federal Repository searches for temperature records have not been successful. Status: Search turned up no additional temperature records.

3. ME Johnson: Forward C-110 drawing list to DG Baide for familiarization and review. Status: List provided.

4. LS Krogsrud: Locate and review any in-tank photos and in-tank videos of the tank's interior surfaces. Update team members before meeting. Status: ME Johnson provided in-tank still photos showing tank dome and inlet and spare inlet nozzles.

5. DA Barnes: Review tank drywell historic data and provide evaluation to team members by next meeting. Status: Completed.

Team Member Actions for May 8th Meeting:

1. DJ Washenfelder: Prepare HNF-3747 In-Tank, Ex-Tank, and Elicitation Forms and Formulas Templates.

2. DA Barnes (with MJ Rodgers): Identify which of the 67 leaking SSTs were categorized as "Assumed Leakers" solely by stable drywell readings.

3. Team: Review the tank C-110 chapter in RPP-ENV-334198 Rev. 1 and begin annotating the C-110 In-Tank and Ex-Tank templates so they can be reviewed at the next meeting.

References:

Briefings:

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MEETING MINUTES (Continued)	Page 5 of 6

SST C-110 Integrity Assessment Review, ME Johnson, April 29, 2008

Correspondence - Emails:

C-110 Leak Assessment Briefing - FeCN Waste Valve Box nearby drwell [sic] 30-10-02, April 29, 2008

Emailing: 87661-8CN_[N1957355] C-110 Wall, Dome, Outlet Nozzle Aug 17 1979, April 30, 2008

RE: C-110 Leak Assessment Briefing - Concrete Support Bridges for Pipinelines [sic] to Furst [sic] Tank in Cascade, April 29, 2008

RE: C-110 Leak Assessment Briefing - Concrete Support Bridges for Pipinelines [sic] to Furst [sic] Tank in Cascade, April 29, 2008 (additional photographs attached)

RE: C-110 Leak Assessment Briefing - 1st Cycle Decontamination Waste Analyses 1951, April 29, 2008

RE: C-110 Leak Assessment Briefing - Photo showing Beach line inside SST C-110, April 30, 2008

SST C-110 Leak Assessment Team, April 9, 2008

Correspondence - Letters:

08-TPD-015, Hanford C Farm Leak Assessments, April 9, 2008

8901832B R1, Single-Shell Tank Leak Volumes, March 17, 1989 [D3688064]

Documents:

GJ-HN-92 Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-110 Appendix A Spectral Gamma-Ray Logs for Boreholes in the Vicinity of Tank C-110, November, 1997 \\hanford\data\Sitedata\HLANPlan\Geophysical_Logs\index.html

HW-20742, Loss of Depleted Metal Waste Supernate to Soil, April 5, 1951 [D8513094]

RPP-8321, 2001, Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-C Tank Farm - 200 West Area, June, 2001, page 351 [D6875724]

RPP-ENV-33418 Rev. 1, Hanford C-Farm Leak Assessments Report: 241-C-101, 241-C-110, 241-C-111, 241-C-105, and Unplanned Waste Releases, February 26, 2008

SD-WM-TI-356 Rev. 0, Waste Storage Tank Status and Leak Detection Criteria, September 30, 1988 [D197006832]

Drawings:

Drawing H-W-72743 "Hanford Engineer Works - BLD.#241 75'0" Dia. Storage Tanks T-U-B & C Arrangement"

Drawing W-71387 "Hanford Engineer Works 75 Ft. Diam. Building No. 241 "T" "U" "B" "C" Concrete Details of Tanks"

Drawing W-74108 "Hanford Engineer Works Building No. 241-T-U-B & C Concrete Details of Pipe

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Supports"	

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A3 C-110 LEAK ASSESSMENT TEAM MEETING #3 MINUTES

MEETING MINUTES Page 1 of 2

SUBJECT: 241-C-110 Leak Assessment Meeting #3

TO: Distribution		BUILDING 2750-E/B-225		
FROM: DJ Washenfelder		CHAIRMAN Same		
DEPARTMENT-OPERATION-COMPONENT	AREA	SHIFT	DATE OF MEETING	NUMBER ATTENDING
Process Analysis/Technical Integration	200-E		05/22/08	004

Distribution:
DG Baide*'
DA Barnes*
DW Brown*
JG Field'
ME Johnson
LS Krogsrud*'
PC Miller*'

*Leak Assessment Team Members
'Attendees

The C-110 annotated HNF-3747 In-Tank, Ex-Tank, and Elicitation Forms and Formulas Templates were reviewed for errors and omissions, and marked up. The elicitation template - used to determine the odds and probability that a leaking tank (or a non-leaking tank) would exhibit the in-tank and ex-tank phenomena observed for the tank - has to be completed. The elicitations will probably be conducted as an individual interview with each assessment team member.

Team Member Actions for May 22nd Meeting:

1. DJ Washenfelder: Prepare HNF-3747 In-Tank, Ex-Tank, and Elicitation Forms and Formulas Templates.

2. DA Barnes (with MJ Rodgers): Identify which of the 67 leaking SSTs were categorized as "Assumed Leakers" solely by stable drywell readings. Status: Completed by Matt Rodgers, but some HNF-EP-0182 cited references were to vague to be used for the categorization. Additional work will be needed to populate the categories that include No Surface Level Measurement Change and No Drywell Measurement Change; and LOW ILL change but No Surface Level Measurement Change and No Drywell Measurement Change.

3. Team: Review the tank C-110 chapter in RPP-ENV-334198 Rev. 1 and begin annotating the C-110 In-Tank and Ex-Tank templates so they can be reviewed at the next meeting. Status: Template was annotated and provided to team members at the May 22 meeting.

References:

Briefings:

SST C-110 Integrity Assessment Review, ME Johnson, April 29, 2008

Correspondence - Emails:

C-110 Leak Assessment Briefing - FeCN Waste Valve Box nearby drwell [sic] 30-10-02, April 29, 2008

Emailing: 87661-8CN_[N1957355] C-110 Wall, Dome, Outlet Nozzle Aug 17 1979, April 30, 2008

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MEETING MINUTES (Continued)	Page 2 of 2

RE: C-110 Leak Assessment Briefing - Concrete Support Bridges for Pipinelines [sic] to Furst [sic] Tank in Cascade, April 29, 2008

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Drawing W-71387 "Hanford Engineer Works 75 Ft. Diam. Building No. 241 "T" "U" "B" "C" Concrete Details of Tanks"

Drawing W-74108 "Hanford Engineer Works Building No. 241-T-U-B & C Concrete Details of Pipe Supports"

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APPENDIX B
TANK C-110 LEAK ASSESSMENT TEAM EXPERT ELICITATION FORMS

B1. TABLE 2 IN TANK DATA

Tank 241-C-110 Leak Assessment In-Tank Data Form DRAFT 2008-05-22
(from HNF-3747, Rev. 0)

SURFACE LEVEL MEASUREMENTS (SLM)	Observation		
ENRAF			
Unexplained, repeatable drop>tolerance ENRAFs were not deployed at the time of the 1977 Questionable Integrity declaration. The declaration was based on a single hit in drywell 30-10-09 detected immediately after the drywell was drilled in 1974.	Yes	No	NA
Significant drop	Yes	No	NA
Significant trend change	Yes	No	NA
FIC			
Unexplained, repeatable drop>tolerance PCSACS records do not show FIC data during the period indicating that there was no FIC in use.	Yes	No	NA
Significant drop	Yes	No	NA
Significant trend change	Yes	No	NA
MANUAL GAUGE			
Unexplained, repeatable drop>tolerance Manual tape with an electrode was used for most tank liquid level measurements during this period, and was most likely being used to monitor the C-110 liquid level. The precision of the manual tape was accepted as $\pm$0.75 inches (see HW-51026, 1957, Page 4, Leak Detection - Underground Storage Tanks) corresponding to ~ 2062.5 gallons. When the soil contamination was detected, C-110 contained about 376 kgal of waste, including 165 kgal of supernatant. The liquid surface was being monitored with a manual tape, and showed no detectable decrease in level for the 1972 - mid-1975 period.	Yes	No	NA
Significant drop No surface level change was detected.	Yes	No	NA
Significant trend change Historical records do not identify a trend change.	Yes	No	NA

LIQUID OBSERVATION WELL (LOW) MEASUREMENTS	Observation		
Unexplained, repeatable drop>tolerance Tank was not equipped with an LOW.	Yes	No	NA
Significant drop	Yes	No	NA
Significant trend change	Yes	No	NA

CORROBORATING EVIDENCE	Corroborates SLM or LOW Data Given		
Thermocouple (Steve K. to provide)	Leak	Alt. Hypoth.	NA
Salt well screen	Leak	Alt. Hypoth.	NA

Tank 241-C-110 Leak Assessment In-Tank Data Form DRAFT 2008-05-22
(from HNF-3747, Rev. 0)

Tank was no equipped with a saltwell screen in 1974. A saltwell screen was installed in 1976 and the tank saltwell pumped between 1976 and 1979.			
Standard Hydrogen Monitoring System Tank was not equipped with a SHMS.	Leak	Alt. Hypoth.	NA
Photos/Videos At the time of the leak investigation, the tank contained ~ 165 kgal of supernatant. Although photos probably exist from the leak investigation time period, it is unlikely that the liquid surface would have provided any additional information about the tank's integrity. An interior tank photo of the side fill inlet nozzles seems to show solidified material in the mouth of the spare inlet nozzle (Photo 8605264-4CN_[N2113041] C-110 Wall, Dome, Inlet Nozzles Aug 12 1986.jpg [Email: RE: C-110 Leak Assessment Briefing - Photo showing Beach line inside SST C-110]). The same photo shows that the reddish-color paint on the interior has been lost from above the inlet lines, which indicates the waste level inside this tank exceeded the height of the inlet lines.	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 The liquid surface was being monitored with a manual tape, and showed no detectable decrease in level for the 1972 - mid-1975 period indicating there was no water intrusion from external sources.	Leak	Alt. Hypoth.	NA
Process history During the 1970 - 1972 period about 1.4 mgal of B Plant concentrator bottoms and IX waste were received and transferred through the tank, equivalent to several fills and empties. Available monthly and quarterly production records show the tank's liquid level at the end of each reporting period, which is not indicative of the maximum fill level the tank may have experienced during the period. Tank C-110 did not see severe service based on the process history records that are available. It did not store high-heat waste. It is unlikely that it was exposed to repeated, rapid heating and cooling cycles, based on the wastes stored in the tank, although actual temperature records have not been located. An observation reported in HW-20742 page 4 (regarding tanks in BX and BY farms is "... The depth of liquid in these tanks is determined by subtracting the elevation of the bottom of the tank from the elevation of the flange on top of a tank riser, and then subtracting from this difference the distance from the flange to the liquid as measured by foot markers placed along the electrode wires. Some electrodes were calibrated to read the liquid depth directly - others were calibrated so that the reading must be subtracted from the overall height as explained in the foregoing.	Leak	Alt. Hypoth.	NA

Tank 241-C-110 Leak Assessment In-Tank Data Form DRAFT 2008-05-22
(from HNF-3747, Rev. 0)

"Considerable confusion exists as to the true elevation for the tank bottom and flanges on tank risers. Recent investigations of the elevations have shown that one of the benchmarks is off by over a foot; that the S Division [200 Areas processing plants and tank farms] Manual, the blue prints, and the surveyors do not agree on the elevations; that some blue prints use the center of the tank bottom for the tank elevation whereas other places use the side of the tank bottom, which could cause as much as [illegible] foot error; and that recent changes in elevations on the blue prints have not been recorded on the S Division records. Some direct reading electrodes were made according to the manual elevations and some were made according to the blue print elevations."			
Occurrence reports The tank was classified as "Questionable Integrity" in 1976 following the 1974 discovery of contamination in the soil around newly-drilled drywell 30-10-09 adjacent to the tank. There is no indication that an Unusual Occurrence report was filed when C-110 was designated as a Questionable Integrity tank. A leak volume estimate was not made until 1989, when a 2 kgal volume was assigned based on the C-110 manual tape sensitivity of +/- 0.75"	Leak	Alt. Hypoth.	NA
Construction history	Leak	Alt. Hypoth.	NA
Gas Release Events	Leak	Alt. Hypoth.	NA
Equipment maintenance calibration	Leak	Alt. Hypoth.	NA
Waste characteristics Tank C-110 did not see severe service based on the process history records that are available. It did not store high-heat waste that might have reduced the tank's service life or contributed to accelerated loss of integrity. It is unlikely that it was exposed to repeated, rapid heating and cooling cycles, based on the wastes stored in the tank, although actual temperature records have not been located. Discussions with the authors of RPP-ENV-33418 Rev. 1 indicate that waste stored in the tank did not meet current AC 5.16 Corrosion Mitigation Controls for the period May, 1946 - March, 1947, when the tank was used as part of a cascade for B Plant 1st Cycle Decontamination Waste with a pH of ~8 (Current AC 5.16 requirements are pH >/= 12).	Leak	Alt. Hypoth.	NA
In-tank operations In February 1956, the TBP Plant supernatant waste was transferred from C-110 to 241-CR Vault for ferrocyanide scavenging of cesium and strontium (HW-41812, *Waste Status Summary; Separations Section, Separations - Projects and Personnel Development Sub-Section, February 29, 1956*, p 4). The scavenging was not conducted in the tank.	Leak	Alt. Hypoth.	NA
Other (specify) - Construction Features - Inlet Lines The tank has 4 side fill inlet lines: V-138, -139, and -140, are connected to the 241-C-153 Diversion Box. The 4th is a capped spare. Capping was accomplished in a variety of ways: friction fit, gasketed caps; plugged with wooden plugs; or plastic-bagged. The centerline of the inlet lines is at 17'-4", equivalent to ~ 547,500 gal of waste storage. The inlet lines pass through the tank wall via a 4' long 4" Sch. 80 pipe sleeve. A 5" id cap shrouds the 4" sleeve at the entry point of the 3" line, and is welded to the 3" line, allowing the 3" line to float in the ~ 1/4" annular void space inside the sleeve. Before welding the cap, the void space between the 3" line and the 4" sleeve is packed with asbestos wick (Drawing H-W-72743 "Hanford Engineer Works - BLD.#241 75'0" Dia. Storage Tanks T-U-B & C Arrangement").	Leak	Alt. Hypoth.	NA

B2 TABLE 3 EX-TANK DATA

Tank 241-C-110 Leak Assessment Ex-Tank Data Form DRAFT 2008-05-22
(from HNF-3747, Rev. 0)

SPECTRAL GAMMA LOGS (SGL)	Observation		
Radionuclides			
Man-made? Contamination was discovered in drywell 30-10-09 when it was first monitored in October 1974. Analysis of the decay rate for the period between 1975 and 1979 indicated the t1/2 was consistent with Ru-106.	Yes	No	NA
Multiple? Spectral gamma logging conducted in 1997 showed very low concentrations of Cs-137 in all of the drywells surrounding the tank. Because of the low concentrations, it was concluded that Cs-137 was not a tag for a C-110 leak.	Yes	No	NA
Distribution			
Peak at bottom of tank? Results of SGL scans of the drywells surrounding C-110 are documented in GJ-HAN-92, Vadose Zone Characterization project at the Hanford Tank Farms: Tank Summary Data Report for Tank C-110, November 1997 (\\hanford\data\Sitedata\HLANPlan\Geophysical_Logs\index.html): "Cs-137 contamination was detected in the upper portions of all the boreholes surrounding tank C-110. This near-surface contamination is probably the result of surface spills that migrated into the backfill material around the tank. "The Cs-137 contamination detected in borehole 30-10-02 from 44 to 63.5 ft and borehole 30-07-11 from 49 to 74.5 ft may be the result of a tank or pipeline leak that has migrated into the Hanford formation sediments beneath the tank. The contamination appears to be correlatable and continuous between the two boreholes. "The Cs-137, Co-60, and Eu-154 contamination detected in borehole 30-07-11 from 1 to 4 ft is probably from material remaining within the transfer line. Soil sampling was conducted around the tank. In addition, an investigation conducted in 1992 indicated that the contamination detected in the borehole at this depth was actually contained in an improperly designed salt-well transfer line. "Data collected from boreholes 30-00-24, 30-00-22, and 30-00-11 indicate Cs-137 contamination in the upper section of all these boreholes. Because these boreholes are located far from tank C-110, the contamination in these boreholes is probably not associated with leaks or spills from tank C-110. All three boreholes are located near diversion boxes and their associated piping. The contamination detected around these boreholes is probably associated with the diversion boxes, rather than tank C-110."	actual data		No or NA
Peak near surface? None of the Grand Junction SGL scans indicated high levels of Cs-137 near the drywells. Most hits were attributed to surface spills or transfer line leaks.	actual data		No or NA
Increased activity in between?	actual data		No or NA
Increased activity below tank? The Grand Junction report attributes contamination detected at or below the tank foundation in drywells 30-10-02 and 30-07-11 to a tank or pipeline leak that has migrated into the Hanford formation sediments beneath the tank.	actual data		No or NA
Activity across boreholes			
Multiple boreholes?	Yes	No	NA

Tank 241-C-110 Leak Assessment Ex-Tank Data Form DRAFT 2008-05-22
(from HNF-3747, Rev. 0)

	The Grand Junction report GJ-HAN-92 does not discuss activity across drywells. Other limited historical data were available in RPP-ENV-33418 Rev. 1.			

Activity over time

	Abrupt increase (bottom)?	Yes	No	NA
	By 1982 the gross gamma peak in the drywell had decayed to background at a half-life decay rate matching RuRh-106 (RPP-8321, 2001, Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-C Tank Farm – 200 West Area, page 351; and SD-WM-TI-356, Waste Storage Tank Status and Leak Detection Criteria, September 30, 1988). The presence of RuRh-106 with a half-life of 368 days suggests that the contamination might have been from relatively fresh waste (10 half-lives to complete decay is a rule-of-thumb.).			
	Abrupt increase (elsewhere)?	Yes	No	NA
	The Grand Junction report GJ-HAN-92 does not discuss activity across drywells. Other limited historical data were available in RPP-ENV-33418 Rev. 1. The hits show a steadily decreasing peak with time.			
	Gradual increase (bottom)?	Yes	No	NA
	The Grand Junction report GJ-HAN-92 does not discuss activity across drywells. Other limited historical data were available in RPP-ENV-33418 Rev. 1. The hits show a steadily decreasing peak with time.			
	Gradual increase (elsewhere)?	Yes	No	NA
	The Grand Junction report GJ-HAN-92 does not discuss activity across drywells. Other limited historical data were available in RPP-ENV-33418 Rev. 1. The hits show a steadily decreasing peak with time.			

Tank 241-C-110 Leak Assessment Ex-Tank Data Form DRAFT 2008-05-22
(from HNF-3747, Rev. 0)

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 Tank has no laterals.	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 The southwest corner of C farm has a run-on berm to prevent intrusive surface flooding; there are no other berms. There is a storm water runoff ditch located east of the tank farm to the depression between AN and C farms. These minimal features indicate that surface flooding has probably never been a problem for the tank farm.	Leak	Alt. Hypoth.	NA
Process history	Leak	Alt. Hypoth.	NA
Drywell drilling logs	Leak	Alt. Hypoth.	NA
Occurrence reports None associated with C-110 were identified in RPP-ENV-33418 Rev 1, *Hanford C-Farm Leak Assessments Report: 241-C-101, 241-C-110, 241-C-111, 241-C-105, and Unplanned Waste Releases*, February 2008.	Leak	Alt. Hypoth.	NA
Surface spills (P. Miller to provide)	Leak	Alt. Hypoth.	NA
Transfer line leaks In November 1952, the cascade overflow line from C-110 to C-111 was noted as being plugged. The tank on filling with TBP Plant waste failed to cascade to C-111 (HW-26486, Manufacturing Department Radiation Hazards Incident Investigation and HW-27627, Radiological Sciences Department Investigation Radiation Incident), but C-110 was not reported as being filled above the spare inlet nozzles. An estimated 5 gallons of waste was inadvertently discharged to the surface on November 26, 1952, when a pump was being installed in C-110 (HW-27627). The resulting ground and equipment contamination was reported as being removed. This pump was used to transfer waste from C-110 to C-111 since the cascade overflow line was plugged. A valve box used for transferring ferrocyanide-scavenged waste was positioned near drywell 30-10-02 The scavenged wastes still contained a small concentration of soluble Cs-137, Sr-90, and sometimes Co-60. Drawing H-2-2909; *Piping Arrangement and Details 1st Cycle Waste Scavenging 241-C Farm* locates this valve box at the 3-o'clock position. All piping and valve flanges were to be welded per notes on this drawing. However, leakage from these valves could have occurred.	Leak	Alt. Hypoth.	NA
Construction history	Leak	Alt. Hypoth.	NA

Tank 241-C-110 Leak Assessment Ex-Tank Data Form DRAFT 2008-05-22
(from HNF-3747, Rev. 0)

C-110 was constructed to the first-generation tank design and was designed for non-boiling waste with a temperature of less than 220 °F. The tank is 75 ft in diameter and has a capacity of 530,000 gallon (gal). Tanks C-110, -111, and -112 are part of a three-tank cascade. The tanks in the cascade series are arranged with each successive tank sited at an elevation 1 ft lower than the previous tank, creating a gradient allowing fluids to flow from one tank to another as they were filled.			

Equipment maintenance calibration	Leak	Alt. Hypoth.	NA

Waste characteristics	Leak	Alt. Hypoth.	NA

In-tank operations	Leak	Alt. Hypoth.	NA

Other (specify) - Construction Features - Concrete Pipe Supports	Leak	Alt. Hypoth.	NA
Drawing W-74108 "Hanford Engineer Works Building No. 241-T-U-B & C Concrete Details of Pipe Supports" was reviewed to obtain the concrete bridge viaduct details. The drawing shows that the viaduct has a 4" high curb running along both edges. The curbing stops about 11'-10" from the tank wall. At about 9'-10" from the tank wall the viaduct surface steps down and the void space between the inlet lines and the viaduct surface is grouted. At this point the viaduct begins fanning out from 2'-8" wide to 7'-4" wide to support the spread placement of the fill lines through the tank wall. The concrete viaduct terminates 2" from the tank wall; the void space is filled with 2" asphalt-impregnated felt.			

B3 TABLE 6 ELICITATION FORMS

Expert Opinion: D. G. Baide

Tank 241-C-110 Leak Assessment Elicitation Form and Formulas
(from HNF-3747, Rev. 0)

Elicitation Date: 6/10/2008

Elicitation from: DG Baide

Eliciation by: DA Barnes/DJ Washenfelder

Hypotheses:

Leaker: A leak from tank 241-C-110 caused the elevated radiation reading in drywell 30-10-09.

Non-Leaker: An overflow from tank 241-C-110 via inlet or outlet line penetrations, a transfer line leak, or other unplanned release created the elevated radiation reading in drywell 30-10-09.

Prior Probability - Part 1

True State L	True State NL	Likilhood Ratio L:NL
p(L)	p(NL)	Ω_0
0.20	0.80	0.25

Low heat tank with non-aggressive process history; only 2 C-100 leakers in farm in 1974 when drywell drilled.

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)
	0.40	0.60	0.67

MT elevation errors, repeated fills and empties could have resulted in an overflow.

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 intersititial 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|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|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.

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)	
	0.60	0.40	1.50	No delta in gross gamma peak, only decay so not an active source.

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

SGL scans don't show much - mostly evidence of surface spills

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 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)
	0.50	0.50	1.00

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 Likilhood Ratios

L(SLM)	L(LOW)	L(SLM|LOW)	L(LOW|SLM)
0.67	1.00	1.00	1.00

L(GGL)	L(SGL)	L(GGL|SGL)	L(SGL|GGL)
1.50	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?	

Expert Opinion: D. A. Barnes

Tank 241-C-110 Leak Assessment Elicitation Form and Formulas
(from HNF-3747, Rev. 0)

Elicitation Date: 6/6/2008

Elicitation from: DA Barnes

Eliciation by: DJ Washenfelder

Hypotheses:

Leaker: A leak from tank 241-C-110 caused the elevated radiation reading in drywell 30-10-09.

Non-Leaker: An overflow from tank 241-C-110 via inlet or outlet line penetrations, a transfer line leak, or other unplanned release created the elevated radiation reading in drywell 30-10-09.

Prior Probability - Part 1

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

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)
	0.20	0.80	0.25

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

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

<table>
<tr><td>Spectral Gamma Drywell Logs</td><td>p(SGL|L)
(if no SGL, enter NA here and in Parts 8 and 9)</td><td>p(SGL|NL)</td><td>L(SGL)</td></tr>
<tr><td></td><td>0.60</td><td>0.40</td><td>1.50</td></tr>
</table>

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

<table>
<tr><td>Gross Gamma Log - Spectral Gamma Log Interdependence</td><td>p(GGL|SGL,L)</td><td>p(GGL|SGL,NL)</td><td>L(GGL|SGL)</td></tr>
<tr><td></td><td>NA</td><td>NA</td><td>1.00</td></tr>
</table>

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

<table>
<tr><td>Spectral Gamma Log - Gross Gamma Log Interdependence</td><td>p(SGL|GGL,L)</td><td>p(SGL|GGL,NL)</td><td>L(SGL|GGL)</td></tr>
<tr><td></td><td>0.50</td><td>0.50</td><td>1.00</td></tr>
</table>

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

<table>
<tr><td>L(SLM)
0.25</td><td>L(LOW)
1.00</td><td>L(SLM|LOW)
1.00</td><td>L(LOW|SLM)
1.00</td></tr>
</table>

<table>
<tr><td>L(GGL)
0.43</td><td>L(SGL)
1.50</td><td>L(GGL|SGL)
1.00</td><td>L(SGL|GGL)
1.00</td></tr>
</table>

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

<table>
<tr><td>SLM & No LOW?</td><td>X</td></tr>
<tr><td>LOW & No SLM?</td><td></td></tr>
<tr><td>SLM & LOW; SLM most important?</td><td></td></tr>
</table>

SLM & LOW; LOW most important?

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?	X
GGL & SGL; SGL most important?	

Ex-Tank Liklihood Ratio		**L(SGL,GGL)**
		0.43

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(SGGL|SGL) x L(LSGL)

Combined Likelihood Ratio for Leak Hypothesis		**L(in,ex)**
		0.11

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
0.10	0.90	0.11

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)

Notes and Key:

Manual entries (Elicited probabilities)
Calculated entries

SLM: Surface Level Measurements
LOW: Liquid Observation Well
GGL: Gross Gamma Log
SGL: Spectral Gamma Log

For elicited probabilities, the ratio column is p(*|L)/p(*|NL).

Other calculations are as follows:
L(SLM,LOW) = L(SLM|LOW) x L(LOW) or L(LOW|SLM) x L(SLM)
L(SGL,GGL) = L(GGL|SGL) x L(SGL) or L(SGL|GGL) x L(GGL)
L(in,ex) = L(SLM,LOW) x L(SGL,GGL)
$\Omega_1 = L(in,ex) \times \Omega_0$
p(L|in,ex) = $\Omega_1/(\Omega_1+1)$

90

Expert Opinion: D. W. Brown

(from HNF-3747, Rev. 0)

Elicitation Date: 6/18/2008

Elicitation from: DW Brown

Eliciation by: DJ Washenfelder/DA Barnes

Hypotheses:

Leaker: A leak from tank 241-C-110 caused the elevated radiation reading in drywall 30-10-09.

Non-Leaker: An overflow from tank 241-C-110 via inlet or outlet line penetrations, a transfer line leak, or other unplanned release created the elevated radiation reading in drywall 30-10-09.

Prior Probability - Part 1

True State L	True State NL	Liklihood Ratio L:NL
p(L)	p(NL)	Ω_0
0.23	0.77	0.30

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)
	0.15	0.85	0.18

Should have seen a manual tape indication of a leak, especially over the 3 year period that the liquid surface level was monitored and stable.

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

<table>
<tr><td>Liquid Observation Well</td><td>p(LOW|L)
(if no LOW, enter NA here and in Parts 4 and 5)</td><td>p(LOW|NL)</td><td>L(LOW)</td></tr>
<tr><td></td><td>NA</td><td>NA</td><td>1.00</td></tr>
</table>

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

<table>
<tr><td>Surface Level Measurement - Liquid Observation Well Interdependence</td><td>p(SLM|LOW,L)
(if no LOW, enter NA)</td><td>p(SLM|LOW,NL)</td><td>L(SLM|LOW)</td></tr>
<tr><td></td><td>NA</td><td>NA</td><td>1.00</td></tr>
</table>

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

<table>
<tr><td>Liquid Observation Well - Surface Level Measurement Interdependence</td><td>p(LOW|SLM,L)
(if no SLM, enter NA)</td><td>p(LOW|SLM,NL)</td><td>L(LOW|SLM)</td></tr>
<tr><td></td><td>NA</td><td>NA</td><td>1.00</td></tr>
</table>

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 interstitial 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

<table>
<tr><td>Gross Gamma Drywell Logs</td><td>p(GGL|L)
(if no GGL, enter NA here and in Parts 8 and 9)</td><td>p(GGL|NL)</td><td>L(GGL)</td></tr>
<tr><td></td><td>0.40</td><td>0.60</td><td>0.67</td></tr>
</table>

The GGL reading is more indicative of an external leak or an overflow from the tank since it never increased after initial monitoring. The interior tank photo shows that the tank was probably filled above the inlet lines at some time. The loose-fitting cap on the spare inlet line would have allowed waste leak out.

The reported leak was small. If the drywell was not located in the leak plume path, or if the leak was too small to reach the drywell, then the GGL would be inconclusive.

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)
	0.40	0.60	0.67

The SGL was inconclusive for a tank leak.

If the drywell was in the wrong location, the SGL would not have detected the 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(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 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)
	0.60	0.40	1.50

The GGL is more informative than the SGL. The SGL and GGL scans are not inconsistent with each other.

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)
0.18	1.00	1.00	1.00

L(GGL)	L(SGL)	L(GGL|SGL)	L(SGL|GGL)
0.67	0.67	1.00	1.50

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

SLM & No LOW?	x
LOW & No SLM?	
SLM & LOW; SLM most important?	
SLM & LOW; LOW most important?	

In-Tank Liklihood Ratio		L(SLM,LOW)
		0.18

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)	

Expert Opinion: L. S. Krogsrud

Tank 241-C-110 Leak Assessment Elicitation Form and Formulas
(from HNF-3747, Rev. 0)

Elicitation Date: 6/10/2008

Elicitation from: LS Krogsrud

Elicitation by: DA Barnes/DJ Washenfelder

Hypotheses:

Leaker: A leak from tank 241-C-110 caused the elevated radiation reading in drywell 30-10-09.

Non-Leaker: An overflow from tank 241-C-110 via inlet or outlet line penetrations, a transfer line leak, or other unplanned release created the elevated radiation reading in drywell 30-10-09.

Prior Probability - Part 1

True State: L	True State: NL	Likelihood Ratio: L:NL
p(L)	p(NL)	Ω_0
0.30	0.70	0.43

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)	Based on MT behavior on liquid surface, would not suspect a leak.
	0.30	0.70	0.43	

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

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)
	0.60	0.40	1.50

The peak below tank foundation did not change; unlikely if the tank liner was leaking.

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)
	0.50	0.50	1.00

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|SGL,L)	p(GGL|SGL,NL)	L(GGL|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|GGL,L)	p(SGL|GGL,NL)	L(SGL|GGL)
	0.50	0.50	1.00

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 Likilhood Ratios

L(SLM)	L(LOW)	L(SLM|LOW)	L(LOW|SLM)
0.43	1.00	1.00	1.00

L(GGL)	L(SGL)	L(GGL|SGL)	L(SGL|GGL)
1.50	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 Likelihood Ratio		L(SLM,LOW)
		0.43

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 Likelihood Ratio		L(SGL,GGL)
		1.50

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)
		0.64

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
0.22	0.78	0.28

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)

Notes and Key:

Manual entries (Elicited probabilities)
Calculated entries

SLM: Surface Level Measurements
LOW: Liquid Observation Well
GGL: Gross Gamma Log
SGL: Spectral Gamma Log

For elicited probabilities, the ratio column is p(*|L)/p(*|NL).

Other calculations are as follows:
L(SLM,LOW) = L(SLM|LOW) x L(LOW) or L(LOW|SLM) x L(SLM)
L(SGL,GGL) = L(GGL|SGL) x L(SGL) or L(SGL|GGL) x L(GGL)
L(in,ex) = L(SLM,LOW) x L(SGL,GGL)
Ω_1= L(in,ex) x Ω_0
p(L|in,ex) = Ω1/(Ω1+1)

90

Expert Opinion: P. C. Miller

Tank 241-C-110 Leak Assessment Elicitation Form and Formulas
(from HNF-3747, Rev. 0)

Elicitation Date:	6/12/2008
Elicitation from:	PpC Miller
Eliciation by:	DJ Washenfelder/DA Barnes
Hypotheses:	
Leaker:	A leak from tank 241-C-110 caused the elevated radiation reading in drywall 30-10-09.
Non-Leaker:	An overflow from tank 241-C-110 via inlet or outlet line penetrations, a transfer line leak, or other unplanned release created the elevated radiation reading in drywall 30-10-09.

Prior Probability - Part 1

True State L	True State NL	Liklihood Ratio L:NL
p(L)	p(NL)	Ω_0
0.33	0.67	0.49

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)
	0.05	0.95	0.05

The manual tape was monitoring a liquid surface at the time of the 1974 drywell event. There was no detectable change in surface level measurement, so it is unlikely that the tank was leaking.

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 intersititial 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|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.

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.

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)
	0.50	0.50	1.00

The gross gamma peak in the 10-09 drywell decayed over time. If the tank was leaking and the drywell intercepted the plume, it is unlikely that the gamma peak would have behaved this way. However a plume from a leak could have missed all of the drywells. Probably not indicative of the tank leak status.

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)
	0.40	0.60	0.67

The radionuclides in drywell 10-09 were mostly naturally-occurring isotopes. If the drywell intercepted the plume, manmade isotopes would have been present.

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)
	0.75	0.25	3.00

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|GGL,L)	p(SGL|GGL,NL)	L(SGL|GGL)
	NA	NA	1.00

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)
0.05	1.00	1.00	1.00

L(GGL)	L(SGL)	L(GGL|SGL)	L(SGL|GGL)
1.00	0.67	3.00	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)
		0.05

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)	
GGL & SGL; SGL most important? (Mark Part 9 NA)	X

Ex-Tank Liklihood Ratio		L(SGL,GGL)
		2.00

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)
		0.11

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

Notes and Key:

Manual entries (Elicited probabilities)
Calculated entries

SLM: Surface Level Measurements
LOW: Liquid Observation Well
GGL: Gross Gamma Log
SGL: Spectral Gamma Log

For elicited probabilities, the ratio column is p(*|L)/p(*|NL).

Other calculations are as follows:
L(SLM,LOW) = L(SLM|LOW) x L(LOW) or L(LOW|SLM) x L(SLM)
L(SGL,GGL) = L(GGL|SGL) x L(SGL) or L(SGL|GGL) x L(GGL)
L(in,ex) = L(SLM,LOW) x L(SGL,GGL)
Ω_1 = L(in,ex) x Ω_0
p(L|in,ex) = $\Omega_1/(\Omega_1+1)$
p(NL|in,ex) = 1- p(L|in,ex)

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)

90

Expert Opinion: D. J. Washenfelder

Tank 241-C-110 Leak Assessment Elicitation Form and Formulas
(from HNF-3747, Rev. 0)

Elicitation Date: 6/6/2006

Elicitation from: DJ Washenfelder

Eliciation by: DJ Washenfelder/DA Barnes

Hypotheses:

Leaker: A leak from tank 241-C-110 caused the elevated radiation reading in drywall 30-10-09.

Non-Leaker: An overflow from tank 241-C-110 via inlet or outlet line penetrations, a transfer line leak, or other unplanned release created the elevated radiation reading in drywall 30-10-09.

Prior Probability - Part 1

True State L	True State NL	Liklihood Ratio L:NL
p(L)	p(NL)	Ω_0
0.20	0.80	0.25

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)
	0.05	0.95	0.05

When the soil contamination was detected, C-110 contained about 376 kgal of waste, including 165 kgal of supernatant. The liquid surface was being monitored with a manual tape, and showed no detectable decrease in level for the 1972 - mid-1975 period. The estimated loss was based on the ± 0.75-inch accuracy of the manual tape measuring a liquid surface, ~ 2,000 gallons loss, rather than any field leak measurement. The 2,000 gallon estimate was not made at the time the drywall 30-10-09 peak was discovered in 1974, but in 1989, 15 years later.

During the 1970 - 1972 period about 1.4 mgal of B Plant concentrator bottoms and IX waste were received and transferred through the tank, equivalent to several fills and empties. Available monthly and quarterly production records show the tank's liquid level at the end of each reporting period, which is not indicative of the maximum fill level the tank may have experienced during the period.

The tank has 4 side fill inlet lines: V-138, -139, and -140, are connected to the 241-C-153 Diversion Box. The 4th is a capped spare. Capping was accomplished in a variety of ways: friction fit, gasketed caps; plugged with wooden plugs; or plastic-bagged. The centerline of the inlet lines is at 17'-4", equivalent to ~547,500 gal of waste storage.

An interior tank photo of the side fill inlet nozzles seems to show solidified material in the mouth of the spare inlet nozzle (Photo 8605264-4CN_[N2113041] C-110 Wall, Dome, Inlet Nozzles Aug 12 1986.jpg [Email: RE: C-110 Leak Assessment Briefing - Photo showing Beach line inside SST C-110]). The same photo shows that the reddish-color paint on the interior has been lost from above the inlet lines, which indicates the waste level inside this tank exceeded the height of the inlet lines.

Drawing H-W-72743 shows the detail for the spare inlet line cover. The 4-3/4" ID x 4" cover is fit over the 4" pipe sleeve and not welded in place. The OD of 4" Sch. 80 pipe is 4-1/2", so the the clearance between the nozzle cover and the pipe sleeve would be about 1/8" all around. However, based on a 1951 investigat

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.

may not represent actual as-built conditions.

Drawing W-74108 "Hanford Engineer Works Building No. 241-T-U-B & C Concrete Details of Pipe Supports" shows that the concrete piping viaduct has a 4" high curb running along both edges. The curbing stops about 11'-10" from the tank wall. At about 9'-10" from the tank wall the viaduct surface steps down and the void space between the inlet lines and the viaduct surface is grouted. At this point the viaduct begins fanning out from 2'-8" wide to 7'-4" wide to support the spread placement of the fill lines through the tank wall. The concrete viaduct terminates 2" from the tank wall; the void space is filled with 2" asphalt-impregnated felt. If C-110 was overfilled as the interior photos suggest, and the waste leaked from the tank via the spare inlet line loose-fit cap, the material would have flowed over the sides of the uncurbed portion of the viaduct, and into the soil.

In November 1952, the cascade overflow line from C-110 to C-111 was noted as being plugged. The tank on filling with TBP Plant waste failed to cascade to C-111 (HW-26486, Manufacturing Department Radiation Hazards Incident Investigation and HW-27627, Radiological Sciences Department Investigation Radiation Incident), but C-110 was not reported as being filled above the spare inlet nozzles.

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|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 interstitial 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

<table>
<tr><td>Gross Gamma Drywell Logs</td><td>p(GGL|L)
(if no GGL, enter NA here and in Parts 8 and 9)</td><td>p(GGL|NL)</td><td>L(GGL)</td></tr>
<tr><td></td><td>0.40</td><td>0.60</td><td>0.67</td></tr>
</table>

Gross gamma soil contamination readings found at the 53' to 56' depth in drywell 30-10-09, about 15 feet below the tank's foundation. The contamination was detected in October, 1974, immediately after the drywell was drilled adjacent to the tank.

By 1982 the gross gamma peak in the drywell had decayed to background at a half-life decay rate matching RuRh-106 (RPP-8321, 2001, Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-C Tank Farm – 200 West Area, page 351; and SD-WM-TI-356, Waste Storage Tank Status and Leak Detection Criteria, September 30, 1988). The presence of RuRh-106 with a half-life of 368 days suggests that the contamination might have been from relatively fresh waste (10 half-lives to complete decay is a rule-of-thumb.).

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

<table>
<tr><td>Spectral Gamma Drywell Logs</td><td>p(SGL|L)
(if no SGL, enter NA here and in Parts 8 and 9)</td><td>p(SGL|NL)</td><td>L(SGL)</td></tr>
<tr><td></td><td>0.50</td><td>0.50</td><td>1.00</td></tr>
</table>

Results of SGL scans of the drywells surrounding C-110 are documented in GJ-HAN-92, Vadose Zone Characterization project at the Hanford Tank Farms: Tank Summary Data Report for Tank C-110, November 1997 (\\hanford\data\Sitedata\HLANPlan\Geophysical_Logs\index.html):

*Cs-137 contamination was detected in the upper portions of all the boreholes surrounding tank C-110. This near-surface contamination is probably the result of surface spills that migrated into the backfill material around the tank.

*The Cs-137 contamination detected in borehole 30-10-02 from 44 to 63.5 ft and borehole 30-07-11 from 49 to 74.5 ft may be the result of a tank or pipeline leak that has migrated into the Hanford formation sediments beneath the tank. The contamination appears to be correlatable and continuous between the two boreholes.

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

<table>
<tr><td>Gross Gamma Log - Spectral Gamma Log Interdependence</td><td>p(GGL|SGL,L)</td><td>p(GGL|SGL,NL)</td><td>L(GGL|SGL)</td></tr>
<tr><td></td><td>NA</td><td>NA</td><td>1.00</td></tr>
</table>

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

<table>
<tr><td>Spectral Gamma Log - Gross Gamma Log Interdependence</td><td>p(SGL|GGL,L)</td><td>p(SGL|GGL,NL)</td><td>L(SGL|GGL)</td></tr>
<tr><td></td><td>0.90</td><td>0.10</td><td>9.00</td></tr>
</table>

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

<table>
<tr><td>L(SLM)
0.05</td><td>L(LOW)
1.00</td><td>L(SLM|LOW)
1.00</td><td>L(LOW|SLM)
1.00</td></tr>
<tr><td>L(GGL)
0.67</td><td>L(SGL)
1.00</td><td>L(GGL|SGL)
1.00</td><td>L(SGL|GGL)
9.00</td></tr>
</table>

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

SLM & No LOW?	x
LOW & No SLM?	
SLM & LOW; SLM most important?	
SLM & LOW; LOW most important?	

In-Tank Liklihood Ratio		L(SLM,LOW)
		0.05

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)
		6.00

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)
		0.32

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
0.07	0.93	0.08

RPP-ENV-33418 Rev. 1 Hanford C-Farm leak Assessments Report: 241-C-101, 241-C-110, 241-C-111, 241-C-105, and Unplanned Releases, February, 2008, reevaluated the decision to declare C-110 an assumed leaker based on data that were not available when original leak assessment was performed in 1974. The new assessment was performed as a basis for selection of retrieval technology and to support eventual tank closure. The assessment concluded that, "The C-110 leak appears to be the result of a tank overflow 17 ft 4 in (208 in) above the tank bottom. As a worst case, the liquid level in SST was steady at 144 in from the tank center from 1971 to 1975, indicating that if there was a breach in the tank wall, it was above this level."

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)

Notes and Key:

Manual entries (Elicited probabilities)
Calculated entries

SLM: Surface Level Measurements
LOW: Liquid Observation Well
GGL: Gross Gamma Log
SGL: Spectral Gamma Log

For elicited probabilities, the ratio column is p(*|L)/p(*|NL).

Other calculations are as follows:
L(SLM,LOW) = L(SLM|LOW) x L(LOW) or L(LOW|SLM) x L(SLM)
L(SGL,GGL) = L(GGL|SGL) x L(SGL) or L(SGL|GGL) x L(GGL)
L(in,ex) = L(SLM,LOW) x L(SGL,GGL)
Ω_1 = L(in,ex) x Ω_0
p(L|in,ex) = $\Omega 1/(\Omega 1+1)$
p(NL|in,ex) = 1- p(L|in,ex)

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