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18. S. E. Kos <i>S. E. Kos</i> 5/10/95 Signature of EDT Date Originator	19. Authorized Representative Date for Receiving Organization	20. J. W. Fassett <i>J. W. Fassett</i> 5/11/95 Cognizant Manager Date	21. DOE APPROVAL (if required) Ctrl. No. N/A ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments
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Assessment of Vadose Zone Radionuclide Contamination Around Single Shell Tank 241-C-103

S. E. Kos

Westinghouse Hanford Company, Richland, WA 99352
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Abstract: Five (5) drywells surrounding single shell tank 241-C-103 were logged with the high-purity germanium logging system to investigate possible leakage of radioactive contamination from the tank. The investigation included integration of the drywell survey results with several other data sources. There is no conclusive evidence showing indications that the 241-C-103 tank has leaked.

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EXECUTIVE SUMMARY

The Westinghouse Hanford Company (WHC), Geophysics Group was requested to investigate a possible leak of radioactive contaminants from single-shell tank 241-C-103 (C-103) into the vadose zone around and below the tank. The investigation included conducting high-resolution, germanium gamma-ray surveys in the five drywells surrounding the tank, and integrating the survey results with several other data sources and reports. The additional information sources and reports included drywell surveillance logs, unusual occurrence reports, special tank studies, construction information, and personal interviews. The investigation identified some inconsistencies and several data gaps that prevented completion of the study as originally scheduled. Although the investigation is complete, remaining data gaps prevent a complete explanation of the subsurface conditions that raised concern. These data gaps should be addressed and resolved. However, the radioactivity concerns in drywells surrounding C-103 that led to questions about the integrity of the tank originated from other sources. This report will identify that Tank C-103 has not leaked.

The term "contamination" is used in this report to indicate that anthropogenic (synthetic) radionuclides are present in the subsurface, however low the concentration levels might be. This usage does not and is not intended to imply that the levels of concentration pose a hazard to the environment or to human health.

Metric measurements have not been used in this report. Conversions from inch/pound measurements to metric units are provided in Appendix A.

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TERMS

cps	counts per second
FIC	Food Instrument Corporation
GM	Geiger-Muller
GPR	Ground-penetrating radar
HPGe	high-purity germanium
MRAL-II	Mobile Radionuclide Analysis Laboratory
RLS	radionuclide logging system
SST	Single-shell tank
TD	total depth
TFPE	Tank Farm Plant Engineering
Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i>
TWRS	Tank Waste Remediation System
WHC	Westinghouse Hanford Company
WIDS	Waste Information Data System

1.0 INTRODUCTION

1.1 BACKGROUND

Single-shell tank (SST) 241-C-103 is located in the 241-C Tank Farm within the 200 East Area of the Hanford Site, as shown on the general location map in Figure 1. Tank C-103 contains high-level, mixed radioactive and hazardous waste from nuclear reactor fuel-rod processing. The distribution of synthetic radionuclides within the tank is unknown. Tank C-103 was proposed as a "leaker" in Brodeur (1993), which investigated possible liquid loss from adjacent tanks C-105 and C-106. The information examined by Brodeur raised questions about the integrity of tank C-103 and is discussed in detail below.

Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) Milestone M-05-13-T2 (Ecology et al. 1994) addressed concerns about possible liquid losses from tanks C-105 and C-106. Historical gross gamma logs of possible contamination, records of past releases, and unaccountable liquid level drops in tanks led to an investigation of those tanks. Spectral gamma-ray logs were acquired by the Geophysics Group in drywells around those tanks and historical data were investigated and integrated with the logs by Brodeur (1993). It was concluded that tanks C-105 and C-106 are not actively leaking. However, contamination anomalies associated with tanks C-103 and C-109 led to recommendations that C-103 be further investigated. Tanks C-105 and C-106 are adjacent to tank C-103 (Figure 2). Tank C-109 is classified as stabilized with essentially no pumpable liquids and therefore does not require immediate investigation. However, tank C-103 is classified as "sound" with 133,000 gallons of liquid.

The basis for designating tank C-103 as a possible leaker (Brodeur 1993) is three unexplained subsurface contamination zones. First, a contamination zone at 27 ft between tanks C-106 and C-103 was identified in the Westinghouse Hanford Company (WHC) Geophysics spectral gamma logs and tank farms gross gamma logs. The gamma-ray activity increases toward tank C-103 tank. Brodeur identified drywells 30-06-04 and 30-03-01 as having significant increases in contamination activities at 27 ft, and explained that contamination in these two drywells cannot be attributed to any of the following:

- Movement caused by the drilling technique
- The drywell acting as a conduit pathway for migration of contamination
- Redistribution of contamination from above the 27-ft interval.

Second, a zone of contamination at 50 ft is present in several drywells around tank C-103, and this depth is below the base of the tank. The highest concentration at 50 ft for tank C-103 occurs in drywell 30-03-01. Brodeur explained that the contamination at this depth cannot be caused by the migration of a surface leak or a near-surface pipeline. Finally, a zone of ⁶⁰Co contamination was identified by the spectral system under tanks C-105 and C-106 at a depth of approximately 80 ft. The drywell containing the highest gamma activity at 80 ft is 30-03-09, which is adjacent to tank C-103 and

Figure 1. General Location Map, C Tank Farm.

Figure 2. 241-C Tank Farm Drywell Locations.

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implicates C-103 as the source. These contamination intervals, at 27, 50, and 80 ft, were present on the oldest tank farms drywell logs available, and have not changed substantially since 1974. However an increase in activity at 80 ft was recorded from 1984 to 1986. In 1987 this increase created great concern that tank C-103 may be leaking. Brodeur concluded that it is unlikely that tank C-103 is actively leaking.

The concern that C-103 tank has leaked is serious and the inconsistencies identified by Brodeur are substantial. The decision reached by this investigation has substantial implications. Expeditious identification of a leaking tank is essential to minimize impact of contamination to the environment. Likewise, incorrectly classifying a sound tank as a leaker, forcing needless studies, special planning, and hasty pumping of the contents (with the possibility of additional spills), is expensive and affects cleanup of other high-priority areas at the Hanford Site.

This report consolidates and presents information available in other reports maintained in the tank farms files. Gaps of information beyond the data collection responsibilities of the tank farms organization have been identified and need resolution to properly evaluate the subsurface soils surrounding tank C-103, as well as other tanks in the C tank farm. Additional studies needed to resolve data gaps are primarily concerned with erroneous classification of the integrity of tanks, and monitoring the geologic interface underlying the C Farm tanks.

In February and March of 1994, WHC Geophysics logged the five drywells surrounding tank C-103 with the radionuclide logging system (RLS) high-purity germanium, spectral gamma-ray system (Figure 2). This report provides an assessment of those drywell survey data. Integration of the drywell survey logs with geologic descriptions, tank farms construction records, and unusual occurrence reports has permitted correlations of preferential pathways for contaminant migration to be established. Some drywell-to-drywell correlations can now be identified and confirmed by review of neutron-moisture borehole survey logs. The neutron-moisture detector operated by Tank Waste Remediation System (TWRS) is not characterized or calibrated, yet some consistent detector responses in the drywells are repeatable between annual surveys, and are consistent with the expected detector response patterns for increased moisture content.

1.2 APPROACH OF STUDY

The study objective was to investigate the vadose zone contaminants around tank C-103 and identify separate contaminant events and sources. Ideally, it should be possible to trace subsurface contamination to its source by incorporating historical data.

The study tasks were as follows.

- Acquire high-resolution, spectral gamma-ray surveys of the drywells surrounding tank C-103. Compare the surveys to construct a three-dimensional interpretation of subsurface conditions. Identify probable contamination events.

- Compare the spectral gamma-ray surveys with the tank farms drywell surveillance logs, and track contaminants to their introduction into the vadose zone and their movement in the subsurface.
- Compare the drywell survey results with geologic sample descriptions. Identify and confirm geologic strata that could influence vertical and horizontal movement of contaminants.
- Review special study reports, incident reports, construction information, and tank monitoring data to identify other relevant information, and shorten the investigation time.

The interpretations in the special study reports were examined for consistency with the data and geologic information. Some problems and inconsistencies were identified; they will be discussed throughout this report.

The investigators preparing this report examined the tank farms neutron surveillance logs with the optimism that some useful information could be gleaned from the data, however subjective those data may be. The tank farms neutron logs are not calibrated for absolute formation-moisture content and probably never will be able to support such a rigorous investigation. The radioactive source-and-detector design is optimized for detector count rate. Generally, this configuration is preferred for unsaturated and low-moisture situations where the probe is in a borehole whose diameter is nearly identical to the probe diameter. However, the detector response is compromised by formation matrix variations, hole rugosity, and rapid logging speed. Thus, precise moisture-content measurements cannot be achieved. However, the relative moisture contents that persist from year to year cannot be discounted and can be factored into the interpretation. Such intervals of higher moisture content have been identified in the tank farms neutron surveillance logs. Figure 3 shows the typical TWRS neutron log response for five annual surveys from 1981 to 1993. Note the increased count rate that indicates increased moisture at 38 and 89 ft.

1.3 GENERAL C-FARM CONSIDERATIONS

Tank C-103 is part of the waste storage system of the C tank farm. While interpreting data and information during this study, many possible sources and migration paths were considered. The sources considered included other tank farm facilities, old leaks, and uncertainties with the C tank farm piping and waste transfer systems.

Tank C-102 does not have any drywells associated with it. It is adjacent to tank C-103, and the two are connected via transport and cascade lines. Unfortunately no subsurface characterization information is available for the soils around this tank. Some significant uncertainties are associated with tank C-102. For example, liquid-level decreases measured in 1975 were difficult to interpret because satisfactory in-tank photographs were not obtainable. Tank C-102 was subsequently scheduled for salt well pumpout, and was removed from service and designated "not intended for reuse."

Figure 3. TWRS Neutron Logs.

The removal of tank C-109 from service in 1976 occurred under similar circumstances. Tanks C-105 and C-106 have been under intense investigation for many years. More information about these two tanks can be found in WHC-SD-EN-TI-185, Rev. 0 (Brodeur 1993).

2.0 HISTORICAL DATA AND DOCUMENT REVIEW

2.1 TANK CONSTRUCTION

Single-shell tank C-103 is an underground reinforced-concrete tank with a single liner of carbon steel. Tank C-103 is a 100-series tank design that has waste metals and first-cycle radioactive waste from the processing of uranium-bearing spent fuel rods. The tank is 75 ft in diameter and 18 ft high at the sides, with a domed top that reaches a maximum height of 30 ft in the center. Figure 4 illustrates the tank construction and layout and assembly of the cascade piping system. All 12 tanks in the C Farm were built in 1944 in an excavation that was approximately 40 ft deep. The top of the tank is buried under approximately 10 ft of cover material. The tanks were constructed in three phases within the excavation.

- Phase 1: All the C Farm tank bases were completed.
- Phase 2: Work proceeded on individual tanks, one at a time. The tank sides were constructed to the 18-ft level. The access hole for the cascade line that connects the tanks was part of that work. Backfill sediment was placed around the completed tank sides to the cascade-line level.
- Phase 3: The cascade line, support piping, and tank dome were completed. The excavation was closed with backfill sediments to a thickness of approximately 10 ft above the dome of the tank.

The waste storage system of the C tank farm is connected with hundreds of feet of piping crossing over and surrounding the tanks (Figure 5). Diversion boxes and pump pits throughout the system help regulate waste constituents. Tank C-103 is connected to tanks C-101 and C-102 by cascade lines. The flow through the cascade lines is from tank C-101 to C-102 to C-103. The cascade line enters tank C-103 15.6 ft above its base on the southwest side at a downward slope of 9 in. in 25 ft. The cascade lines allow materials and vapors to move among the three tanks. All the C Farm tanks are connected in this manner.

A unique connection on the northeast side of tank C-103 connects it to the 241-C-801 cesium loadout facility, which is part of the C tank farm network. Two French drains are associated with the facility. The Cesium Loadout Facility operated from 1962 to 1976, and is currently radioactively contaminated with an estimated of 30 Ci of beta-emitting radionuclides.

Figure 4. Tank Cross Section with Cascade Line Details.

Figure 5. Piping System Plan View, Top of Tank C-103.

Tank C-103 was an in-farm steering tank and was used as temporary storage before waste was diverted to other C farm tanks. Therefore, much of the waste in the C tank farm passed through tank C-103.

2.2 DRYWELL CONSTRUCTION

The drywells surrounding tank C-103 were constructed in 1974, 30 years after the C tank farm was built. Drilling samples were collected every 5 ft during well construction and examined by a geologist. The drilling logs for the five drywells investigated in this report have been correlated with the spectral gamma-ray surveys. They are graphically presented in Appendix A. The drilling logs are considered to be only approximate because the lithologic descriptions are for 5-ft intervals.

The drywells were constructed with a cable tool drilling rig that drove a "drive barrel" into the ground ahead of the casing. The drive barrel removed up to 3 ft of soil with each trip out of the hole. The casing was advanced by driving it down as the soil was removed. The casing has a "drive shoe" of hardened steel welded on the first joint to prevent collapsing or bending from gravel and rocks present in the subsurface. The drive shoe is at least 0.5 in. thick and is about 0.25 in. thicker than the casing. This difference in size aids in drilling by reducing the friction as the casing is pushed through the subsurface. However, voids between the casing and formation will result. Caving during well construction was not recorded on the drill logs.

Casing sections (joints) about 10 ft long are welded to the casing sticking out of the ground. The most efficient operation and maximum safety occurs when 10 ft of open hole is drilled ahead of the casing, and a new casing joint is welded on and driven into the ground 10 ft. This practice is strongly discouraged by staff responsible for characterizing the geologic strata because the unconsolidated Hanford formation can cave into the open hole without warning, creating excessive voids that will remain behind the casing when it is advanced. The void spaces behind the casing may provide a conduit along which contaminants can rapidly migrate vertically down toward the groundwater. Incidents of caving during well construction were not recorded.

Each drywell (borehole) in the tank farms is identified by two numbering systems. The first is a Hanford facility number, which in the C farm appears as "299-E27-xxx." The 299 indicates the 200 Areas, the E the East Area, the 27 the 'block' number in the area, and the last number is a borehole sequence number that starts at 1 and increases without limit. Water wells are assigned numbers 1 through 49, and vadose boreholes (drywells) begin at number 50. The Hanford number is the sequence number in which each borehole was drilled in the 'block'. An example is 299-E27-78.

The second drywell identification number is a tank farm drywell identification number. This number is based on the following three factors.

- The tank farm number (C farm is identified as 30)
- The tank number within the farm (C-103 is truncated to 03)

- The drywell location around the tank (positioned around the clock with 12 o'clock assigned to the north side of the tank).

The complete number would be 30-03-09.

2.3 C-103 TANK CONTENTS

The C farm tanks contain three general waste forms. They are sludge, salt cake, and liquid (Figure 6).

Sludge consists of the solids (hydrous metal oxides) precipitated from the neutralized acid wastes before transfer to the tank. The sludge is estimated to be about 50 percent liquid, which is not considered to be pumpable or drainable.

Salt cake is composed of crystals formed by evaporation, cooling, and/or settling of waste. The salt cake may rise above the liquids but generally extends into the liquids. The drainable liquid content of the salt cake is estimated to be 60 percent, while about 40 percent will be held in place by capillary forces. There is presently no salt cake in tank 103-C.

Liquids are present as supernate and interstitial liquid. Supernate (supernatant liquid) floats above the sludge and is computed from the volume difference between the measured liquid level and the measured average level of sludge in the tank. Interstitial liquid is the liquid that fills the pore space in the solids portion of the waste, both sludge and salt cake.

Estimating the character of the waste in the C-103 tank is difficult because it served as a steering tank for waste. This management technique means that numerous wastes streams have been intermingled with the contents of tank C-103. In addition, the waste in a tank is not uniform and varies from natural processes of settling, stratification, and segregation. Ventilation, isotope decay, and chemical transformation also affect the character of waste. The best way to track subsurface contamination to a leaking tank will be by characterizing the contents of a tank with the type of measurement that will be used in the vadose zone to study the situation (i.e., a spectral gamma-ray detector).

2.4 CHRONOLOGY OF EVENTS

Tank C-103 primarily supported the B Plant and Purex processes. The chronology of events associated with tank C-103 is reviewed and the events' conclusions are summarized to track the attitude of previous studies. An increase in the gamma activity from 1984 to 1986 in drywell 30-03-09 is the primary driver that prompted the investigation of the historic reports.

2.4.1 1979 Liquid Transfer

On July 30, 1979, the materials in tank C-103 were pumped into tank C-104, and a baseline of 67.4 in. was established. After the pumping, the tank contained approximately 175,000 gal of sludge, 25,000 gal of

Figure 6. Typical Single-Shell Tank and Surveillance Instrumentation.

supernate, and 14,000 gal of interstitial liquid. The liquid level in tank C-103 is monitored using a Food Instrument Corporation (FIC) automatic liquid gauge (Figure 6). The device consists of a conductivity probe connected to a calibrated steel tape, a tape reel housing, and a controller that automatically raises and lowers the probe. The leak detection criterion for tank C-103 is 0.5 in. below the baseline. A decrease greater than the detection criterion would result in a baseline change if sufficient justification exists, or an occurrence report if it is determined that the tank may be leaking.

2.4.2 1988 Liquid-Level Decrease

The FIC liquid levels increased by 0.65 in. to 68.1 in. from August 1979 to September 1981. A new baseline was then established at 68.1 in. The levels decreased over the following 6 years to 67.6 in. in March 1988 (see Figure 7). Sufficient justification of the decrease to change the baseline was not available, therefore an unusual occurrence report was issued (WHC-UO-88-034-TF-05, November 1988). The report addressed the decreasing FIC level and attributed the liquid-level decreases to natural breathing of the tank and its ventilation system. Regression analyses was performed on the liquid-level data from 1979 to 1988, and the results indicated that between August 1982 and August 1983 the liquid level began to decrease.

Changes in the drywell surveillance logs (especially for borehole 30-03-09) were occurring between 1983 when the liquid level began to decrease and 1988 when the 0.5-in. liquid-level action criterion was exceeded.

2.4.3 1987 Drywell Radiation Increase

In May 1987, an environmental protection deviation report (EPDR 87-10) addressed an increase in the radiation levels in drywell 30-03-09, as shown in Figure 8. The radiation profiles at a depth of approximately 80 ft had increased over the previous two years (1984 to 1986) both in width and activity, from 50 counts per second (cps) to 100 cps. The report attributed the activity increase to tank C-103 because of the well's close proximity to the tank (approximately 5 ft from the footing of the tank base). It was suspected that the tank had leaked because drywells 30-03-01 and 30-03-03 had shown the presence of contamination since first surveyed in 1974. However, redistribution of preexisting contamination was suggested. It was reported that the waste in tank C-103 contained about 40 $\mu\text{Ci/L}$ of ^{60}Co whereas the surrounding tanks, C-102, C-105, and C-106 contained negligible amounts of ^{60}Co . A review of the FIC liquid-level data for 1982 to 1987 indicated a stable level at approximately 68.0 in. with no evidence of leakage. Recommendations to assess the problem included in-tank photography, survey of the surrounding drywells with the moisture probe, FIC calibration and maintenance, and logging drywell 30-03-09 with Analytical Systems Laboratory's Mobile Radionuclide Analysis Laboratory (MRAL-II) logging system, a high-resolution germanium logging system.

The contamination at 80 ft in 30-03-09 is ^{60}Co only, while the contamination higher up in 30-03-09 and in 30-03-01 and 30-03-03 is ^{137}Cs only. The total segregation and no zone of coexistence is highly unusual and

Figure 7. C-103 Tank Liquid Level Measurements.

119405005.15

Figure 8. TWRS Gross Gamma-Ray Logs, Drywell 30-03-09, 1984-1986.

suggests two distinct and different sources. The misinterpretation in the EPDR report can be explained by an inadequate understanding of subsurface fluid migration conditions.

2.4.4 1987 Drywell Study

The drywell was surveyed with the MRAL-II logging system and the interpretation of the results were presented in WHC Internal Memo 65452-87-242 (Ulbricht 1987). Cobalt-60 was identified in the well at maximum activity at 79.5 ft. Cesium-137 was identified at maximum activity at 7.5 ft and 48.5 ft. Directional measurements were made in the ^{60}Co contamination zone and showed an approximate 20-percent increase in activity to the south-southeast. Vertical migration was dismissed because downward migration of the ^{60}Co would have been observed in the tank farm gross gamma log and no such movement was observed. Also, water would be the most likely mode of transport of the ^{60}Co , so moisture profiles between the upper contamination zones and the ^{60}Co zone should show elevated moisture profiles, but they remained low for the previous 6 years. It was determined that, most likely, some of the ^{60}Co contamination would have come from some horizontal source. Ulbricht further discussed the ^{60}Co contamination relative to elevated moisture levels in the soil surrounding the well at 80 ft. He suggested that the ^{60}Co may be in a moving stream of water and that the contamination originates near drywell 30-05-07. The gamma activity in drywell 30-05-07 is intense throughout its depth because of transfer line leakage of materials high in ^{60}Co . Ulbricht recommended additional MRAL-II logging in surrounding wells to confirm the presence of ^{60}Co .

The directional survey indicating an increase signal intensity of 20 percent to the south-southeast cannot be considered an absolute indication of the direction of contamination. Such a minor increase can be expected as a statistical variation that may exist in the soils just by natural inhomogeneity. Also, the presence of ^{60}Co in 30-05-07 is inferred and was not directly measured by the 1993 RLS survey. Drywell 30-05-07 is only 65 ft deep and the detector counting system was saturated from 34 ft to the maximum survey depth of 65 ft. As with all other high-activity intervals where excessive gamma-ray activity is encountered, the last detectable radionuclide is ^{137}Cs . Ulbricht (1987) inferred that ^{60}Co was traveling in a near-horizontal stream of water that passed through the C-105 cascade line leak plume. Note that three drywells are located between 30-05-07 and 30-03-09. These drywells (30-05-05, 30-05-04, and 30-05-03) were logged in 1993 by the RLS, and trace amounts of ^{60}Co were found in each at between 70 and 80 ft. However, the supposed leak of ^{60}Co from around 30-05-07 would have had to move past these three drywells without increasing any tank farm log above the background. A leak movement of more than 175 ft horizontally should have left a better trail.

2.4.5 1987 Subsurface Moisture Horizon

WHC Internal Memo 65261-87-128 (Stong 1987) described a moisture transport system from drywell 30-05-03 to 30-03-09 based on soil moisture profiles for these wells (the Tank Farm neutron surveillance logs were used for Stong's interpretation). The moisture profiles for several wells

surrounding tanks C-103, C-104, and C-105 show similar moisture profiles, but the tank farm gross gamma logs did not indicate contamination. Stong suggested that the contamination in drywell 30-03-09 may have been the result of leakage from an old transfer line in the vicinity of drywell 30-05-07 that flowed east-northeast along the moisture transport system. Recommendations proposed by Stong included investigating the moisture system to determine source and destination, and surveying additional drywells with the MRAL-II system to characterize the contamination.

RLS surveys conducted in 1993 confirm that each interval containing elevated moisture does contain trace amounts of ^{60}Co . Therefore a moisture transport system is present. However the areal extent is not confined to these three tanks.

2.4.6 1988 MRAL-II Surveys

Several wells between tanks C-103, C-105, and C-106 were logged with the MRAL-II system, and the observations were outlined in Internal Memo WHC-12221-ASL88-065 (Ulbricht 1988). Ulbricht concluded that the ^{60}Co contamination originated between tanks C-104 and C-105, an area that contains a transfer line into tank C-105 and a cascade line between tanks C-104 and C-105. Ulbricht described the ^{60}Co contamination as moving because the ^{60}Co activity was decreasing faster than it would through natural decay. Other leakages were not ruled out. Recommendations were made to log other drywells with MRAL-II because correlating gross gamma logs was unreliable for indicating the presence of ^{60}Co . The gamma activity at 80 ft in drywell 30-03-09 from a 1974 TWRS surveillance log is shown in Figure 8.

The decrease in count-rate activity from 1974 to 1979 was determined from TWRS surveillance logs, which confirmed that ^{60}Co is the only radionuclide isotope present. Laboratory studies with ^{106}Ru have demonstrated that it should be considered as mobile as ^{60}Co . If ^{106}Ru , which has a half-life of 1.02 years, were initially present in the waste, the decrease in gamma activity at the rate observed would be explained, and no detectable quantities of ^{106}Ru would have been present in 1987 for MRAL-II to identify. The 1988 report apparently did not consider a source from any other locations. Tank C-109 should have been investigated.

2.4.7 1988 Synopsis

A synopsis of the investigations into the source of the contamination at the 80-ft depth in drywell 30-03-09 was presented in WHC Internal Memo 13331-88-088 (Groth 1988). D. R. Groth, manager of Tank Process Engineering Unit, concluded that the findings indicated that the contamination is not the result of any leaking tanks in the C tank farm but were caused by leakage from an area between tanks C-104 and C-105, the transfer line into C-105, and the cascade line between C-104 and C-105. Operational events to support failure before August 1974 were cited for the piping system, thermal shock, and overfilling of tank C-105. Groth described the moisture transport system as a "sloping water lens" based on moisture profiles and geologic cross sections. Moisture sources were possible condensate leakage through cascade and fill-line tank-wall penetrations (old packing seals), and natural sources.

Recommendations included routine moisture probe surveys and development of moisture tools to quantitatively measure moisture levels. Groth stated that issues raised in EPDR 87-10 were investigated and resolved to meet Tank Farm Plant Engineering (TFPE) obligations.

No identifiable change in the conditions associated with Tank C-105 between 1974 and 1984 were given. All implications of changes before 1984 for Tank C-105 and the piping-system failure are speculative.

2.5 TANK C-103 LIQUID LEVEL MEASUREMENTS

As discussed earlier, no significant information was derived from the drywell surveys to determine if tank C-103 was leaking. FIC liquid levels continued to decrease since the issuance of WHC-UO-88-TF-05 in November 1988. The trend of decreasing levels was closely monitored and the liquid loss was attributed to evaporation by exhauster operation on the tank. However, losses were also observed for periods when the exhauster was shut down. The baseline was reestablished in January 1990 after the liquid level was significantly decreased by operation of the exhauster for two months ending December 27, 1989. However, the liquid level continued to decrease at rates higher than occurred before November 1989. The SST stabilization engineer revised the statistics for tank C-103 waste in October 1990, resulting in a 5,000-gal decrease in total waste from 200 Kgal to 195 Kgal. In January 1991, the tank met the leak detection criterion again at 0.5 in. below the baseline. This decrease coincided with a modification to the tank ventilation system. The evaporation modelling process used to evaluate liquid loss from tank C-103 produced results consistent with the observed FIC levels.

The model used for the evaluation was based on water only, and did not take into account the organic layer covering the water in tank C-103. Also, when the total waste quantity was revised in October 1990, the liquid level baseline was not reestablished.

In April 1991, water and organics were added to tank C-103 during a pressure test of piping systems. The liquid-level baseline was reestablished at that time, and liquid-level decreases continued at a rate of about 0.8 in. per year. The details of the liquid-level decrease evaluation are provided in WHC-SD-WM-ER-145 (Claybrook 1992). The model developed for tank C-103 predicted a liquid-level drop from evaporation consistent with the measured FIC liquid level. The model was adjusted to compensate for the organic layer in the tank. It was suggested in WHC-SD-ER-145 that by sealing tanks C-101, C-102, and C-103 (except the filter system), the evaporation rate in C-103 would be reduced, and therefore the vapor problems for tank farm workers would be reduced. Also, it was estimated that the evaporation rate for C-103 would decrease to less than 0.1 in./yr. A plot of the liquid level data is presented in Figure 7.

2.6 HAZARDOUS VAPORS FROM TANK C-103

In January 1988, the waste in tank C-103 was identified as a potential health hazard to tank farm workers. Two workers experienced respiratory problems after exposure to irritating vapors while working on equipment

installed on the tank. Characterization of the vapor in C-103 began immediately. Ammonia, acid gases, and volatile organics were identified in the vapor-space samples. The details of the analyses were presented in WHC Internal Memo 13331-88-018 (Carothers 1988).

The organic vapor was analyzed in 1992 and was found to contain normal paraffin hydrocarbon, a potentially flammable material. In two separate events in September 1991, workers were exposed to vapors in the C tank farm. Occurrence Report RL-WHC-Tankfarm-1992-0069 addresses the floating organic layer in tank C-103 as an unreviewed safety question.

2.7 241-C-801 CESIUM LOADOUT FACILITY

Gamma-ray survey logs for drywells around C-103 and other tanks record contamination from the surface to several feet into the vadose zone. The amount of surface contamination and depth of penetration is greater around C-103 than the other tanks. The implication is that a surface spill occurred in the vicinity of tank C-103. During review of drawings of the C tank farm, a facility unique to the C-103 tank was identified. The facility is 241-C-801 and is generally identified as the Cesium Loadout Facility. The facility includes a building, piping from the building to tank C-103, and an access pit at the tank. The piping from the tank to the building runs between drywells 30-03-01 and 30-03-03. These drywells have the highest concentration of contamination from the surface, contamination that penetrated to the base of the tank and beyond. The details of the piping-system connections at tank C-103 and proximity to the drywells is depicted in Figure 9.

An unplanned release in the vicinity of the Cesium Loadout Facility was identified in the *Handbook 200 Areas Waste Sites* (RHO 1979). According to the map in the report (UN-216-E-11), the release was located in an area of high levels of cesium surface contamination, on the north side of tank C-103. However, the report of the unplanned release describes animal droppings in the B-C crib area, south of the Baltimore Street entrance to the 200 East Area. This inconsistency between the map and descriptive text needs to be resolved. Identifying and correcting problems in RHO (1979) is beyond the scope of this study.

A contribution by the Cesium Loadout Facility to the surface contamination remains a possibility, although at the time of this study, a leak in the piping system of the facility has not been identified. The Waste Information Data System (WIDS) was interrogated to identify unplanned releases around tank C-103, however none were identified.

The date and cause of the surface contamination release in the C farm remain unknown. The contamination was recorded on the first drywell logs acquired after the wells were completed in 1974. Therefore, the release occurred before 1974. The log surveys since 1974 have not identified any downward movement of the contamination greater than the depth resolution capabilities of the TWRS surveillance system.

Figure 9. C-103 Tank/241-C 801 Piping System.

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2.8 GEOLOGY OF THE C-TANK FARM

Lithologic data for the five drywells surrounding tank C-103 were compiled during the drilling of the wells. Samples were collected over 1- to 5-ft intervals and were analyzed for grain size and distribution, as well as for percentage of calcium carbonate. The lithologic logs provided in Appendix B are graphical presentations of the information reported on the driller's logs. Copies of the driller's logs are on file in the Geosciences Resource Center.

Lithologic data from well construction reports were also plotted along with synthetic and natural gamma-ray-emitting radionuclide concentrations from RLS spectral gamma-ray surveys performed in 1994.

2.8.1 Geology from Drywell Construction in 1976

Price and Fecht (1976) described the sediments underlying the C tank farm. In their report, lithologic data collected during the drilling of the 26 unsaturated-zone monitoring drywells and two groundwater monitoring wells were compiled and reviewed. Samples of the sediments were analyzed for grain size and distribution and calcium carbonate content. The data were used to classify the sediments and create cross sections through the C tank farm. Cross sections, from Price and Fecht, through tank C-103 are included in Figures 10, 11, 12, and 13. The cross sections indicate that the sediments underlying tank C-103 are mainly sand with minor amounts of silt and gravel. The sediments at the base of the tank are slightly silty coarse sand to coarse sand.

The C tank farm is underlain by three major stratigraphic units. The Columbia River Group basalt is the bedrock beneath the C tank farm, and lies approximately 280 ft below the surface. The Ringold Formation is layer of unconsolidated sediments and semicemented gravels approximately 80 ft thick directly overlying the basalt. The glacio-fluvial sediments of the Hanford formation are unconsolidated gravels, sands, and silts that lie on top of the Ringold and continue to the surface at a thickness of 200 ft. The depth to the unconfined groundwater under the C farm is approximately 250 ft.

The Hanford formation sediments were deposited by cataclysmic flood waters that drained out of glacial Lake Missoula on several occasions (Fecht et al. 1987, Doe 1988, and Baker et al. 1991). The sediments are of particular interest in assessing leaks because variations in grain size and texture have been shown to control the migration of leaked contaminants.

2.8.2 Geology from Monitor Well Construction in 1989

Caggiano and Goodwin (1991) integrated the data from Price and Fecht (1976) with the lithologic data collected during the drilling of monitor wells adjacent to the C tank farm. Selected cross sections of sediments under the C farm are presented in Figures 14, 15, and 16. Caggiano and Goodwin (1991) indicate that the sediments are mainly sandy gravel to gravelly sand.

Figure 10. Cross Section Index.

Figure 11. Geologic Cross Section A-A' (after Price and Fecht 1976).

Figure 12. Geologic Cross Section B-B' (after Price and Fecht 1976).

The Hanford formation was investigated in detail by Lindsey (1992). It was divided into three facies (gravel dominated, sand dominated, and silt dominated) based on texture and lithology. These facies represent three energy levels of the depositing flood waters.

- The gravel-dominated facies were deposited in or immediately adjacent to the main flood channel in the high-energy region of the floodwaters.
- The sand-dominated facies were deposited adjacent to the main channel or where floodwaters spilled out of the main channel. The sand-dominated facies may also represent periods of decreased flooding.
- The silt-dominated facies were deposited in a backwater, low-energy environment.

Observation of the distribution of these facies throughout the 200 East study area led to the division of the Hanford formation into the lower gravel, sand, and upper gravel sequences. The contacts between the sequences are often difficult to distinguish and lateral correlations are problematic. The difficulty occurs because flooding rivers can quickly remove earlier deposits and deposits within their channels may not be continuous or cover large areas.

The moisture interface has been identified at about 80 ft in several drywells in C farm by the presence of ^{60}Co and by TWRS moisture surveys. The interface has not been studied in sufficient detail to be adequately described at this time. The drilling samples alone were not sufficient to completely describe it or determine its extent. Additional review by Lindsey is scheduled. The importance of the fine-grained moisture interface in the effort to quickly identify tank leaks and to monitor contaminant movement will be examined and explained at that time.

2.8.3 Geology from Tank Farm Construction

During construction of the tank farm, the Hanford sediments were excavated to a depth of approximately 40 ft. The sand, silt, and gravel sediments were not segregated during excavation and were used as backfill around and over the completed tanks. During the construction of the tank bases the excavation was exposed to heavy traffic, construction processes (e.g., concrete placement), and the elements (rain, wind, and snow). These activities could have created a compacted, localized interface that cause vertically migrating fluids to spread horizontally.

On completion of the tank bases and sides, the excavation was backfilled to approximately the level of the cascade line connection. The cascade lines are approximately 15 ft above the base. To construct the cascade lines the backfill would have been placed below this depth at approximately 27 ft (40 minus 13). Construction of the tank top, piping, and diversion box structures was then completed. This second construction level would have likely created an interface as described above. After construction of the tank top, the excavation was backfilled to grade (ground surface). The backfill over the dome of the tanks is from 6 to 9 ft thick.

Figure 14. Cross Section Index.

WHC:JJA:200EAST:241-C

Figure 15. Geologic Cross Section G-G' (after Caggiano and Goodwin 1991).

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Figure 16. Geologic Cross Section H-H' (after Caggiano and Goodwin 1991).

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The backfill materials around and over the tanks were placed according to engineering practices to prevent subsidence as natural compaction occurred, and to support the tank walls. Ground-penetrating radar (GPR) surveys conducted by WHC Geophysics around the tanks to identify locations for placing electrical grounding rods revealed that the backfill material has uniform layers of highly reflective interfaces. This layering from differential compaction that developed in the backfill could affect the downward movement of materials throughout the subsurface. The GPR uses an electro-magnetic wave to detect materials in the subsurface with contrasting dielectric properties. Moisture and soil compaction that would result from earth-moving machinery and repeated watering do create changes in dielectric properties.

2.9 REVIEW OF TANK FARM SURVEILLANCE GROSS GAMMA-RAY LOGS

The subsurface logging vans used for leak detection surveillance within the tank farms have operated since 1979 with no significant modifications. Until this date, drywell gamma-ray logs were acquired from less sophisticated equipment mounted in the back of a pick-up truck. Until 1994 the primary purpose of drywell surveillance was leak detection or detection of significant changes in the subsurface.

The gamma-ray equipment responds to all gamma-ray events (referred to as gross gamma) and cannot identify the energy levels of the gamma rays. Thus, gross gamma detection systems also are not capable of identifying individual radionuclides, or even the primary radionuclide present.

The response time of all pulse-counting systems is generally engineered to be short relative to the rate at which pulses may occur. This processing time is the "dead-time" of the equipment. Unfortunately, at the Hanford Site the dead-time must be considered when processing the gamma rays captured by the detector. The dead-time correction to the TWRS borehole equipment has not been evaluated to the satisfaction of WHC Geophysics. Fortunately, the gamma-ray activity observed in the drywells around tank C-103 are low enough to not require significant dead-time corrections.

Two types of gamma-ray detectors are used at TWRS to monitor the subsurface. The most sensitive is a sodium-iodide crystal doped with thallium, NaI(Tl). The NaI(Tl) detector used by TWRS has a 1-in. diameter and is 1 in. long. The small size of the detector generally reduces the potential for damage from routine handling, but care must still be taken to prevent cracking or clouding, which can severely degrade performance. This is the most frequently used detector for drywell surveillance. The detector count-rate response to the natural radionuclides in the Hanford formation is about 25 cps, or one sixth the count rate observed by the RLS germanium detector. The TWRS NaI(Tl) detector response to 90 pCi/g of ¹³⁷Cs in the soils records about 200 cps. The TWRS NaI(Tl) probe may be shielded with a high-density metal shell to permit its operation in drywells with greater gamma-ray radiation.

The second type of detector used at TWRS is Geiger-Muller (GM) tubes. The GM tubes selected for drywell surveillance are less sensitive than the NaI(Tl) detector. Two GM tube sizes have been selected. The larger, higher sensitivity tube identified as GM-Green is about one-tenth as sensitive as the

NaI(Tl) detector. The smaller, least sensitive tube is identified as GM-Red and is the second most frequently used probe.

The TWRS sensors are calibrated for the detector only in a field of ionizing radiation from a point source. The truck electronics are not used in the calibration process. Corrections for gamma-ray attenuation from the casing(s) between the detector and formation have not been determined. Therefore, the equipment is not calibrated under the conditions in which it is operated and the calibration cannot be traced to national standards. The annual calibration is inappropriate for its intended purpose, but it can be used to demonstrate that the detector is performing in a consistent fashion to two ionizing radiation fields.

The drywell surveillance vans are computer controlled. The most critical tasks of the equipment operator are to position the probe above a drywell and enter the hole number and probe type into the computer. The computer retrieves the maximum log depth from an internal table. The computer program controls the cable winch and weight sensors. It lowers the probe to the ground surface or cement collar around the casing to establish the zero reference for depth measurements. The computer then lowers the probe into the drywell to the predetermined depth and begins recording the detector count rate at 1-ft intervals as the probe is withdrawn from the hole at a rate of 45 ft/min. This logging speed and the overhead of the computer processing time permit about 1-second counting intervals to be recorded. The computer stops recording detector activity before the probe reaches the zero-depth reference. Because the objective of drywell surveillance is to detect tank leaks, the loss of data from the first several feet down the drywell is not a major concern.

The uncertainty of such short measuring times for natural radionuclides, whose decay activity is about 25 cps, is 10 cps at the two sigma (95%) confidence interval and 15 cps at three sigma. Thus, the apparently poor quality of the TWRS logs is the result of the small detector size, fast logging speed, and long sample distance. The most recent TWRS gross gamma-ray logs are provided in Appendix C.

2.10 REVIEW OF NEUTRON-NEUTRON LOGS

The neutron-neutron drywell logs run by TWRS are acquired by the same surveillance vans used to record gamma-ray activity. Only one type of neutron probe is used for the drywell surveillance. The probe is constructed to receive a chemical source that constantly emits high-energy epithermal neutrons. The probe is equipped with a thermal neutron detector that is positioned as close as possible to the source, i.e., zero spacing. The detector position was selected to optimize the count rate with no consideration for other factors that influence the quality of the measurement. High-energy epithermal neutrons must lose a majority of their energy to be counted by the detector.

A cloud of epithermal and thermal neutrons constantly surrounds the source. The size of the cloud and average number of neutrons at any distance away from the source will vary depending on the materials with which the neutrons interact. Neutrons lose the most energy in the transition from

epithermal to thermal from collisions with elements having nearly the same mass as they do (i.e., hydrogen). Thus, the maximum radius of the epithermal neutron cloud is controlled more by the hydrogen (water or liquids) in the formation than any other element or component. Once the neutrons are slowed to thermal-energy levels, the cloud distribution and density as a function of distance from the detector is controlled by elements that are more likely to capture the thermal neutrons. The thermal neutron capture cross sections of all elements have been extensively studied and are well known. Common elements such as chlorine, iron, and potassium have larger capture cross sections than soils (silicon, carbon, oxygen, and hydrogen) and will influence the neutron cloud density. Less common elements such as boron, cadmium, gadolinium, europium, rhodium, and cobalt may have such high thermal neutron capture cross sections that even small amounts can severely influence the cloud density. Therefore, the transformation of a thermal detector count rate to formation moisture content is not a linear or simple arithmetic function.

These problems and the variations of probe position relative to the drywell wall, voids behind the casing, and homogeneity of the formation materials prevent accurate calibration of the TWRS neutron probe for formation moisture content. However, some general detector response characteristics exist. Given the extremely short source-detector spacing, the detector response will increase as hydrogen content increases.

3.0 SPECTRAL LOG MEASUREMENTS

3.1 RLS SYSTEM DESCRIPTION

The WHC RLS uses a high-purity germanium (HPGe) passive gamma-ray detector. Gamma-ray interactions with the HPGe crystal yield very sharp charge pulses corresponding to energies of the impinging gamma-ray, resulting in excellent energy resolution. Precise energy resolution permits absolute identification of the gamma-emitting radionuclides and, with proper calibration, an accurate assay of their decay activities.

The HPGe detector is housed in the logging tool along with the high-voltage power supply, preamplifiers, and a cryogenic system used to maintain the detector at liquid-nitrogen temperatures. The nitrogen is vented to the atmosphere through the center of the logging cable.

The surface components of the system include gamma-ray spectroscopy amplifiers and counting electronics interfaced with a computer. The hydraulic winch is computer controlled during logging and maintains accurate positioning and movement of the tool in the drywell.

3.2 RLS PROCEDURES AND SURVEY PARAMETERS

The procedures regulating geophysical logging are outlined in WHC-CM-7-7, EII 11.1. Procedures specific to both NaI and RLS spectral gamma-ray logging are described in Appendix C of EII 11.1.

The RLS surveys of the tank C-103 drywells were conducted for the total depth of each well less approximately 0.5 ft, which is the distance from the center of the detector to the bottom of the tool housing. The detector zero is established for each drywell by positioning the center of the detector at the ground surface. The distance between sample points (survey stations) was 0.5 ft, and the acquisition time at each survey station was 80 seconds. The acquisition time was adequate to assay the concentration of ^{137}Cs and ^{60}Co to 0.2 pCi/g. These specifications are appropriate for "screening" surveys and allowed one drywell of not more than 90 ft to be surveyed per day. A 2.5-ft repeat section to verify equipment performance was collected during each survey. A sample spectrum representing analysis of one 0.5-ft interval is presented in Figure 17. The RLS survey data are presented in Appendix C.

The C tank farm surface is contaminated with radioactive materials. To avoid contaminating and regulating the RLS, the drywell logging was conducted from outside the eastern perimeter fence of the tank farm. The sheave wheel, which holds the logging cable and houses the depth-measuring encoder, was suspended by a boom trailer at each drywell. A 100-lb weight was added to the tool to improve depth control and to counterbalance the weight of the logging cable from the truck to the boom trailer. The drywells were logged from the surface to the maximum depth, allowing a single radiological survey at the end of logging as the cable and detector were removed from the tank farm.

3.3 RLS CALIBRATION

The data collected during the logging of tank C-103 drywells were analyzed using the calibration data collected in November 1991 at the U.S. Department of Energy calibration model facilities in Grand Junction, Colorado. Koizumi et al. (1991 and 1992), and Brodeur et al. (1991) describe the calibration models and procedures and other details. A calibration session was conducted in April 1993 at the Grand Junction models and April 1994 at the Hanford models. The details of the calibration and results are presented by Randall (1994).

3.4 RLS GENERAL LOGGING RESULTS

The center of the germanium detector is positioned at ground level for the zero-depth reference position. The tank farm drywells are, for the most part, flush with ground surface, and thus an easy sight of ground level is achieved. All five drywells are constructed of 6-in.-diameter, carbon steel casing.

The RLS germanium detector responds only to gamma rays. Thus, only gamma-ray-emitting radionuclides can be detected from drywell logging. Radionuclides that emit only beta or alpha particles cannot be detected through the steel drywell casing. Tritium decays by beta particles only, and therefore cannot be detected by gamma-ray spectroscopy. When it is stated that the only synthetic radionuclide found at a particular depth was ^{60}Co , it is understood that ^{60}Co was the only gamma-emitting synthetic radionuclide found at that depth. The RLS survey plots show the gamma-radiation decay activity for each radionuclide detected.

Figure 17. RLS Spectrum from Well 30-03-01.

The following sections describe the radionuclides detected in each drywell. No reference or correlation to neighboring, or even distant, drywells is given in this discussion. Refer to Appendix B for a graphical presentation of the RLS survey results. Logarithmic scales are used for ^{137}Cs and ^{60}Co plots; linear scales are used for the total-gamma and natural radionuclide (potassium, uranium, and thorium) plots.

3.4.1 Drywell 30-03-01

Drywell 30-03-01 (299-E27-74) is located on the northeast side of tank C-103. It was logged with the RLS from ground surface to 121.5 ft.

The RLS survey identified ^{137}Cs from the surface to 86 ft in two distinctive zones that exceeded 10 pCi/g, 0 to 31 ft and 52 to 66 ft. The deepest zone in which ^{137}Cs was detected occurred from 100 to 103 ft with decay activities that did not exceed 1 pCi/g. The maximum ^{137}Cs decay activity of 340 pCi/g occurred at 1.5 ft.

Cobalt-60 was identified from 95 to 114 ft, and intermittently down to 119 ft. The maximum ^{60}Co decay activity of 1.1 pCi/g occurred at 101.5 ft. As noted, a very thin zone from 100 to 103 ft of low ^{137}Cs concentration is associated with the ^{60}Co .

The profile of the total gamma log closely duplicates the profile of the ^{137}Cs activity from 0 to 76 ft. The ^{60}Co contamination from 95 to 113 ft, and the ^{137}Cs activity are also distinguishable on the total gamma-ray log.

Review of the natural radionuclide logs of potassium, uranium, and thorium reveals an increase in the potassium concentration from 45 ft to the total depth (TD) of the borehole. An increase in potassium activity occurs over an interval from 45 to 49 ft. No significant changes occur on the uranium and thorium logs throughout the survey. No correlation of these features can be made with the lithologic information reported on the driller's log.

The tank farm gross gamma log shows the upper ^{137}Cs zones at 0 to 30 ft, and 52 to 70 ft, however the zone from 100 to 103 ft of ^{137}Cs and ^{60}Co is indistinguishable from background radiation.

3.4.2 Drywell 30-03-03

Drywell 30-03-03 (299-E27-75) is located east of tank C-103. It was logged with the RLS from the surface to 94.5 ft.

The RLS survey identified ^{137}Cs contamination from the surface to 39.5 ft. The maximum decay activity of 230 pCi/g occurred at 8 ft.

Cobalt-60 was identified from 85 ft to the maximum survey depth of 94.5 ft. The maximum ^{60}Co activity of 1.8 pCi/g occurred at 90 ft.

The profile of the total gamma-ray count closely duplicates the profiles of the ^{137}Cs and ^{60}Co concentrations.

An increase in the potassium activity occurs at 38 ft. The bottom of the fill material is estimated to be between 38 and 40 ft.

A 2- to 3-in.-thick silt layer was reported on the driller's log in the interval between 85 to 90 ft. The potassium activity is increased in an interval from 89 to 90 ft, which may be the actual location of the silt layer. This is also the location of the highest ^{60}Co activity identified by the RLS survey.

The tank farm gross gamma-ray log identified the entire ^{137}Cs contamination zone and responded to the ^{60}Co zone at 90 ft where the maximum activity was observed.

3.4.3 Drywell 30-03-05

Drywell 30-03-05 (299-E27-76) is located southeast of tank C-103. It was logged with the RLS from the surface to 95.5 ft.

The RLS survey identified ^{137}Cs from ground surface to 28 ft, from 34.5 to 41 ft, and from 55 to 77.5 ft. The maximum ^{137}Cs decay activity of 33 pCi/g occurred at 1 ft. Analysis was performed for ^{60}Co , but none was identified.

The potassium, uranium, and thorium logs could not be correlated with the lithology recorded on the driller's log.

Only the surface zone of ^{137}Cs activity was distinguishable on the total gamma-ray log. The activity of this zone ranged from a high of 33 pCi/g at 1 ft, to less than 1 pCi/g at 28 ft.

The tank farm gross gamma-ray log recorded a slightly higher than background activity from the surface to 10 ft. The remaining ^{137}Cs in the formation is below the detection limits of the tank farm system and undistinguishable from background radioactivity. The gross gamma-ray log recorded a slightly increased count rate from 56 to 67 ft, which roughly correlates to the lower ^{137}Cs zone.

3.4.4 Drywell 30-03-07

Drywell 30-03-07 (299-E27-77) is located south-southwest of tank C-103. It was logged with the RLS from the surface to 96.5 ft.

Cesium was identified by the RLS survey from ground surface to 40 ft, from 42.5 to 64.5 ft, and intermittently from 93.0 to 96.5 ft, the maximum survey depth. The maximum ^{137}Cs decay activity was 18 pCi/g at 7 ft. The RLS total gamma-ray log closely duplicates the ^{137}Cs concentration from 0 to 10 ft, and from 46 to 52.5 ft. Analysis was performed for ^{60}Co , however none was identified.

The potassium concentration increased at 40 ft, the estimated depth of fill material. The character of the log also changed; the peaks below 40 ft

are wider. The log indicates no significant lithologic changes above or below the bottom of the excavation depth. The drilling samples reported by the driller's log indicate varying percentages of coarse, medium, and fine sand. The samples between 45 and 55 ft, where the ^{137}Cs zone is identified, are described as silt, pea gravel, and sand.

The tank farm gross gamma-ray log shows the surface ^{137}Cs (to 10 ft), and the lower interval from 44 to 50 ft.

3.4.5 Drywell 30-03-09

Drywell 30-03-09 (299-E27-78) is located west of tank C-103. It was surveyed with the RLS from the surface to 95.5 ft.

The RLS survey identified ^{137}Cs contamination from ground surface to 41 ft, and from 45 to 62 ft. Cesium was also detected intermittently at concentrations much less than 1 pCi/g in other zones from 64.0 to 94.5 ft. The maximum ^{137}Cs decay activity of 54 pCi/g was observed at 7 ft.

Cobalt was identified from 78 ft to the maximum survey depth of 95.5 ft. The maximum ^{60}Co decay activity of 4 pCi/g occurred at 79 ft.

The profile of the total gamma-ray log generally reflects both the ^{137}Cs and ^{60}Co concentrations. The intermediate ^{137}Cs contamination zone from 20 to 41 ft (maximum decay activity of 4 pCi/g at 39.5 ft) is barely discernible on the tank farm gross gamma-ray log. This ^{137}Cs contamination zone is located just above the bottom of the excavation base; no ^{137}Cs is detected between 41 and 45 ft.

The driller's log reports a silty-sand zone in the interval above 40 ft, which probably is acting as a barrier to the downward migration of the surface contamination. The ^{137}Cs activity identified from 45 to 62 ft starts abruptly at 45 ft. This contamination zone begins in a silty sand horizon that may absorb and wick materials easily, and ends in a gravelly sand horizon that is less effective at retaining liquids.

The potassium concentration is higher in the undisturbed sediments below 40 ft. The bottom excavation boundary is not clearly defined as in other logs. However, the character of the potassium log changes at 45 ft instead of the usual 40 ft. Below this depth the peaks are wider, possibly indicating slightly thicker bedding.

The drilling sample descriptions report a lithology change from "coarse to fine sand" to "coarse to fine sand and silt" in the interval between 30 and 50 ft. A change in the potassium log is observed at this depth. Below 50 ft the sample descriptions of the sediment range from gravelly sand to slightly silty gravelly sand to TD. An increase in the potassium activity is observed at 48.0 ft, which may correlate to increased silt content of the sediments.

The tank farm gross gamma-ray log records major activity peaks at 4, 8, 39, 48, and 80 ft, which correspond to the RLS logs. However, the extent of the contamination between these depths is indistinguishable from the background radiation.

4.0 RESULTS

Tank C-103 is part of a complex system of waste storage in the C farm that has undergone design modifications and updates continually since the excavation pit closed in 1944. The interconnection of the C farm tanks and support systems does not allow for a review of only tank C-103. Support equipment and facilities complicate the picture at the C farm.

4.1 UNCERTAINTIES

In characterizing the subsurface from drywell to drywell, remembering the uncertainties inherent in geologic, hydrologic, and radiologic data is important. Geologic information is based on 5-ft drilling sample descriptions that are inadequate to accurately establish thicknesses, to identify and locate thin strata, and to observe subtle changes in texture. The hydrologic information in the vadose zone depends on the tank farms neutron probe, which is not properly designed for precise formation-moisture content and is not calibrated. The radiologic data includes the RLS spectral gamma and the tank farm gross gamma-ray leak detection logs. The gross gamma-ray logging program was designed to detect ^{106}Ru , which is no longer present at detectable quantities; the gross gamma cannot identify radionuclides.

The uncertainties and unknowns always limit an absolute determination of contamination in the subsurface, as well as complicate source delineation. Spectral gamma-ray data surrounding tank C-103 support explicit interpretation of contamination coming from identified sources and a reliable characterization of gamma-emitting contamination in the subsurface.

4.2 CORRELATION OF CONTAMINATION WITH PAST EVENTS

A review of the tank farm gross gamma-ray logs and the RLS survey data revealed five somewhat distinct regions of interest in the drywells surrounding tank C-103. They are:

- Surface contamination from the surface to a depth of 10 ft
- An interval from 10 ft to the bottom of the tank-construction excavation, approximately 40 ft deep
- The bottom of the excavation
- Cesium contamination below the excavation
- Cobalt contamination at approximately 80 ft.

4.2.1 Surface Contamination

The ^{137}Cs contamination in the top 10 ft of backfill is not associated with cascade line leaks or tank leaks. The complex network of piping over and

around tank C-103 provides numerous sources for leaks of radioactive materials.

All the drywells surrounding tank C-103 indicate ^{137}Cs contamination at ground surface, and in all drywells except drywell 30-03-09 the contamination extends to 40 ft or deeper. Also, except for drywells 30-03-07 and 30-03-09, the contamination was in place before 1974 when the newly installed drywells were first logged. The most intense and extensive (in depth) ^{137}Cs contamination is found in drywells 30-03-01 and 30-03-03. They are located on the northeast side of tank C-103 on either side of a pipeline running from the 241-C-801 Cesium Loadout Facility to the tank. As discussed previously, no reported spills associated with the facility could be located, but the intensity of the ^{137}Cs activity in both of these drywells suggests a source nearby. The drywells more distant from drywell 30-03-01 exhibit decreasing intensity.

4.2.2 Contamination from 10 to 40 Feet

Contamination from 10 to 40 ft could have leak sources associated with the C-103 tank itself, the cascade line (approximately 15 ft above the base of the tank), and any other near-surface leak or surface spill. A factor complicating leaks in this region is that material spilled or leaked over the tank would migrate down through the soil to the tank top, move laterally along the domed top until it reached the side of the tank. Leakage would then migrate vertically down the backfill/tank wall interface to the tank base. Depending on the soil material present, it could spread laterally, or continue to migrate downward. Leaked tank material could follow a similar process.

Significant variations in contamination activity over short lateral and vertical extent are frequently observed. The proximity of a drywell to the tank is significant in identifying leaks. The drywells surrounding tank C-103 range in distance from 3 to 15 ft from the tank wall. A drywell close to the side of a tank would more likely be able to detect contamination moving down the tank side than a drywell further away. Also, depending on the size and flow of the leak, a leak occurring on one side of the dome could spread over to the opposite side of the tank. Multiple peaks observed in drywell 30-03-01 could suggest multiple sources or represent several events. The backfill described for this interval is medium to coarse sand. Normally this sediment would not seem to restrict flow; however, tank C-103 had accumulated waste of every type sent to the C tank farm. It is possible that once the waste entered the sediment it did not move readily, and successive leaks were restricted by precipitation of previous waste (e.g., reduction of permeability).

In most cases observed in the C tank farm data, radionuclide activity decreases with increasing depth. However, of the tank C-103 drywell data, only the data in drywells 30-03-05 and 30-03-07 follow this pattern. The remaining drywells show increases with depth, the most obvious being drywell 30-03-01. The surface contamination would show a decreasing trend except that the activity increased at approximately 27 ft. This could be the result of a surface spill, line leak, or possibly a tank leak. Because of distance and sediment type, it is not observed in the other drywells.

The two sharp peaks in drywell 30-03-01 at approximately 36 ft and 45 ft could possibly represent contamination attracted to welds in the casing as the drywell was being constructed. The magnetic properties induced into the casing during welding could have attracted contaminated material when it was put in place. This phenomenon has been observed at other sites and most recently during the 200-BP-1 crib drilling. The sediment at this depth in drywell 30-03-01 is not conducive to trapping downward migrating contamination.

4.2.3 Excavation Bottom

The excavation bottom in all drywells except drywell 30-03-01 acted as a barrier to downward migration of contamination. Drywells 30-03-03 and 30-03-09 penetrated fine, medium, and coarse sand and silt. Drywells 30-03-01, 30-03-05, and 30-03-07 penetrated fine, medium, and coarse sand. The contamination in drywell 30-03-01 migrated through the excavation boundary with no observed restriction in movement, then decreased according to observed trends. The movement, or lack of movement, in the other drywells suggests that the excavation bottom was a barrier because of construction processes described previously, not because of sediment type. The sediments identified in the driller's log at a depth of 40 ft in drywells 30-03-03 and 30-03-09 range from 10- to 20-percent silt content. A silt lens is not described.

4.2.4 Cesium Contamination Below 40 Feet

Cesium contamination below 40 ft is observed in drywells 30-03-01, 30-03-05, 30-03-07, and 30-03-09. The contamination was present in all drywells in 1974 when the drywells were first logged. No movement was observed in the tank farm gross gamma-ray logs; however, in 1988 the shape of the gross gamma-ray profile in drywell 30-03-01 changed to its present appearance. The contamination in all drywells is associated with a medium to coarse sand, pea-gravel horizon. The contamination occurs at approximately a 52-ft depth in drywell 30-03-01, is the most intense ^{137}Cs activity, and occupies the thickest zone. The absence of the contamination in drywell 30-03-03 with the geologic horizon present suggests distance from the source. The character of the contamination in drywell 30-03-01 suggests a close source, possibly on the northwest side of tank C-103. Because the source originates at a depth of approximately 50 ft, a surface spill or near-surface or tank leak is possible. Source contamination near drywell 30-03-01 would migrate unobstructed downward because of the medium to coarse sand sediments present, encounter the sand/gravel horizon, and spread laterally. Tank leak material would migrate similarly. The contamination is also observed in drywells 30-06-03 and 30-06-04, which further suggests a source near drywell 30-03-01.

The ^{137}Cs contamination at a depth of 92 ft in drywell 30-03-07 does not appear to have a source from tank C-103, but is probably associated with ^{137}Cs contamination observed at tank C-106 at approximately that depth. The contamination occurs in a sand-gravel horizon.

4.2.5 Cobalt Contamination

Cobalt contamination was observed in drywells 30-03-01, 30-03-03, and 30-03-09 at a depth of approximately 80 ft. This contamination was considered to be from a source other than tank C-103 because no ^{60}Co is observed above 80 ft. If the ^{60}Co migrated downward from the surface or a tank leak, some ^{60}Co would most likely have been adhered to the sediments. A moisture transport system was described previously and was studied briefly in this investigation. A source of contamination near drywell 30-08-02 and associated with tank C-108 is considered a possible source for the ^{60}Co contamination observed in the C-103 drywells. A study of the moisture logs for the drywells between drywell 30-08-02 and the drywells surrounding tank C-103 revealed a moisture "high" that is invariably present, and is present in the same slightly silty, coarse to medium sand geologic layer from drywell 30-08-02 to drywell 30-03-01. It appears that some textural feature within the layer is attracting or collecting moisture and controlling the movement of contamination.

4.3 CESIUM CONTAMINATION

RLS spectral gamma-ray surveys have been acquired for 20 boreholes in the C farm. Surface contamination has been identified in all surveys and the only radionuclide present in the surface contamination is ^{137}Cs . The most likely explanation is a single release of sufficient magnitude to cover a very large area. The chemical composition of the release possibly complexed the ^{137}Cs and increased its penetrating capabilities through the subsurface sediments. A single release with these two properties is more likely than multiple leaks from either a common source location or several sources. The release occurred between 1944 (tank farm construction date) and 1974 (drywell construction date). The ^{137}Cs profiles for the tank C-103 drywells are shown in Figure 18.

The arguments against multiple releases are as follows:

- Multiple release locations likely would not have guaranteed that surface contamination would be located at all boreholes within a large semi-circular area
- Multiple leaks most likely would have contained additional contaminants other than ^{137}Cs alone, which would be readily detected in the geophysical surveys
- The subsurface distribution profiles from multiple leaks would leave fingerprints that would not be consistently explained by a single release incident.

The single, surface-contamination release extended over tanks C-103, C-105, and C-106, and probably tank C-102. The surface ^{137}Cs around the first three tanks has been confirmed by RLS surveys. The ^{137}Cs around tank C-102, which has no drywells, is inferred by its location. The maximum penetration depth and high concentrations encountered in drywells 30-03-01 and 30-03-03 indicated either the release point or the location where the liquids pooled before infiltrating into the subsurface. The 40 ft of backfilled soils above the tank base effectively absorbed the contaminants and prevented widespread

Figure 18. Cesium Concentration Profiles C-103 Tank Drywells.

intrusions into the undisturbed formation below the excavation at 40 ft. However, the tank shell effectively shed the contaminated liquids and directed the flow over its sides toward the base footing.

The volume of contaminated liquids reaching the tank base all the way around tank C-103 was sufficient to permit contaminant penetration into the Hanford formation to 80 ft. This conclusion is reached by correlating the contaminant distribution below 40 ft (from the RLS surveys) with the distance from the tank to the drywell positions. The drywell farthest (15 ft) from the tank (30-03-03) did not encounter any ^{137}Cs contamination below 40 ft.

The contamination encountered below 40 ft in the drywells adjacent to tanks other than C-103 is consistent with their distance from the tank and the contaminant distribution from the surface to 20 ft. Therefore, the center of the surface contamination release is above the north and east quarter of the C-103 tank.

4.4 COBALT CONTAMINATION AT APPROXIMATELY 80 FEET

Cobalt-60 contamination was identified in three of the five drywells surrounding tank C-103. The contaminant depth range for each drywell is as follows:

30-03-01	95 to 114 ft
30-03-03	85 to 94 ft (TD)
30-03-09	78 to 95 ft (TD)

Cobalt-60 has also been identified by RLS surveys in several drywells around tanks C-105 and C-106. The contaminant depth range of each is as follows:

30-05-02	72 to 84 ft
30-05-03	73 to 85 ft
30-05-04	80 to 86 ft
30-05-05	69 to 78 ft
30-06-04	85 to 90 ft
30-06-10	85 to 111 ft
30-06-12	89 to 95 ft (TD)

The depth of the ^{60}Co indicates that the subsurface strata likely dips to the northeast and may be overbank fine-grained sediments.

Drywells 30-05-06, 30-05-07, 30-05-08, 30-05-09, 30-05-10, 30-06-02, 30-06-03, and 30-06-09 are too shallow to allow detection of the ^{60}Co .

Elevated gamma-ray activity in drywell 30-03-09 at 80 ft has been present in the logs since the drywell was originally drilled in 1974. The source of this contamination probably originated at the cascade line leak between tanks C-104 and C-105. The decrease in activity from 1974 to 1979 that exceeds the expected decay rate of ^{60}Co probably was indicating the presence of a radionuclide with a shorter half life such as ^{106}Ru , which has been demonstrated to be at least as mobile as ^{60}Co .

However, the gamma activity began to increase slowly in drywells 30-03-09 from 1984 to 1986. The ^{60}Co contamination coincides with moisture (hydrogen) increases detected in the TWRs neutron logs of these drywells. Even logs of drywells where no ^{60}Co contamination was encountered identified the moisture interface\layer. Thus, a natural interface for horizontal migration of mobile contaminants is probable.

The increase of ^{60}Co contamination at 80 ft in drywell 30-03-09 was demonstrated by MRAL-II in 1987 by W. H. Ulbricht. All other tank farm leak detection surveillance logs from 1974 to 1988 were examined between the depth of 50 ft to the maximum survey depths for changes in the responses. The logs for three drywells contain changes from 1980 to 1982 in the zones immediately above and in the moisture layer, prompting additional review. The three drywells are located between tanks C-108 and C-109 (30-08-02, 30-09-06, and 30-09-07). In drywell 30-08-02, a contamination zone at about 50 ft was apparently moving down and is currently at 76 ft. During a 2-year interval (12/80 to 12/82), the center of the contamination appeared to move from 59 to 70 ft. When this contamination began its greatest movement in 1980, the moisture interface at about 76 ft in drywells 30-09-06 and 30-09-07 quickly increased in gamma activity from a natural count (25 cps) to over 200 cps.

The path of the contaminant migration from the source may follow some preferred sedimentary interface, lensing, or channelling.

5.0 CONCLUSIONS

WHC Geophysics used high-resolution spectral gamma-ray drywell logging to investigate a possible leak in SST 241-C-103 (C-103) to implement a follow-up recommendation by Brodeur (1993). The basis for designating tank C-103 as a possible leaker stemmed from three unexplained subsurface contamination intervals. First, contamination at 27 ft between tanks C-106 and C-103 was identified in two drywell surveys and the intensity of the contamination increased toward C-103. Second, a zone of contamination at about 50 ft is present in several drywells around tank C-103; this depth is below the base of the tank. The highest concentration occurs in a drywell that is less than 5 ft from the tank, with the next nearest tank more than 60 ft away. It appears, therefore, that tank C-103 is the most probable source of the contamination. Third, a zone of contamination at 80 ft in a drywell less than 5 ft from tank C-103 slowly increased in concentration from 1984 to 1986, just a short time after in-tank liquid levels fell below the baseline. An unusual occurrence report and several special investigations followed.

This investigation has identified two incidents that explained the subsurface contamination present over, around, and under tank C-103. The first is a surface spill that concentrated over the tank and extended to all adjacent tanks and beyond. The chemistry of the liquids saturated the soils to 10 ft for much of the area and as deep as 30 ft on the east side of the tank. The tank exterior shed the downward migrating contaminants, permitting them to penetrate past the 40-ft construction base to as deep as 75 ft. This spill occurred before 1974 when the drywells were installed. The contaminants from this ^{137}Cs -laden spill have not moved since 1974. This incident explains

the zones at the 27-ft and 50-ft depths that raised suspicions about the integrity of the tank.

The second incident that created the increase in contamination at 80 ft below tank C-103 occurred between tanks C-108 and C-109, when moving contamination intercepted a finer grained moisture interface. The contamination was recorded in three drywells at almost the same time in late 1980. The contamination continued to spread along the moisture interface at about the 80-ft depth, as identified by repeated surveys using a neutron-moisture probe. The contamination has been identified in the drywells between the source and tank C-103 in the moisture layer at about 80 ft. Therefore, the final zone of suspicion at 80 ft under tank C-103 can be tracked to an incident at another tank through a connecting strata in the subsurface.

6.0 RECOMMENDATIONS

Several data gaps have been identified that prevent adequate study and absolute defense of the investigation results. These gaps, which were discussed throughout this report, still exist and should be investigated and resolved. They are as follows.

- In-tank measurements of the radionuclide distribution and composition is needed for correlating subsurface contamination with the source. The measurement must be made with a detector capable of measuring the gamma-energy distribution. The silicon detector operated by Moore and Associates has demonstrated that accurate gamma-energy distributions in very intense radiation fields (reactor cores) have been obtained.
- Moisture-distribution profiles of the subsurface must be accurately measured and monitored for changes in the contaminant-driving fronts. The moisture measurements must be taken with a characterized and calibrated detector capable of identifying minor changes in the moisture content.
- The surface spill or near-surface leak that occurred before 1974 and extended over tank C-103 must be identified. The release date, volume, effluent chemistry, and radionuclides present must be resolved.
- The composition and extent of the moisture interface/layer at about 80 ft under the C farm and beyond must be mapped. The capabilities of using this interface to quickly resolve and identify future tank leaks must be shown.

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APPENDIX A

241-C-103 WELL CROSS REFERENCE

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APPENDIX A

241-C-103 WELL CROSS REFERENCE

<u>Drywell ID</u>	<u>Hanford Well Number</u>
30-03-01	299-E27-74
30-03-03	299-E27-75
30-03-05	299-E27-76
30-03-07	299-E27-77
30-03-09	299-E27-78

Geologic Logs

Geologic Logs/Geophysical Logs

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WELL SUMMARY SHEET

Boring or Well No. **299-E27-74**
 Northing _____ Easting _____
 Sheet 1 of 2

Location _____ Project **GEOPHYSICS PROJECT: C-TANK FARM**
 Elevation **645.00** Drilling Contractor _____
 Driller **WJ RODDA** Drilling Method and Equipment **CABLE TOOL**
 Prepared by _____ Reviewed By _____ Date **6-28-74**
 (Sign/Print Name) (Sign/Print Name)

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Well Construction		Graphic Log	Lithologic Description
6" DIAM .28" THICK PERMANENT CARBON STEEL CASING (0' TO 125')		0		0-50' Very coarse sand, medium sand
		10		
		20		
		30		
		40		
		50		
		60		
		70		
		80		
				60-65' Coarse sand, medium sand, fine sand
				65-75' Medium sand, fine sand, very fine sand
				75-80' Very coarse sand, pea gravel

Inches
 20 20 12 8 4 0 4 8 12 20 20

C/Z S P C/B

WELL SUMMARY SHEET

Boring or Well No. **299-E27-74**
 Northing _____ Easting _____
 Sheet **2** of **2**

Location _____ Project **GEOPHYSICS PROJECT: C-TANK FARM**
 Elevation **645.00** Drilling Contractor _____
 Driller **WJ RODDA** Drilling Method and Equipment **CABLE TOOL**
 Prepared by _____ Reviewed By _____ Date **6-28-74**
(Sign/Print Name) (Sign/Print Name)

CONSTRUCTION DATA			Depth in Feet	GEOLOGIC/HYDROLOGIC DATA		
Description	Well Construction			Graphic Log	Lithologic Description	
					80-85' Very coarse sand, pea gravel, silt	
					85-95' Fine sand, very fine sand, silt	
			90			
					95-100' Coarse sand, medium sand, fine sand	
			100		100-110' Fine sand	
			110		110-125' No data	
			120			
TOTAL DEPTH = 125'			130			
			140			
			150			
			160			
Inches 28 20 12 8 4 0 4 8 12 20 28			C/Z S P C/B			

WELL SUMMARY SHEET

Boring or Well No. **299-E27-75**
 Northing _____ Easting _____
 Sheet 1 of 2

Location _____ Project **GEOPHYSICS PROJECT: C-TANK FARM**
 Elevation 645.00 Drilling Contractor _____
 Driller WJ RODDA Drilling Method and Equipment CABLE TOOL
 Prepared by _____ Reviewed By _____ Date 7-2-74
 (Sign/Print Name) (Sign/Print Name)

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Well Construction		Graphic Log	Lithologic Description
6" DIAM .28" THICK PERMANENT CARBON STEEL CASING (0' TO 100')				0-30' Very coarse sand, medium sand
		10		
		20		
		30		30-46' Coarse sand, medium sand, silt
		40		
		50		46-61' Coarse sand, medium sand, fine sand
		60		
		70		61-71' Coarse sand, medium sand, fine sand, gravel
		80		71-81' Coarse sand, medium sand
Inches 28 20 12 8 4 0 4 8 12 20 28			C/Z S P C/B	

WELL SUMMARY SHEET

Boring or Well No. **299-E27-75**
 Northing _____ Easting _____
 Sheet **2** of **2**

Location _____ Project **GEOPHYSICS PROJECT: C-TANK FARM**
 Elevation **645.00** Drilling Contractor _____
 Driller **WJ RODDA** Drilling Method and Equipment **CABLE TOOL**
 Prepared by _____ Reviewed By _____ Date **7-2-74**
 (Sign/Print Name) (Sign/Print Name)

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Well Construction		Graphic Log	Lithologic Description
TOTAL DEPTH = 100'		81		81-85' Very coarse sand, medium sand, pea gravel 85-95' 2-3" SILT -- depth unknown; samples are missing; radiologically contaminated
		82		
		83		
		84		
		85		
		86		
		87		
		88		
		89		
		90		
		90		
		100		
		110		
		120		
		130		
		140		
		150		
		160		

Inches

C/Z S P C/S

WELL SUMMARY SHEET

Boring or Well No. **299-E27-76**
 Northing _____ Easting _____
 Sheet 1 of 2

Location _____ Project **GEOPHYSICS PROJECT: C-TANK FARM**
 Elevation 645.00 Drilling Contractor _____
 Driller WJ RODDA Drilling Method and Equipment CABLE TOOL
 Prepared by _____ Reviewed By _____ Date 7-31-74
 (Sign/Print Name) (Sign/Print Name)

CONSTRUCTION DATA			Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Well Construction			Graphic Log	Lithologic Description
6" DIAM .28" THICK PERMANENT CARBON STEEL CASING (0' TO 100')			0		0-15' Very coarse sand, medium sand, topsoil and gravel
			10		
			20		15-30' Very coarse sand, medium sand
			30		
			40		
			50		
			60		30-60' Very coarse sand, medium sand, fine sand
			70		
		80		60-70' Very coarse sand, medium sand, pea gravel	
					70-75' Medium sand, fine sand
					75-80' Coarse sand, medium sand, very fine sand

Inches
 20 20 12 8 4 0 4 8 12 20 20

C/Z S P C/B

WELL SUMMARY SHEET

Boring or Well No. **299-E27-76**
 Northing _____ Easting _____
 Sheet **2** of **2**

Location _____ Project **GEOPHYSICS PROJECT: C-TANK FARM**
 Elevation **645.00** Drilling Contractor _____
 Driller **WJ RODDA** Drilling Method and Equipment **CABLE TOOL**
 Prepared by _____ Reviewed By _____ Date **7-31-74**
 (Sign/Print Name) (Sign/Print Name)

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Well Construction		Graphic Log	Lithologic Description
TOTAL DEPTH = 100'		80		80-90' Medium sand, fine sand, very fine sand
		90		90-95' Medium sand, silt
		95		95-100' Medium sand, fine sand
		100		
		110		
		120		
		130		
		140		
		150		
		160

		C/Z S P C/B		

C/Z S P C/B

WELL SUMMARY SHEET

Boring or Well No. **299-E27-77**
 Northing _____ Easting _____
 Sheet 1 of 2

Location _____ Project **GEOPHYSICS PROJECT: C-TANK FARM**
 Elevation **646.00** Drilling Contractor _____
 Driller **WJ RODDA** Drilling Method and Equipment **CABLE TOOL**
 Prepared by _____ Reviewed By _____ Date **9-18-74**
 (Sign/Print Name) (Sign/Print Name)

CONSTRUCTION DATA			Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Well Construction			Graphic Log	Lithologic Description
6" DIAM .28" THICK PERMANENT CARBON STEEL CASING (0' TO 100')			0		0-15' Very coarse sand, gravel
			10		15-30' Very coarse sand, medium sand, silt
			20		
			30		30-45' Very coarse sand, medium sand, very fine sand
			40		
			50		45-55' Very coarse sand, medium sand, pea gravel, silt
			60		55-65' Very coarse sand, coarse sand, medium sand
			70		65-75' Coarse sand, medium sand, fine sand
		80		75-80' Coarse sand, medium sand, gravel	

Inches
 28 20 12 8 4 0 4 8 12 20 28

C/Z S P C/B

WELL SUMMARY SHEET

Boring or Well No. **299-E27-77**
 Northing _____ Easting _____
 Sheet 2 of 2

Location _____ Project **GEOPHYSICS PROJECT: C-TANK FARM**
 Elevation 646.00 Drilling Contractor _____
 Driller WJ RODDA Drilling Method and Equipment CABLE TOOL
 Prepared by _____ Reviewed By _____ Date 9-18-74
(Sign/Print Name) (Sign/Print Name)

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Well Construction		Graphic Log	Lithologic Description
TOTAL DEPTH = 100'		80-85'		80-85' Coarse sand, pea gravel
		85-95'		85-95' Medium sand, fine sand
		90		
		95-100'		95-100' Coarse sand, medium sand, fine sand
		100		
		110		
		120		
		130		
		140		
		150		
		160		

Inches
 26 20 12 8 4 0 4 8 12 20 26

C/Z S P C/B

WELL SUMMARY SHEET

Boring or Well No. **299-E27-78**
 Northing _____ Easting _____
 Sheet 1 of 2

Location _____ Project **GEOPHYSICS PROJECT: C-TANK FARM**
 Elevation 646.00 Drilling Contractor _____
 Driller WJ RODDA Drilling Method and Equipment CABLE TOOL
 Prepared by _____ Reviewed By _____ Date 6-25-74
 (Sign/Print Name) (Sign/Print Name)

CONSTRUCTION DATA			Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Well Construction			Graphic Log	Lithologic Description
6" DIAM .28" THICK PERMANENT CARBON STEEL CASING (0' TO 100')			0		0-30' Very coarse sand, medium sand
			10		
			20		
			30		30-50' Coarse sand, medium sand, fine sand, silt
			40		
			50		50-60' Very coarse sand, pea gravel
			60		60-65' Very coarse sand, fine sand
			70		65-70' Very coarse sand, pea gravel, silt
			80		70-80' Very coarse sand, medium sand, pea gravel, silt
			Inches 20 20 12 8 4 0 4 8 12 20 20		

WELL SUMMARY SHEET

Boring or Well No. **299-E27-78**
 Northing _____ Easting _____
 Sheet **2** of **2**

Location _____ Project **GEOPHYSICS PROJECT: C-TANK FARM**
 Elevation **646.00** Drilling Contractor _____
 Driller **WJ RODDA** Drilling Method and Equipment **CABLE TOOL**
 Prepared by _____ Reviewed By _____ Date **6-25-74**
(Sign/Print Name) (Sign/Print Name)

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Well Construction		Graphic Log	Lithologic Description
TOTAL DEPTH = 100'		80		80-85' Medium sand, fine sand, silt
		85		85-90' Coarse sand, medium sand, silt
		90		90-100' Medium sand, fine sand, silt
		95		
		100		
		105		
		110		
		115		
		120		
		125		
		130		
		135		
		140		
		145		
		150		
		155		
		160		

Inches
 28 20 12 8 4 0 4 8 12 20 28

C/Z S P C/B

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 pCi/g)	Cs 137 Log (1x10 pCi/g)	Co 60 Log (pCi/g)			Depth (Feet)
75		75-80' Very coarse sand, pea gravel								75
80		80-85' Very coarse sand, pea gravel, silt								80
85		85-95' Fine sand, very fine sand, silt								85
90										90
95		95-100' Coarse sand, medium sand, fine sand								95
100		100-110' Fine sand								100
110		110-125' No data								110
120										120
130										130
140										140

A-14

CZ SP/CB

0 4 2 0 2 4 6

0.5 4.5 5 25 0.5 4.5 2 18 10 80

TOTAL DEPTH = 125'

Project: GEOPHYSICS PROJECT: C-TANK FARM				Well No.: 299-E27-76 (30-03-05)				Page 2 of 2	
Depth (Feet)	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 pCi/g)	Cs 137 Log (1x10 pCi/g)	Co 60 Log (pCi/g)	Depth (Feet)		
70-75'	Medium sand, fine sand						80		
75-80'	Coarse sand, medium sand, very fine sand						90		
80-90'	Medium sand, fine sand, very fine sand						100		
90-95'	Medium sand, silt						110		
95-100'	Medium sand, fine sand						120		
			TOTAL DEPTH = 100'				130		
							140

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 pCi/g)	Cs 137 Log (1x10 pCi/g)	Co 60 Log (pCi/g)			Depth (Feet)
75		75-80' Coarse sand, medium sand, gravel								75
80		80-85' Coarse sand, pea gravel								80
85		85-95' Medium sand, fine sand								85
90										90
95		95-100' Coarse sand, medium sand, fine sand								95
100				TOTAL DEPTH = 100'						100
110										110
120										120
130										130
140										140

A-26

MHC-SD-EV-11-299, REV. 0

APPENDIX B

RLS SURVEYS

Tank Farm Gross Gamma-ray Logs

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Westinghouse Hanford Company
RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: C-103 TANK

Borehole	<u>30-03-01</u>		
Coordinates	<u>NA</u> N	<u>NA</u> W	Feet (Hanford System)
Elevation	<u>NA</u> ft	Top of casing	

Borehole Environment Information

Borehole liquid depth <u>None</u> (ft) from zero (0.0) depth reference of log			
Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
6	0.280	0.0	122.0

RLS Passive Spectral Gamma Survey Information

Logging Engineers <u>R. Cram</u> <u>J. Kiesler</u>			
Log depth reference at zero (0.0) depth is <u>ground level</u>			
Log Date	Archive file names	Log mode speed	Depth interval (ft) Top Base Incr
Feb 22, 1994	C300301\A526	MSA 80sec RT	0.0 121.5 0.5

MSA: Move Stop Acquire
RT: Real Time

Calibration and Analysis Information

RLS Calibration Date: Nov. 21, 1991	
Calibration Report: WHC-SD-EN-TRP-001	
Analyst Names: <u>S. E. Kos</u>	<u>R. K. Price</u>
Analysis Date: <u>Feb 24, 1994</u>	
Analysis Notes: <u>Drywell, single casing</u>	
Radionuclides Identified: <u>Cs-137, Co-60</u>	

RLS Spectral Gamma-Ray Borehole Survey

Project: C-Tank Farm

Log Date: Feb 22, 1994

Borehole: 30-03-01

Analysis Date: Feb 24, 1994

RLS Spectral Gamma-Ray Borehole Survey

Project: C-103 TANK
Borehole : 30-03-01

Log Date : Feb 22, 1994
Anal Date: Feb 24, 1994

RLS Borehole Survey Report

Borehole: 30-03-01

Casing	Depth: 0.0' - 122.0'	Size: 6"	Thickness: 0.280"
Water	None		
Survey	Depth: 0.0' - 121.5'		Date: Feb 22, 1994

General Notes:

The well was surveyed from outside of the tank farm with the sheave suspended from the boom trailer.

The well was surveyed from 0.0' to 121.5' at an acquisition time of 80 sec RT; the sample interval is 0.5'. A repeat section was conducted from 119.0' to 122.0'. The data is included on the plots.

The concentrations of the naturally occurring radionuclides potassium, uranium, and thorium are typical for Hanford sediments.

Man-made Radionuclides

Cesium (Cs-137) was identified from 0.0' to 84.5', and from 100.0' to 102.5'. The maximum activity of 340 pCi/g occurred at 1.5'.

Cobalt (Co-60) was identified from 95.0' to 113.5', and intermittently from 115.0' to 118.5'. The maximum activity of 1.1 pCi/g occurred at 101.5'.

Westinghouse Hanford Company
 RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: C-103 TANK

Borehole	<u>30-03-03</u>		
Coordinates	<u>NA</u> N	<u>NA</u> W	Feet (Hanford System)
Elevation	<u>NA</u> ft	Top of casing	

Borehole Environment Information

Borehole liquid depth <u>None</u> (ft) from zero (0.0) depth reference of log			
Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
6	0.280	0.0	95.0

RLS Passive Spectral Gamma Survey Information

Logging Engineers <u>R. Cram</u> <u>J. Kiesler</u>			
Log depth reference at zero (0.0) depth is <u>ground level</u>			
Log Date	Archive file names	Log mode speed	Depth interval (ft) Top Base Incr
Feb 18, 1994	C300303\A525	MSA 80sec RT	0.0 94.5 0.5

MSA: Move Stop Acquire
 RT: Real Time

Calibration and Analysis Information

RLS Calibration Date: Nov. 21, 1991	
Calibration Report: WHC-SD-EN-TRP-001	
Analyst Names: <u>S. E. Kos</u>	<u>R. K. Price</u>
Analysis Date: <u>Feb 24, 1994</u>	
Analysis Notes: <u>Drywell, single casing</u>	
Radionuclides Identified: <u>Cs-137, Co-60</u>	

RLS Spectral Gamma-Ray Borehole Survey

Project: C-Tank Farm

Log Date: Feb 18, 1994

Borehole: 30-03-03

Analysis Date: Feb 24, 1994

RLS Spectral Gamma-Ray Borehole Survey

Project: C-103 TANK
Borehole : 30-03-03

Log Date : Feb 18, 1994
Anal Date: Feb 24, 1994

RLS Borehole Survey Report

Borehole: 30-03-03

Casing	Depth: 0.0' - 95.0'	Size: 6"	Thickness: 0.280"
Water	None		
Survey	Depth: 0.0' - 94.5'		Date: Feb 18, 1994

General Notes:

The well was surveyed from outside of the tank farm with the sheave suspended from the boom trailer.

The well was surveyed from 0.0' to 94.5' at an acquisition time of 80 sec RT; the sample interval is 0.5'. A repeat section was conducted from 92.0' to 94.5'; the data is included on the plots.

The concentrations of the naturally occurring radionuclides potassium, uranium, and thorium are typical for Hanford sediments.

Man-made Radionuclides

Cesium (Cs-137) was identified from 0.0' to 39.5', and intermittently from 40.5' to 45.5'. The maximum activity of 228 pCi/g occurred at 7.0'.

Cobalt (Co-60) was identified from 85.0' to 94.5'. The maximum activity of 1.8 pCi/g occurred at 90.0'.

Westinghouse Hanford Company
RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: C-103 TANK

Borehole	<u>30-03-05</u>		
Coordinates	<u>NA</u> N	<u>NA</u> W	Feet (Hanford System)
Elevation	<u>NA</u> ft	Top of casing	

Borehole Environment Information

Borehole liquid depth <u>None</u> (ft) from zero (0.0) depth reference of log			
Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
6	0.280	0.0	96.0

RLS Passive Spectral Gamma Survey Information

Logging Engineers <u>R. Cram</u> <u>J. Kiesler</u>						
Log depth reference at zero (0.0) depth is <u>ground level</u>						
Log Date	Archive file names	Log mode	speed	Depth interval (ft)		
				Top	Base	Incr
Feb 17, 1994	C300305\A523	MSA	80sec RT	0.0	79.5	0.5
Feb 17, 1994	C300305\A524	MSA	80sec RT	80.0	95.5	0.5

MSA: Move Stop Acquire
RT: Real Time

Calibration and Analysis Information

RLS Calibration Date: Nov. 21, 1991	
Calibration Report: WHC-SD-EN-TRP-001	
Analyst Names: <u>S. E. Kos</u>	<u>R. K. Price</u>
Analysis Date: <u>Feb 23, 1994</u>	
Analysis Notes: <u>Drywell, single casing</u>	
Radionuclides Identified: <u>Cs-137</u>	

RLS Spectral Gamma-Ray Borehole Survey

Project: C-Tank Farm

Log Date: Feb 17, 1994

Borehole: 30-03-05

Analysis Date: Feb 23, 1994

RLS Spectral Gamma-Ray Borehole Survey

Project: C-103 TANK
Borehole : 30-03-05

Log Date : Feb 17, 1994
Anal Date: Feb 23, 1994

RLS Borehole Survey Report

Borehole: 30-03-05

Casing	Depth: 0.0' - 96.0'	Size: 6"	Thickness: 0.280"
Water	None		
Survey	Depth: 0.0' - 95.5'		Date: Feb 17, 1994

General Notes:

The well was surveyed from outside of the tank farm with the sheave suspended from the boom trailer.

The well was surveyed from 0.0' to 95.5' at an acquisition time of 80 sec RT; the sample interval is 0.5'. A repeat section was conducted from 93.0' to 95.5'; the data is included on the plots.

A failure of the electrical power generator caused an interruption of the survey at 79.5'. Repairs were made and the survey was restarted at 80.0' and continued to TD. A return error of minus 12" (tool zero at ground surface) was observed at the conclusion of logging.

The concentrations of the naturally occurring radionuclides potassium, uranium, and thorium are typical for Hanford sediments.

Man-made Radionuclides

Cesium (Cs-137) was identified from 0.0' to 28.0', 34.5' to 41.0', intermittently from 43.5' to 47.5', and from 55.0' to 77.5'. The maximum activity of 33.2 pCi/g occurred at 1.0'.

Presence of Cobalt (Co-60) was analyzed, but it was not identified. The Co-60 plot track is included on the plot for uniformity in presentation.

Westinghouse Hanford Company
RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: C-103 TANK

Borehole	<u>30-03-07</u>		
Coordinates	<u>NA</u> N	<u>NA</u> W	Feet (Hanford System)
Elevation	<u>NA</u> ft	Top of casing	

Borehole Environment Information

Borehole liquid depth <u>None</u> (ft) from zero (0.0) depth reference of log			
Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
6	0.280	0.0	98.0

RLS Passive Spectral Gamma Survey Information

Logging Engineers <u>R. Cram</u> <u>J. Kiesler</u>					
Log depth reference at zero (0.0) depth is <u>ground level</u>					
Log Date	Archive file names	Log mode	speed	Depth interval (ft)	
				Top	Base Incr
Feb 15, 1994	C300307\A521	MSA	80sec RT	0.0	96.5 0.5

MSA: Move Stop Acquire

RT: Real Time

Calibration and Analysis Information

RLS Calibration Date: Nov. 21, 1991	
Calibration Report: WHC-SD-EN-TRP-001	
Analyst Names: <u>S. E. Kos</u>	<u>R. K. Price</u>
Analysis Date: <u>Feb 23, 1994</u>	
Analysis Notes: <u>Drywell, single casing</u>	
Radionuclides Identified: <u>Cs-137</u>	

RLS Spectral Gamma-Ray Borehole Survey

Project: C-Tank Farm

Log Date: Feb 15, 1994

Borehole: 30-03-07

Analysis Date: Feb 23, 1994

RLS Spectral Gamma-Ray Borehole Survey

Project: C-103 TANK
Borehole : 30-03-07

Log Date : Feb 15, 1994
Anal Date: Feb 23, 1994

RLS Borehole Survey Report

Borehole: 30-03-07

Casing	Depth: 0.0' - 98.0'	Size: 6"	Thickness: 0.280"
Water	None		
Survey	Depth: 0.0' - 96.5'		Date: Feb 15, 1994

General Notes:

The well was surveyed from outside of the tank farm with the sheave suspended from the boom trailer.

The well was surveyed from 0.0' to 96.5' at an acquisition time of 80 sec RT; the sample interval is 0.5'. A repeat section was conducted from 94.0' to 96.5', and a 300 sec stationary measurement was acquired at 96.6'. This data is included on the plots.

The concentrations of the naturally occurring radionuclides potassium, uranium, and thorium are typical for Hanford sediments.

Man-made Radionuclides

Cesium (Cs-137) was identified from 0.0' to 40.0', 42.5' to 60.0', 61.5' to 64.5', intermittently from 75.5' to 93.5', and from 96.0' to 96.5'. The maximum activity of 25.2 pCi/g occurred at 0.0'.

Presence of Cobalt (Co-60) was analyzed, but it was not identified. The Co-60 plot track is included on the plot for uniformity in presentation.

Westinghouse Hanford Company
RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: C-103 TANK

Borehole	<u>30-03-09</u>		
Coordinates	<u>NA N</u>	<u>NA W</u>	Feet (Hanford System)
Elevation	<u>NA</u> ft	Top of casing	

Borehole Environment Information

Borehole liquid depth <u>None</u> (ft) from zero (0.0) depth reference of log			
Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
6	0.280	0.0	96.0

RLS Passive Spectral Gamma Survey Information

Logging Engineers <u>R. Cram</u> <u>J. Kiesler</u>						
Log depth reference at zero (0.0) depth is <u>ground level</u>						
Log Date	Archive file names	Log mode	speed	Depth interval (ft)		
				Top	Base	Incr
Feb 14, 1994	C300309\A520	MSA	80sec RT	0.0	95.5	0.5

MSA: Move Stop Acquire
RT: Real Time

Calibration and Analysis Information

RLS Calibration Date: Nov. 21, 1991	
Calibration Report: WHC-SD-EN-TRP-001	
Analyst Names: <u>S. E. Kos</u>	<u>R. K. Price</u>
Analysis Date: <u>Feb 15, 1994</u>	
Analysis Notes: <u>Drywell, single casing</u>	
Radionuclides Identified: <u>Cs-137, Co-60</u>	

RLS Spectral Gamma-Ray Borehole Survey

Project: C-Tank Farm

Log Date: Feb 14, 1994

Borehole: 30-03-09

Analysis Date: Feb 15, 1994

RLS Spectral Gamma-Ray Borehole Survey

Project: C-103 TANK
Borehole : 30-03-09

Log Date : Feb 14, 1994
Anal Date: Feb 15, 1994

RLS Borehole Survey Report

Borehole: 30-03-09

Casing	Depth: 0.0' - 96.0'	Size: 6"	Thickness: 0.280"
Water	None		
Survey	Depth: 0.0' - 95.5'		Date: Feb 14, 1994

General Notes:

The well was surveyed from outside of the tank farm with the sheave suspended from the boom trailer.

The well was surveyed from 0.0' to 95.5' at an acquisition time of 80 sec RT; the sample interval is 0.5'. A repeat section was conducted from 93.0' to 95.5'; the data is included on the plots

The concentrations of the naturally occurring radionuclides potassium, uranium, and thorium are typical for Hanford sediments.

Man-made Radionuclides

Cesium (Cs-137) was identified from 0.0' to 41.0', 45.0' to 62.0', and intermittently from 64.0' to 95.5'. The maximum activity of 54.2 pCi/g was occurred 0.0'.

Cobalt (Co-60) was identified from 78.5' to 95.5'. The maximum activity of 3.8 pCi/g occurred at 79.0'.

30-03-01

Tank Farms Gross Gamma-Ray Log

Activity, cps

Depth, Feet

30-03-03

Tank Farms Gross Gamma-Ray Log

Activity, cps

Depth, Feet

30-03-05

Tank Farms Gross Gamma-Ray Log

Activity, cps

Depth, Feet

30-03-07

Tank Farms Gross Gamma-Ray Log

Activity, cps

Depth, Feet

30-03-09

Tank Farms Gross Gamma-Ray Log

Activity, cps

Depth, Feet

05-300030

05-300030

0.02

0.02

0.02

0 20

11-8-93

40

60

3-26

80

100

120

140

51 57011303 // 4 (13) 75281003

31 DEC 1957

APPENDIX C

CORRESPONDENCE

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P.O. Box 1970 Richland, WA 99352

November 23, 1988

8857174

Mr. R. E. Gerton, Director
Waste Management Division
U. S. Department of Energy
Richland Operations Office
Richland, Washington 99352

Dear Mr. Gerton:

FINAL UNUSUAL OCCURRENCE REPORT, WHC-UO-88-034-TF-05

The attached Unusual Occurrence Report, "The automatic FIC surface level measurement indicates a decreasing trend in the liquid level in Tank 241-C-103, -0.50 inch since December 1984. No decrease criteria have been violated," documents an event in which the integrity of a single shell tank was in question.

Tank Farm Plant Engineering and Tank Farm Surveillance Analysis & Support performed a single shell waste storage tank integrity evaluation and determined that the total loss of liquid in Tank 241-C-103 over the past six years can be accounted for by the natural breathing of the tank and its adjunct active ventilation system.

The event had no programmatic impact. Public Health and Safety were not affected.

This report has undergone a classification and Unclassified Controlled Nuclear Information (UCNI) review and the report is satisfactory for public release.

Very truly yours,

DD Woodrich for

H. F. Daugherty, Manager
Defense Waste Management Division

bmh

Attachment

DOE-HQ - Director, Quality Assurance

DOE-OR - William Cooper
J. L. Meinhardt

DOE-RL - J. L. Rhoades
A. W. Kellogg (w/o attachment)
G. J. Bracken

Unusual Occurrence Report

Contractor: Westinghouse Hanford Company

1. Report Number WHC-UO-88-034-TF-05
Reference: TFS&O-EFS-88-0124

Date of Report: Initial - 10-11-88
Interim
Final - 11-21-88

Date of Event/Occurrence 10-03-88
Time of Event/Occurrence _____

Division/Department or Project: Tank Farm Surveillance Analysis & Support

2. Facility, System, and/or Equipment

Tank 241-C-103 C-Farm 200 East Area

3. Subject of Event/Occurrence

The automatic FIC surface level measurement indicates a decreasing trend in the liquid level in Tank 241-C-103, -0.50 inch since December 1984. No decrease criteria have been violated.

4. Apparent Cause: Design _____ Material _____ Personnel _____ Other X _____

The decrease in the liquid level in Tank 241-C-103 is attributed to evaporation.

5. Description of Event/Occurrence

gts A baseline of 67.40 inches was established for Tank 103-C on July 30, 1979, after the tank was pumped to 104-C. The leak detection decrease criterion for the tank is -0.50 inch from this baseline. From August 1979 to September 1981, the automatic FIC surface level measurement increased from 67.45 inches to 68.10 inches (+0.65 inch). The level appeared constant at 68.10 inches until December 1984, when the level started to show a very slow decrease to March 1988 when the level reached 67.60 inches (-0.50 inch). The level has remained stable at 67.60 since March 1988. The leak detection criteria have not been exceeded.

During the period of the reported decrease, there was an exhaustor connected to the central ventilation cascade system containing this tank.

Tank 103-C was also under investigation in 1987 due to leak detection dry well (30-03-09) radiation level increase (Environmental Protection Deviation Report 87-10). Two additional drywells associated with Tank 103-C (30-03-01 and 30-03-03) have indicated the presence of radionuclides since first monitored in 1974, but are showing no increase at this time.

Event Fact Sheet TFS&O-EFS-88-0124 was issued October 3, 1988.

6. Operating Conditions of Facility at Time of Event/Occurrence

Inactive, partial interim isolated single shell underground waste storage tank.

7. Immediate Evaluation:

Although the surface level measurement appeared to be stable from September 1981 until December 1984, a statistical evaluation performed by Process Chemistry & Engineering Laboratories showed an indication that sometime between August 1982 and August 1983, the liquid level began to decrease.

Tank Farm Plant Engineering (TFPE) and Tank Farm Surveillance Analysis & Support (TFSA&S) investigations concluded that the total loss of liquid in Tank 241-C-103 over the past six years can be accounted for by the natural breathing of the tank and its adjunct active ventilation system.

8. Immediate Action Taken and Results:

- 1) The FIC was flushed and calibrated May 20, 1987. Readings were unchanged.
- 2) Drywells associated with Tanks 241-C-103, 105 and 106 were monitored with the neutron probe on June 12, 1987. The results indicated that no significant changes had occurred.
- 3) Directional and multichannel analyzer data was obtained for drywell 30-03-09 (June 26, 1987, and July 2, 1987). The directional probe test results found that the only radioisotopes found at the 80-ft depth were cobalt-60 and naturally occurring potassium-40. Tank Farm Plant Engineering investigation evaluation, addressing Environmental Protection Deviation Report 87-10, concluded the increased radiation levels in drywell 30-03-09 were due to a material migration from an old transfer line leak.
- 4) In-tank photographs were taken July 22, 1987, and showed a liquid surface. The FIC plummet is contacting liquid.

9. Is Further Evaluation and/or Corrective Action Necessary? Yes ☐ No ☒
If Yes, Before Further Operation? Yes ☐ No ☐

If Yes, By Whom? N/A
When?

10. Final Evaluation and Lessons Learned

Emergency pumping is not justified. This tank will be stabilized as scheduled.

Ninety eight of the 149 single shell tanks (SST) have been stabilized. An active program has been defined to interim stabilize the remaining SSTs with a completion target date of 1996. The environmental impact of working to this date has been evaluated and is found to be acceptable.

11. Corrective Action Taken ☐ Recommended ☐ To Be Supplied ☐

N/A

12. Programmatic/Project Cost and Schedule Impact:

N/A

Unusual Occurrence Report

Contractor: Westinghouse Hanford Company

1. Report Number WHC-UO-88-034-TF-05

13. Impact Upon National Codes and Standards, Including NE Standards

N/A

14. Similar Unusual Occurrence Report Numbers:UOR#OR#

WHC-UO-88-028-TF-03

82-01

WHC-UO-88-029-TF-04

81-03

15. Signatures:

Originator *D.J. Vermeulen* Date 11-21-88
 NJ Vermeulen, Engineer, TFSA&S

Approved by *RK Welty* Date 11-21-88
 RK Welty, Manager, TFSA&S

Approved by *R.B. Gelman* Date 11-21-88
 RB Gelman, Manager, Chemical Plant Quality Assurance

Approved by *AR Schade* Date 11-21-88
 AR Schade, Manager, Nuclear Facility Safety

Approved by *RJ Baumhardt* Date 11-22-88
 RJ Baumhardt, Manager, Tank Farms

Approved by *DD Daugherty* Date 11/23/88
 HF Daugherty, Manager, Defense Waste Management Division

Approved by *R.E. Wheeler* Date 11-22-88
 GD Carpenter, Manager, Environmental Assurance

Classification *RA Zinsli* 11-22-88 ☒ Unclassified
 RA Zinsli ☒ Not UCNI

ENVIRONMENTAL PROTECTION DEVIATION REPORT

DEPARTMENT	FACILITY	WORK AREA
Tank Farm Surveillance & Operations	241-C Tank Farm, Tank 103-C	200 East
PORT NO.	DATE AND TIME OF EVENT/SITUATION	
87-10	May 1987	

SUBJECT

Increasing Radiation Levels in Dry Well No. 30-03-09

1. DESCRIPTION OR EVENT/SITUATION

☒ Material
 ☐ Equipment
 ☐ Procedure
 ☐ Personnel
 ☐ Other

Although there has been no criteria violation, the radiation levels measured in dry well 30-03-09 have shown a small increase over the past two years. The radiation profile at a depth of approximately 80 feet appears broader and the peak height has increased from about 80 c/s to 130 c/s.

FIC Liquid level data reviewed for the past five years appears stable at ~68.00 inches (+0.20 inches) with no evidence of leakage. However, the activity in dry well 30-03-09 is associated with tank 103-C, because of its close proximity to the tank and also the fact that two additional dry wells associated with tank 103-C (30-03-01 and 30-03-03) have indicated the presence of radionuclides since first monitored in 1974.

2. OPERATING CONDITIONS OF THE FACILITY AT TIME OF EVENT/SITUATION

Tank 103-C is a 530,000 gallon capacity waste storage tank that is classified sound/deactivated. The tank contains ~175,000 gallons of sludge, 25,000 gallons of supernatant plus 14,000 gallons of drainable interstitial liquor (reference RH0-RE-SR-14, March 1987).

Dry well 30-03-09 is located on the East side of the tank approximately five feet from the tank footing. There are five dry wells directly associated with tank 103-C. All were drilled and monitored for the first time in 1974.

3. IMMEDIATE EVALUATION, RESULTS AND RECOMMENDATIONS

After reviewing available data, it is difficult to say if tank 103-C has a very small leak or if existing radionuclides in the soil from a previous leak are being redistributed. However, the activity in dry wells is very strong evidence that tank 103-C has leaked.

Dry wells are of limited use as a leak detection tool because ruthenium that moves so readily with a leak front is no longer present in measurable quantities in single-shell tank waste. Tank 103-C waste does however, contain cobalt-60.

Laboratory test show that the drainable interstitial liquor taken from core samples of the waste in tank 103-C contain about 40 uCi/liter of cobalt-60. Core samples of the waste in tanks adjacent to tank 103-C (tanks 102-C, 105-C, and 106-C) contain negligible amounts of cobalt-60.

Recommendations

If appropriate, a peer review team should be established to determine the integrity classification of tank 103-C.

4. CORRECTIVE ACTION RESPONSE

DUE DATE 6/12/87

Action

1. Directional and multichannel analyzer data should be obtained for dry well number 30-03-09. (completed)
Tank Farm Surveillance and Operations
2. Flush and recalibrate FIC (Completed 5/20/87).
Tank Farm Surveillance and Operations
3. Monitor the dry wells associated with tanks 103-C, 105-C and 106-C with the neutron probe. (completed 6/12/87)
Tank Farm Surveillance and Operations
4. Obtain in-tank photographs. Tank Farm Surveillance and Operations (completed 7/22/87)

ORIGINATED BY: B. W. Anderson *B. W. Anderson* TITLE Specialist

DATE 5/22/87

APPROVED BY: D. R. Ellingson *D. R. Ellingson* TITLE Manager, WMHP

DATE 5/22/87

DISTRIBUTION:	B. W. Anderson	D. W. Lindsey	J. H. Roecker
	F. E. Boyd	P. E. McCourt	R. H. Sucmann
	C. R. Groth	G. C. Owens	B. F. Weaver
	D. G. Harlow	R. E. Peterson	J. C. Womack

DEPARTMENT

Tank Farm Surveillance & Operations

FACILITY

241-C-103

WORK AREA

200 West

REPORT NO.

-10

DATE AND TIME OF EVENT/SITUATION

Previous Six Months

SUBJECT

241-C-103 Slight Upward Trend In Drywell Data -

1. DESCRIPTION OR EVENT/SITUATION

☒ Material ☐ Equipment ☐ Procedure ☐ Personnel ☐ Other

This preliminary report is based on a slight upward trend in the radiation drywell data over the past six months. There has been no violation of criteria.

2. OPERATING CONDITIONS OF THE FACILITY AT TIME OF EVENT/SITUATION

241-C-103 is a 75-foot diameter, 530,000-gallon capacity, single-wall tank. This tank is categorized as sound/deactivated. The measuring device is an automatic FIC.

3. IMMEDIATE EVALUATION, RESULTS AND RECOMMENDATIONS

The immediate evaluation was set forth in the attached letter. It is recommended that the investigation continue at the present level of effort. If a criteria is violated or the present investigation confirms the anomaly a follow-up deviation report will be written.

4. CORRECTIVE ACTION RESPONSE

DUE DATE 6/1/87

References: 1) Memorandum, Analytical Systems Laboratories, 12221-ASL88-065
2) Memorandum, Single-shell Tank Process Engineering Unit, 13331-88-088

The dry well 30-03-09 radiation peak increase was considered to originate from an old pipeline leak near tanks 104-C and 105-C. Based on information referenced above, we recommend that this EPDR 87-10 be closed.

Approval

N. J. VermeulenR. K. WeltyR. J. BaumhardtORIGINATED BY: V. D. Maupin *V.D. Maupin* TITLE Senior Engineer

DATE 5/1/87

APPROVED BY: D. R. *D. R. Ertling* TITLE Manager, WMHP

DATE 5/18/87

DISTRIBUTION:	F. E. Boyd	D. W. Lindsey	R. H. Sugman
	D. R. Groth	G. C. Owens	B. F. Weaver
	D. G. Harlow	J. H. Roecker	J. C. Womack

From: Analytical Systems Laboratories
Phone: 3-2378 MO-037/200W
Date: September 18, 1987
Subject: INVESTIGATION OF DRY-WELL 30-03-09 IN THE C-TANK FARM WITH HIGH
RESOLUTION GAMMA RAY SPECTROSCOPY

65452-87-242

To: CM Walker 2750E/200E

cc: DA Dodd MO-037/200W
DR Ellingson 2750E/200E
DR Groth 2750E/200E
DW Lindsey 2750E/200E
VD Maupin 2750E/200E
FS Stong 271T/200W
RR Rios 2750E/200E
RC Routson 2750E/200E
RK Welty 2750E/200E
WHU File/LB

BACKGROUND

Total gamma ray profiles of well 30-03-09 in the C-tank farm, made by Tank Farms Operations, have shown a zone of elevated activity at a depth of approximately 80 feet for at least 13 years. Recently, the activity in this zone exceeded an alarm limit. The Analytical Systems Laboratories were asked to investigate the zone to determine specific radionuclides and the direction of highest activity. These measurements were requested to identify the source of contamination.

EQUIPMENT

To characterize these radionuclides in-situ, a high resolution germanium gamma ray detector in the form of a sonde was lowered into this well using the Mobile Radionuclide Analysis Laboratory II (MRAL II). A slotted radiation shield mounted on the detector was used to determine the direction of highest activity. Data from the detector was collected in a multichannel analyzer, which orders gamma ray data for display into histograms called spectra (x-axis = gamma ray energy, y-axis = population). The spectra were computer analyzed for radionuclide identity and activity levels based on geometry standards. Spectra and collection parameters are archived on floppy disk.

CM Walker
Page 2
September 18, 1987

65452-87-242

ANALYSES

The maximum activity for the zone was determined to be at 79.5 feet and spectral analysis of this activity showed the only man-made radionuclide to be cobalt-60 (Co-60). Two other zones of elevated activity at 7.5 and 48.5 feet were also examined to identify radionuclides. Only cesium-137 (Cs-137) was detected. Directional measurements at a depth of 79.5 feet showed approximately a 20% increase in Co-60 activity in the south-southeast direction.

DISCUSSION

The presence of Co-60 alone at 79.5 feet and Cs-137 alone at 7.5 and 48.5 feet may have arisen in several ways. Vertical separation by the soil for a mixture of Co-60 and Cs-137 that started close to the surface and near this well is easy to visualize, but two pieces of evidence show this to be unlikely. First, if vertical movement had occurred, it should be observable over the last 13 years, but no significant movement of the zones at 48.5 or 79.5 feet has been observed. Second, since water is considered to be the most likely means of transport, the moisture level between these zones would be expected to be elevated. The moisture level has been observed to be low between these zones for at least the last six years. Cobalt-60 may have been borne into the zone in flowing water from near horizontal adjacent locations.

Over the last 13 years the activity of the zone at 79.5 feet has not decreased in a pattern consistent with radioactive decay. With a half-life of 5.27 years, the activity from a fixed quantity of Co-60 around the well would now (1987) be less than 20% of the 1974 level. This is not the case. It seems reasonable to assume that Co-60 is being transported into this zone at a rate slightly faster than it is decaying. Moisture profiles show an elevated level of moisture in the soil around the well at about 80 feet for at least the last six years, thus providing the means of transport. If the source of Co-60 remote from this well is fixed and not being replenished, this would mean that the amount of material flowing to the soil around well 30-03-09 is increasing because that fixed amount is being reduced by radioactive decay. Therefore, the total amount being transported must be increasing, possibly due to an increased water flow rate.

The directional data indicates only a 20% increase in activity in the south-southeast direction. The relatively low directionality of this data coupled with the penetrating nature of the Co-60 gamma rays at 1.173 MeV and 1.333 MeV tend to indicate that well 30-03-09 is within a formation with some extension to the south-southeast which may be due to plume contour rather than direction of flow.

CM Walker
Page 3
September 18, 1987

65452-87-242

Since Co-60 is not held up appreciably in most soils it may be that this is not a deposit but a moving stream of water containing Co-60. If so, then Co-60 in the stream continues past this well. Further, the Co-60 content of the water must be considerably higher than was observed in the well due to dilution by the soil.

Other wells in an upgradient position should show both increased gamma activity and moisture near 80 feet in depth [with a fairly wide separation to any other zones of increased activity (such as Cs-137 at 48.5 feet in this example)]. Wells 30-05-03 and 30-03-01 both show increased moisture and activity near 80 feet and wide separation between other zones of activity. Other nearby wells show some increase in moisture near 80 feet but no increase in gamma activity. A narrow plume containing Co-60 could exist along a path between 30-03-01, 30-03-09, and 30-05-03 (see attached figure). Also, this plume could extend further west toward well 30-05-07 (approximately 65 feet deep) which shows intense gamma activity along most of its length as a result of an old transfer line leak of materials high in Co-60.

RECOMMENDATIONS

Conjecture about the source of Co-60 at well 30-03-09 is based upon the hypothesis that a Co-60 plume originates near well 30-05-07 and extends through 30-05-03, 30-03-09, and 30-03-01. This is speculation at this point. What seems plausible is that moisture containing Co-60 is flowing to the soil around well 30-03-09 at a depth of 79.5 feet at a slowly increasing rate.

To confirm the presence of a plume, high resolution gamma ray data is needed from the surrounding wells to confirm the presence of Co-60. Further, this data should be assembled to show both moisture and radioisotope flows.

ACKNOWLEDGEMENTS

Thanks to Ray Cram who has kept MRAL II going and who helped to make this effort work. Thanks also to Fred Stong for our discussions and for sharing his insights into this problem.

W. H. Ulbricht, Chemist
Analytical Systems Laboratories

cse

Geologic Cross Section Drawings

I - I: DWG H-2-70503 I - I

H - H: DWG H-2-70504 H - H

FIGURE

Westinghouse
Hanford Company

Internal
Memo

From: FS Stong
Phone: 373-2046 MO-381/200West
Date: September 18, 1987
Subject: DRYWELL 30-03-09 DATA REVIEW

65261-37-128

To: CM Walker 2750E/A-108/200E

cc: DR Ellingson 2750E/C-100/200E
DR Groth 2750E/A-135/200E
DW Lindsey 2750E/A-107/200E
YD Maupin 2750E/A-108/200E
RR Rios 2750E/C-100/200E
CP Schroeder *CH* MO-381/001/200W
WH Ulbricht, Jr MO-936/200W
TB Veneziano 2750E/D-100/200E
RK Welty 2750E/D-201/200E
FSS/File/LB

Routine Drywell Van gross gamma profiles of "C" tank farm drywell 30-03-09 have revealed an increased indication of activity at 80 feet. (See Attachment 1). Mobile Radionuclide Analysis Laboratory (MRAL) gamma energy analysis has shown the activity to be due to Co-60. Static, less intense activity at 50 feet was determined to be due to Cs-137.

Drywell Van scans of pertinent wells around TK-103-C, 105-C and 106-C were used to provide additional data on soil moisture concentration and gross gamma activity for a global overview of the region. (See Attachment 2.) It should be noted that waste tank TK-102-C has no wells.

The very depth of the 30-03-09 radiation intercept at 80 feet tends to indicate that the activity has traveled some distance and is not simply a convoluted leak plum from adjacent TK-103-C downward. The mobility of Co-60 resulting from waste leakage greatly exceeds that of Cs-137 in the sediments. Therefore, alternatives to a leak from TK-103-C were immediately explored.

A preliminary review of the available data indicates that considerable support exists for an increasing moisture transport system from well 30-05-03 (See Attachment 3) to well 30-03-09 (See Attachment 4.) The latter has a similar moisture profile to the former but also indicates a rising moisture concentration at the 80 foot level. (Compare Attachment 4 with Attachment 5.) The actual moisture concentration at this point is difficult to assess with the present data because the depth of the plume is only a few inches across. The probe calibration relates to homogenous surrounding media rather than the thin layer encountered. Even so, the count numbers are sufficient to suggest the presence of enough moisture to result in movement. That is, the moisture concentration in the narrow plume can be in excess of 30% and probably has been on the increase.

volume

CM Walker
Page 2
September 18, 1987

There was an old transfer line spill in the vicinity of drywell 30-05-07. The profile of this well shows high levels of gamma activity, with a maximum of about 10 r/hr adjacent to the bottom of tanks TK-104-C and 105-C. (See Attachment 6.) This well only extends to a depth of 68.5 feet, but is contaminated to some extent over its full depth. Assuming the presence of Co-60 in this plume (which surely exceeds the depth of the well), selective migration in conjunction with the moisture transport system described previously is plausible. The migration seems to follow the direction indicated by the dotted arrow shown on Attachment 2; from adjacent well 30-05-07, passed 30-05-03, passed 30-03-09 and finally, passed 30-03-01. By contrast, wells 30-05-02, 30-05-04, 30-06-04, 30-03-03 and 30-03-05, which bracket the indicated migration, show no significant gamma activity at this depth.

Moisture profiles of many of the wells (eg., those just mentioned) exhibit profiles similar to 30-03-09 and 30-05-03 at about the 80 foot depth but do not indicate statistically significant gamma radiation. This would suggest that the moisture source is likely separate from the original radioactivity contributing leak plume and is intersecting it with the resultant transport. Determining the possible source and destination of this moisture (which can be natural drainage) may be important to a complete investigation of the radiological event.

The available data is insufficient to preclude the possibility that the activity in question results directly from a leak from one or more of the adjacent tanks. However, the situation overall seems pretty solid that the cause is transport of debris from the old spill. Additional testing data from the Drywell Van and the MRAL systems are needed for more definitive results. In this regard, a three dimensional color computer model of the data would greatly enhance this and future investigations.

The MRAL information was obtained from WH Ulbricht, Jr. with whom these results were coordinated.

J. S. Stong, Staff Engineer
Instrumentation Systems

kid

Attachments (6)

10-10-70

20
-27-87

40

50

80

100

ATTACHMENT 2

30-05-03
6-12-87

6-12-87

C-18

30-03-09 15X100

30-03-09

12/81

1000

From: Analytical Systems Laboratories
Phone: 3-2378 MO-936/200W T6-31
Date: February 11, 1988
Subject: REPORT OF 241-C TANK FARM WELL LOGGING

12221-ASL88-065

To: C. M. Walker R1-51

cc: J. R. Brodeur T7-25
D. A. Dodd T6-50
G. L. Dunford R1-51
D. R. Groth R1-51
A. G. Law R2-84
V. D. Maupin R1-51
R. C. Routson R2-84
J. P. Slougher T6-18
F. S. Stong ~~R2-78~~ X3-28
R. K. Welty R2-78
WHU File/LB

Please find attached the Analytical Systems Laboratories' results from the 241-C tank farm well logging investigation. If you have any questions, please contact me.

W. H. Ulbricht, Jr.
W. H. Ulbricht, Jr.
Chemist

cse

Attachment

SOURCE OF COBALT-60 ACTIVITY IN THE C-TANK FARM

INTRODUCTION

An increase in the gross gamma activity in well 30-03-09 at a depth of approximately 80 feet prompted an investigation of this well. High resolution gamma ray apparatus from the Mobile Radionuclide Analysis Laboratory (MRAL) II showed that this activity was due to cobalt-60 (Co-60) alone. Because the activity in the well decreased faster than was consistent with its half life of 5.27 years, the Co-60 was assumed to be flowing through the subsoil surrounding the well at the 80 foot depth. These findings were published in an internal letter #65452-87-242 on September 18, 1987.

The purpose of this work is to locate the probable source of the Co-60 contamination seen in well 30-03-09. Both gross gamma ray data and high resolution gamma ray data will be used to determine the Co-60 flow path and narrow the location of the Co-60 source. The location between tanks 104-C and 105-C was hypothesized in the above mentioned letter to be the source, and will be considered in the investigation.

OBSERVATIONSA. Investigation of Surround Wells

Wells close to 30-03-09 were checked for gross gamma ray activity patterns similar to those of 30-03-09. Of those, 30-05-03 and 30-03-01 showed increased activity at or near the 80 foot depth. These wells lie on a line that can be extrapolated through the region between tanks 104-C and 105-C. Table 1 presents a list of wells along this projection. Gross activity profiles of these wells were checked for increased activity at the depth of interest. Of those listed in Table 1, the ten wells marked with asterisks appear most likely to contain Co-60 and were logged using the high resolution gamma measurements system of MRAL II.

TABLE 1
SUSPECT WELLS

*30-03-01	*30-05-07
30-03-09	*30-05-08
30-03-07	30-05-09
*30-03-09	30-04-01
30-06-04	*30-04-02
30-05-02	*30-04-03
*30-05-03	*30-04-04
30-05-04	*30-04-08
*30-05-05	30-04-12
30-05-06	

The results of these in-situ analyses are shown in Figure 1. The depth at which Co-60 was found decreased from 95 feet at well 30-03-01 to 26 feet at well 30-04-03. Wells 30-04-04 and 30-04-08 located along this line but beyond 30-04-03 were found to be free of Co-60 contamination.

8. Activity Versus Time Along Flow Path

Profiles of gross activity as a function of time at a depth of 80 feet for well 30-03-09 and at 22 feet for well 30-04-04 are shown in Figure 2. There are similarities between the two curves. First, a general downward trend from 1975 to 1978 and a general upward trend between 1981 and 1987 are evident in both sets of data. Several rises in the 30-04-03 curve at 4/11/79, 4/27/82, and 3/27/82 follow similar rises in the 30-03-09 curve at 4/15/80, 3/24/83, and 4/17/85, respectively. The data for 30-03-09 is very similar to that to of 30-04-03 but is displaced about one year, possibly indicating that the flow of Co-60 from 30-04-03 to 30-03-09 took about one year.

A decay curve for Co-60 is superimposed over the initial portion of the 30-03-09 profile in Figure 2. Because the rate data lies below this curve, it indicates that the Co-60 activity is decreasing faster than by decay. For this to occur Co-60 must be removed from the vicinity of the well, a further indication that Co-60 is moving.

CONCLUSIONS

An investigation of the ten marked wells of Table I shows that Co-60, which was first detected in well 30-03-09, originates from the region between tanks 104-C and 105-C. This is supported by the following arguments:

1. Co-60 subsoil contamination followed a path that passes through well 30-03-09 and into but not beyond the 104-C and 105-C region.
2. The depth at which Co-60 was detected increased as the distance from the region between 104-C and 105-C tanks increased indicating both vertical as well as horizontal flow of Co-60 from that location.
3. The activity versus time profiles of wells 30-03-09 and 30-04-03 appear to show that activity passing by well 30-04-03 also passes by 30-03-09 about one year later.
4. The general trend of the curves indicates the possibility of at least two separate events which introduced radioactivity, one prior to 1975 and another in 1984-1986.

The region between tanks 104-C and 105-C contains a transfer line for introducing liquids into 105-C and a cascade line for allowing flow between the two tanks. Both lines make connections with tanks between 18 and 22 feet from the soil surface. Well 30-04-03 shows the shallowest Co-60 activity at a depth of 26 feet, which is consistent with a leaking line but does not rule out a tank leak. At this point there is not enough data to make sound judgments about the precise location of any leak.

Although this area appears to be the major source of the leak, other leakage paths cannot be entirely excluded. Gross gamma ray profiles were not very reliable in indicating the presence of Co-60. In many instances the Co-60

regions were found to be located below larger peaks on a gross gamma versus depth profile. The large peaks were from another contaminant, cesium-137. Therefore, it is possible that other paths of Co-60 contamination exist but did not appear on the gross gamma profiles. High resolution gamma ray investigations of the other wells listed in Table 1 would clarify this point.

The activity versus time profiles show correlation between wells 30-04-03 and 30-03-09. Causes of the activity increases have not yet been correlated with known occurrences.

FIGURE 2

Probe Activity (c/s)

WELL 30-03-07
GROSS GAMMA RAY PROFILE
DEPTH = 80'

RADIOACTIVE
DECAY CURVES
FOR 20-90

Probe Activity $\times 10^3$ (c/s)

WELL 30-04-03
GROSS GAMMA RAY PROFILE
DEPTH = 22'

DATE OF ASSAY

2/4/83
WHL

Westinghouse
Hanford Company

Internal
Memo

From: Single Shell Tank Process Engineering Unit 13331-88-088
Phone: 3-4258 2750-E/200-E R1-51
Date: February 22, 1988
Subject: ENVIRONMENTAL PROTECTION DEVIATION REPORT 87-10,
RADIATION LEVEL INCREASE IN DRYWELL 30-03-09

To: R. K. Welty R2-78

cc: R. J. Baumhardt	R2-40	V. D. Maupin	R1-51
F. E. Boyd	S5-04	R. C. Routson	R2-78
D. A. Dodd	T6-50	F. S. Stong	X3-28
G. L. Dunford	R1-51	W. H. Ulbricht	T6-50
D. R. Ellingson	R1-80	N. J. Vermeulen	R1-80
D. E. Forehand	T5-09	D. O. Wodrich	R2-51
D. G. Harlow	R2-01	C. M. Walker	R1-51
R. E. Larch	R2-53	DRG:CMW	File/LB

- References: (1) Memorandum, W. H. Ulbricht to C. M. Walker,
"Report of C Farm Data Logging,"
February 11, 1988.
- (2) Memorandum, W. H. Ulbricht to C. M. Walker,
"Investigation of Dry Well 30-03-09 in the C-Tank
Farm with High Intensity Gamma Ray Spectroscopy,"
September 18, 1987.
- (3) Memorandum, F. S. Stong to C. M. Walker, "Dry
Well 30-03-09 Data Review," September 18, 1987.
- (4) Memorandum, D. R. Groth to R. J. Baumhardt,
"Increasing Radiation Readings in Drywell
30-03-09," July 22, 1987.
- (5) Memorandum, D. R. Groth to R. J. Baumhardt,
"Increasing Radiation Levels in Drywell
30-03-09; TK-103-C," July 9, 1987.
- (6) Memorandum, W. H. Ulbricht to C. M. Walker,
"Logging of Dry Well 30-03-09 in C Tank Farm,"
July 2, 1987.
- (7) DSI, D. R. Groth to B. F. Weaver, "Increasing
Radiation Levels in Drywell 30-03-09,"
May 28, 1987.
- (8) Environmental Protection Deviation Report
Number 87-10, B. W. Anderson, "Increasing
Radiation Levels in Drywell 30-03-09."
May 22, 1987.

R. K. Welty
Page 2
February 22, 1988

13331-88-088

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- (9) Memorandum, S. S. Bath to J. W. Bailey, "Heat Study of TK-104-C," December 13, 1977.
 - (10) Atlantic Richfield Hanford Occurrence Report 74-120, G. T. Dukelow, "Increasing Dry Well Radiation Between Tanks 104-C and 105-C," August 21, 1974.

It is the purpose of this letter to summarize the findings of engineering investigations undertaken in response to the reference (8). These studies are now completed, and it is hereby concluded that the activity increase observed at the 80-foot depth in Leak Detection Drywell (DW) 30-03-09 is not the result of liquid leakage from either Tank 241-C-103 or any other 241-C farm tank. Instead, the change is due to migration of old contamination from an area between Tanks 241-C-104 and -105. The investigation results and recommendations for further action are stated in the following discussion.

DISCUSSION

The initial investigation addressed Tank 241-C-103 as the possible source of the gamma activity increase detected at the 80-foot depth in DW 30-03-09. The studies designed to determine tank integrity included a liquid level history review, in-tank photography to confirm the validity of the measurement data, soil moisture analysis at drywells in the near vicinity, and special scans (directional and multi-channel) to identify the radionuclide(s) and a possible direction of movement. On the basis of results obtained, it was concluded that Tank 241-C-103 was not the source of the activity increase. All of these studies have been covered in references (4), (5), (6) and (7), and there is no need for further discussion in this letter.

With elimination of Tank 241-C-103, further effort was directed to other possible locations. A first clue was provided by review of well scan (neutron and gamma) data, and of geologic cross section drawings of the underlying vadose zone. Here it was noted [references (3) and (4)] that the DW 30-03-09 radiation profile coincided with a moisture peak seen in the neutron probe scans, and that certain of the near-vicinity wells showed similar moisture peaks at the same general depth. Also, these depths appeared to diminish in a northwesterly direction (i.e., toward Tanks 241-C-105 and -104). This suggested a sloping water lens as an active carrier of the mobile cobalt-60 radionuclide, and the geologic profile maps appeared to support the possibility. It was thereby recommended that wells intercepting this lens (see Attachments I and II) be investigated to track the path of migration. Pertinent information derived at this time were the following:

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The only radionuclide detected in the 80-foot depth peak of DW 30-03-09 was cobalt-60. However, this could not be used to identify a specific tank, because varying amounts of the material were found in the core and supernatant assays for each of the Tanks 241-C-101 through -106.

With the one exception of DW 30-04-03, all of the other 241-C Farm dry well scans were stable over the past thirteen years, or exhibited evidence of radiation level decrease of their existing contamination. The radiation increase in DW 30-04-03 was at the 20/24-foot depth and commenced in 1985.

The 241-C Farm geology maps show stratification in the underlying soils at depths generally corresponding to the depths and the slope suggested by the neutron probe scans (see Attachment II).

Attachment III is a record of the DW 30-03-09 radiation readings taken at the 80-foot depth. The most significant feature of this plot is its inconsistency; where a first indication of instability was seen in 1985, and which was then followed by a period of decrease before the final increases that continued through June, 1987. Finally, the most recent data suggest a second decrease trend. As the activity has been identified as cobalt-60, with a half life of 5.25 years, the decreases over such short periods are not consistent with a typical contamination plume. Instead, the readings suggest the intermittent introduction of activity into a water lens, and transport to and beyond the well. It has also been noted [reference (5)] that gamma activity was seen at the same depth when the well was first scanned in 1974. This activity (166 cps) subsequently decreased to normal background by early 1981. It is therefore evident that this well has had a long history of sporadic activity at the 80-foot depth.

On September 22, 1987, funding was provided for the performance of the special scans recommended by reference (2). However, accomplishment was superseded by other Analytical Systems Laboratory monitoring commitments, and the work was not completed until January 18, 1988. The tests [reference (1)] found that the depth at which cobalt-60 was detected decreased until DW 30-04-03 was reached (see Attachment I), and wells beyond this point (30-04-04 and 30-04-08) showed no cobalt-60. The shallowest depth at which cobalt-60 was found in DW 30-04-03 was 26 feet. As this level is in proximity to that of the fill and cascade piping and is well above the 104C/105C liquid levels over the past eight years, the activation source appeared to be in the region of the pipelines. As an attachment, reference (1) had a plot of activity at the 80-foot depth in

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DW 30-03-09 and at 22 feet for DW 30-04-03 as a function of time since 1974. These graphs (see Attachment IV) show interesting similarities: first a downward trend from 1975 to 1978, and then a general upward trend between 1981 and 1987. While similar, there is a displacement of approximately one year between the DW 30-04-03 data and that of DW 30-03-09. Again, it is to be noted that the 22-foot depth for the DW 30-04-03 data suggest a transfer line source.

Earlier investigations of the extremely high levels of contamination found between Tanks 104-C and 105-C are described in reference (10). The following observations were documented at that time and were the bases for the conclusion that both tanks were sound:

The occurrence report was issued in 1974 in response to a radiation increase at the 40-foot depth in DW 30-04-02. The well is at a midpoint between the two tanks, and first scans (taken in 1972) showed high levels of contamination between 15 and 40 feet. Initial action involved the drilling of four exploratory wells between the two tanks (and two others, see Attachment I), and the first scans in all but one (DW 30-04-01) showed extremely high levels of activity at depths commencing at 15 to 21 feet. These depths coincided with those of the tank fill line V103 at a point where it passes over the cascade pipeline and the fill and cascade pipe tank wall penetrations (see Attachment V).

The fill line V-103 was stated to have been abandoned at an earlier date due to pipeline leakage, and the activity noted in DW 30-03-02 could have been due to migration of pre-existing contamination that was first seen in the exploratory well scans. This line was a part of the old PUREX supernatant (PSN) transfer route from Tank 241-AX-101. The material was thermally hot, and water injection was required to maintain a temperature below 60°C. The cause of failure was believed to have been due to thermal shock induced by the intermittent transfers.

In-tank photographs failed to show any evidence that either tank was unsound. However, the Tank-241-C-105 photos indicated that the tank had been filled to a level above that of the cascade and sidefill pipelines. The possibility of leakage through the wall penetration seals was discussed.

The liquid levels in Tank 241-C-105 and -104 remained at a high level for almost six months after the first exploratory well scans, and the observed activities, including that in DW 30-03-02, had

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remained stable throughout, whereas seepage from either tank would normally have been seen as steadily increasing radiation at the 35 to 41 feet farm excavation depth. The activity at this depth however has diminished in all wells since 1974.

The above discussion is the basis for a conclusion that the radiation peak changes were due to transport of debris from an old pipeline spill. However, there remains the question of cause for the liquid level decrease observed in Tank 241-C-104, which commenced at the time that the Tank 241-C-105 12-inch inlet vent (R-13) was sealed by Project B-181 isolation activities. The deviation was first reviewed shortly thereafter and then again in 1983 when in-tank photographs showed the waste surface to be approximately 85 percent exposed solids (the surface liquid volume was estimated to be less than 3000 gallons). In both cases, the changes noted were attributed to evaporation and mass transport to an operating exhaustor via the Tank 104-C/105-C cascade pipeline. Justification was based upon ventilation balance measurements that indicated negative pressures in both tanks and a pressure differential in the range of -0.4" WG. Calculations, using this pressure drop and an estimated vapor space temperature of only 85°F, amply accounted for the liquid level change. Also, Tank 241-C-105 outlet air psychrometric measurements consistently accounted for the 104-C/105-C total change. Of further significance is the period between December 1984 and March 1985 when the Project B-480 105-C/106-C exhaustor was upgraded. The liquid level showed a slight increase in the daily readings during this period, and the trend returned to a decrease subsequent to work completion. Reference (9) describes the heat load of this tank and states that wall temperatures could reach 325°F after the tank has evaporated to dry solids. Attachment VI is a summary description of the Tank 241-C-104 status.

ACTIVATION MOISTURE SOURCE

Finally, there is the question of a moisture source sufficient to activate movement of the contamination from the vicinity of the cascade and fill pipelines, and then along the 60'- 80' lens in the vadose zone. The most credible possibility is condensate leakage from the cascade pipeline, or through the old packing (Oakum) seals at the cascade and fill pipe tank wall penetrations. These seals were installed when the tank was constructed in 1944 and are of a type no longer considered acceptable for such an application. Leakage from such wall penetrations has been noted elsewhere and is called the "Cold Finger Effect" in the literature. This condensate could include cobalt-60 aerosols. A second

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possibility is activation by pressurization of the V103 pipeline at the time of the contamination release from the 241-C-151 Diversion Box on January 11, 1985. Line V103 is from this box, and investigations subsequent to the event found that its wall nozzle had not been blanked. The possibility that a significant volume of water could have entered the pipe during box decontamination operations was examined, but it has been determined that very little water was used (telecon, H. L. Winters to C. M. Walker, January 10, 1988). However, it is interesting to note that the evidence of activity increase at the 23-foot depth in Drywell 30-04-03 and the 80-foot depth in Drywell 30-03-09 was not seen until some time after this event. Isolation blanks are now in place on all 241-C-151 wall nozzles, and the box itself has been weather sealed.

Another possibility is that movement of activity along the moisture lens beneath the farm could be from a totally different source than that within the old contamination plume. Reference (3) discusses the fact that many of the 241-C Farm wells exhibit moisture profiles similar to that of DW 30-03-09, but show no statistically significant gamma radiation. This indicates a possibility that contamination is channeling down and is being picked up and transported laterally by water moving within the lens. The reference further states that determination of the source and destination of this moisture (which could be natural drainage) may be an important facet of this investigation.

RECOMMENDATIONS

1. The long term status of Tank 241-C-104 should be reviewed to define a possible need for supplemental ventilation. After evaporation of the estimated 26,000 gallons of interstitial liquid remaining, reference (9) states that tank wall temperatures could reach 325°F. An additional benefit to be derived by tie-in of the tank to the 105C/106C exhaustor would be the elimination of the cascade pipeline as a condensate leakage source.
2. The neutron probe scans are seen as a valuable resource in the assessment of moisture movement within the tank farms and in the underlying sediments. However, procurement frequency and technological modifications are needed. The following actions are recommended:

Selected dry wells (approximately 12 per farm) should be committed to a once-per-yr scan schedule. The only scans available to this investigation were those taken in 1981 and a selected number specially requested in 1987.

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The Analytical Systems Laboratory should be tasked to develop a surveillance technology that is both more reliable and which can be calibrated to indicate specific levels of moisture. The Analytical Systems Laboratory special monitoring van is now being upgraded, and soil moisture analysis should be one of its new capabilities.

Tank Farm Plant Engineering obligations in the EPOR 87-10 investigation are now considered to have been completed. Should you require additional information, please contact either myself or Mr. C. M. Walker on 373-1844.

D. R. Groth, Manager
Single Shell Tank Process Engineering Unit

bjb

Attachments 7

Radiation Readings: DW 30-03-09

Peak Reading at the 80-Foot Depth

C-37

Counts Per Second

Regression Analysis

Time
— St.Dev. 1/-25.439

x Polyno

ATTACHMENT III: DW 30-03-09 Radiation Peak History

Counts per Second
(Thousands)

Counts per Second

ATTACHMENT V: C-Farm Plot Plan

SUMMARY

TK-104-C is categorized Sound/Deactivated. The tank was under investigation in 1974 due to a leak-detection dry well (30-04-02) radiation level increase between March and July of that year. Additional dry wells (30-04-03, 30-04-04, and 30-04-05) were drilled at that time, and none have shown any significant increases. Soil auger samples were taken in support of the investigation, and these too did not identify TK-104-C as a leak source. The investigation results (reference a) indicated that the activity was due to an old TK-105-C overflow through spare inlets and cascade line packing. The tank received approximately 11,000 gal of insoluble strontium-leached sluicing solids (terminal solids) during 1977. The strontium 89-90 contents of this material is calculated as being no more than 255 kCi, but the quantity is anticipated to result in a high-heat load after removal of interstitial liquid (reference b).

The tank contains an estimated 41.9 kg of fissile material, with approximately 31.1 kg being ²³⁵U received during the PUREX thorium campaigns between 1969 and 1972.

Two Operating Limit Deviation Reports (OLDR) were issued in 1982 because of surface-level measurements exceeding the decrease criterion. OLDR 82-02 was issued in February and 82-07 in May. The investigation attributed the decreases to evaporation. Environmental Protection Deviation Report (EPDR) No. 83-04 was issued in November 1983 because the liquid-level measurement exceeded the decrease criterion. The decrease was attributed to evaporation and reduced liquid area in contact with the FIC plummet. Dry wells associated with tank 104-C have remained stable during the review period and are now the primary means of leak detection as the surface liquid continues to be removed by evaporation.

- Reference:
- (a) Occurance Report 74-120, "Radiation Increase in Drywell Between TK-104-C and TK-105-C," August 21, 1974.
 - (b) Letter dated December 13, 1977, S. S. Bath to J. W. Bailey, "Heat Study for TK-104-C."

ACTION CRITERIA

1. Dry-well increase: see p. 30-00-04.
2. Liquid-level limits: see p. 30-00-05.

ATTACHMENT VI: Summary of Status - Tank 241-C-104

ENGINEERING DATA TRANSMITTAL

1. EDT 121736

2. To: (Receiving Organization) Distribution		3. From: (Originating Organization) Waste Characterization Analysis		4. Related EDT No: N/A	
5. Proj/Prog/Dept/Div:		6. Cog/Proj Engr: S. W. Claybrook		7. Purchase Order No: N/A	
8. Originator Remarks: Item #1 is transmitted for approval. Item #2 provides supporting information only and is available for review through Waste Characterization Analysis				9. Equip/Component No: N/A	
				10. System/Bldg/Facility: N/A	
				12. Major Assm Dwg No: N/A	
				13. Permit/Permit Application No. N/A	
11. Receiver Remarks:				14. Required Response Date:	

61713
943-0861

15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev No.	(E) Title or Description of Data Transmitted	Impact Level	Reason for Transmittal	Originator Disposition	Receiver Disposition
1	WHC-SD-WM-ER-145	1	0	Tank C-103 Evaporation Analysis	3	1		
2	WCA-92-012	1	0	Tank C-103 Evaporation Analysis Task Record	4	3		

16. KEY		
Impact Level (F) 1, 2, 3, or 4 see MRP 5.43 and EP-1.7	Reason for Transmittal (G) 1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist (Receipt Acknow. Required)	Disposition (H) & (I) 1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Impact Level for required signatures)										(G)	(H)
Reason	Disp	(J) Name	(K) Signature	(L) Date	(M) MSIN	(J) Name	(K) Signature	(L) Date	(M) MSIN	Reason	Disp
1	I	Cog./Proj. Eng S. W. Claybrook	<i>S. W. Claybrook</i>	2/27/92	H0-34						
1	I	Cog./Proj. Eng. Mgr. W. L. Knecht	<i>W. L. Knecht</i>	2/3/92	H0-34						
1	I	QA M. L. McElroy	<i>M. L. McElroy</i>	2/27/92	S1-57						
		Safety									
1	I	G. T. Frater	<i>G. T. Frater</i>	2-27-92	R1-51						

18. S. W. Claybrook <i>S. W. Claybrook</i> 1/31/92 Signature of EDT Originator Date		19. <i>G. T. Frater</i> 2-27-92 Authorized Representative Date for Receiving Organization		20. W. L. Knecht <i>W. L. Knecht</i> 2/3/92 Cognizant/Project Engineer's Manager Date		21. DOE APPROVAL (if required) Ltr No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments	
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NAI 9116-03

TANK C-103 EVAPORATION ANALYSIS

January 1992

S.W. Claybrook

Numerical Applications, Inc.
825 Goethals Drive, Suite A
Richland, WA 99352

prepared for
Westinghouse Hanford Company

INTRODUCTION

In January of 1990, the liquid level in tank C-103 began decreasing at a rate of about 0.5 inches per year. The observation of this level drop coincided with a modification to the tank ventilation system, which included the addition of a trace heated vapor filtering system. Based on an analysis of the tank and observations related to liquid level trends, it was concluded that evaporation was a likely cause of the liquid level decrease⁽¹⁾.

In April of 1991, water was added to C-103 and the liquid level was rebaselined. Since that time, the level has continued to decrease at a rate of about 0.8 inches per year. The purpose of this analysis is to determine whether or not evaporation can still be considered a likely cause of the liquid level decrease.

MODEL DESCRIPTION

Two models were used to evaluate the recent liquid level decrease in C-103. The first model utilized the GOTHIC computer code, which is designed to model multicomponent, two-phase flows⁽²⁾. The second is a simple mass transport model, which was developed specifically to calculate evaporation from the liquid organic layer in tank C-103. The following paragraphs describe both models.

The GOTHIC evaporation model for C-103 is shown in Figure 1. Lumped parameter volumes labeled 1, 2, and 3 represent tanks C-101, C-102, and C-103, respectively. Volume 4 represents the ventilation system and volume 5 represents the atmosphere. Boundary conditions attached to volume 5 are used to control the atmosphere pressure, temperature, and relative humidity.

Flow paths 1 and 2 between the three lower volumes represent the cascade lines that connect the tanks. Flow paths 3 and 4 represent piping and related components associated with the ventilation system. Flow paths 5, 6, and 7 model leak paths between the atmosphere and the tanks, while flow paths 8 and 9 connect the atmosphere to the boundary conditions.

Heater components labeled 1H, 2H, and 3H, are used to model the heat generation in each waste tank. Heater 4H models the trace heaters on the ventilation system. Thermal conductors are also included in the model to represent the thermal characteristics of the tank walls and surrounding earth.

The three volumes representing the waste tanks are located at a top elevation 7 ft below grade level. The bottom elevations are based on a total height of 30 ft for an empty tank and vary according to the quantity of waste that each tank contains. Tanks C-101 and C-102 are modeled with solid waste 26.5 and 149 inches deep, respectively. Tank C-103 is modeled with a pool of water in the bottom to represent liquid waste. Initial depth of the liquid pool is 67.0 inches, corresponding to the measured level in April of 1991. The gas space volume in tank C-101 is 104,740 ft³ and in C-102 it is 60,009 ft³. The volume for C-103, including both gas and liquid, is 114,643 ft³.

Volume 4 is located at a bottom elevation 0.5 ft above grade level to represent the location of the filter system carbon absorption drums. This volume has a height of 3 ft and a gas space volume of 21 ft³. The volume used represents all of the ventilation system piping and components.

The flow paths between tanks are 25 ft long and 3 inches in diameter. These dimensions represent the cascade lines which connect the tanks. Loss coefficients for these flow paths account for entrance and exit losses at the connections between the tanks and piping. It is assumed that the pipe is free flowing with no obstructions, crust, scale, or partial blockage.

The flow paths associated with the ventilation system are 2 inches in diameter, representing the flex hose that connects filter and absorption drum components. Lengths and loss coefficients were calculated to account for the flow resistance of the hose, absorption drums, filter, and 4-inch piping. Manufacturers' data were used to determine the flow characteristics of the filter and the absorption drums.

Characteristics of the flow paths representing leakage between the tanks and the atmosphere are based on estimates of leakage areas from December 1991 photographs of the pump and valve pits over each tank. The photographs show that weather covers have been removed from some of the pits to gain access to the tanks. There are significant infiltration leakage paths into the pits around valve handles, electrical cords, ladders and other openings where tape has been removed. Infiltration flow path areas estimated from the photographs are larger than those that were assumed in the earlier analysis of tank C-103⁽¹⁾.

Heater components in tanks C-101 and C-102 model a heat generation rate of 10,000 Btu/hr each⁽³⁾. In tank C-103, the generation rate is 18,000 Btu/hr, which goes into the liquid in the tank.

The heater component in the ventilation system volume is based on a rated power output of 512 watts. This includes trace heaters on the filter housing and absorption drums, as well as the connecting piping. The rated heater power has been adjusted per vendor data to account for the fact that power output decreases with increasing pipe temperature.

Thermal conductors in each tank volume represent the tank walls and surrounding soil. The tank walls include 1/4 inch of steel and 13 inches of concrete. The soil thickness for conductors exposed to the gas space in each of the three tanks is 7 ft, representing the depth of soil over the tank. The soil side of these conductors is connected to the outside atmosphere. The conductor in C-103 that is connected to the liquid in the bottom of the tank has a soil thickness of 163 ft, which represents the depth from the bottom of the tank to the water table. The soil side surface temperature for this conductor is held constant at 55 °F to represent the ground water temperature.

A thermal conductor is also included in the ventilation system volume to represent Armaflex insulation 2 inches thick. This conductor models heat transfer between the trace heated system components and the atmosphere.

Pressure and flow boundaries in the model control outside atmospheric conditions. These are based on measured data for the Hanford site. The model uses an average outside pressure of 14.348 psia, which varies on a daily cycle to account for typical variations in barometric pressure. Atmosphere temperature and humidity variations are based on monthly average data.

The mass transport model used in this analysis is shown in Figure 2. This model uses a lumped parameter approach to model the liquid layer and the tank vapor space. Differential equations based on conservation of mass combined with liquid and vapor diffusion principles were developed and solved numerically. Material properties for dodecane ($C_{12}H_{26}$) were used to represent the organic layer, which is primarily NPH (Normal Paraffin Hydrocarbon). Diffusion coefficients for evaporation from the liquid surface were calculated from the equations shown in the figure⁽⁴⁾. Volumetric flow rates into and out of the tank are required as inputs. These were obtained from the natural circulation flow rate calculated with the GOTHIC model.

LIQUID LEVEL PREDICTIONS

Figure 3 shows a comparison of liquid level measurements and predictions from both models. The results shown in the figure represent the time period from the middle of April through December, 1991. Agreement between calculations and measured data is good for both GOTHIC and the mass transport model, although the latter over estimates the level drop by about 10 percent.

GOTHIC does not have the capability of modeling the liquid organic layer in tank C-103 directly, since the two-phase capabilities of the code are based on water only. To compensate for this, the GOTHIC results shown in Figure 3 were adjusted using available water and organic vapor measurement data. A discussion of the method used to adjust GOTHIC results is contained in the report on the previous modeling effort⁽¹⁾.

Infiltration flow areas used in the GOTHIC model are only rough estimates, despite attempts to characterize them through examination of the photographs described earlier. Therefore, model predictions for a range of flow areas were studied. It was concluded that the flow rate predicted by the current model is limited by the size of the cascade line between tanks C-102 and C-103. Therefore, the current uncertainty in infiltration flow area will affect the GOTHIC results shown in Figure 3 only slightly. The increase in flow area from the assumptions of the earlier modeling effort accounts for the increase in predicted liquid level drop.

As mentioned in the previous section, the mass transport model calculates evaporation rates for both water and organic material from the pool surface. However, it does not calculate natural circulation flow through the tank. Instead, a volumetric flow rate is required as input. The predictions shown in Figure 3 are based on a flow rate of 15 cfm, which is the natural circulation flow calculated by the GOTHIC model.

CONCLUSIONS AND RECOMMENDATIONS

GOTHIC and mass transport models developed for tank C-103 predict a liquid level drop due to evaporation that is consistent with the actual level drop. This suggests that evaporation is a likely cause of the current liquid level trend, but it does not rule out the possibility of a leak in the tank.

In order to provide increased confidence that the tank is not leaking, it is suggested that the pits over tanks C-101, C-102, and C-103 be resealed except for the filter system which is currently in place over C-103. This will allow the tanks to breath with barometric pressure fluctuations, but it will eliminate the relatively large natural circulation flow that currently exists through the tanks. The result will be a decrease in the evaporation rate of C-103 and elimination of the organic vapor problem that currently exists for workers in the vicinity of the tank.

Verification that the tanks are well sealed should be made by pulling a slight vacuum on C-103 and taking flow and pressure measurements. If the tanks are perfectly sealed except for the filter system, the models predict the evaporation rate for C-103 should decrease to less than 0.1 inches per year. If the suggested flow and pressure measurements are made available, another evaporation rate estimate can be made based on those measurements.

REFERENCES

1. Claybrook, S.W. and T.M. Burke, Evaporation Modeling for Tank C-103, WHC-SD-WM-ER-127, August 1991, Westinghouse Hanford Company, Richland, WA.
2. Wiles, L.E., GOTHIC Containment Analysis Package Qualification Report for GOTHIC S, NAI 8907-09, June 1991, Numerical Applications, Inc., Richland, WA.
3. Lewis, W.S., "Replacement of Defective Thermocouples in Single-Wall Tanks," Letter 65950-86-437 to S.J. Joncus, Rockwell Hanford Operations, Richland, WA, dated July 23, 1986.
4. Bolz, R.E. and G.L. Tuve, CRC Handbook of Tables for Applied Engineering Science, 2nd edition, (c) 1973, pp. 543-544, CRC Press, Cleveland, OH.

Figure 1. GOTIIC Evaporation Model for Tank C-103.

Figure 2. Mass Transport Model for Tank C-103.

C103REV1 - EVAP. RE-EVALUATION; APR 12-DEC 31, 1991
S.W. Claybrook
11:47:56 02-JAN-92
GOTHIC Version 3.4 - April 1991

Figure 3. Liquid Level Predictions for Tank C-103.

From: Tank Farms Plant Engineering
Phone: 3-4556 R1-51
Date: January 20, 1988
Subject: TANK 103-C CHARACTERIZATION INTERIM STATUS

13331-88-018

To: Distribution

cc: KGC File/LB

- References: (1) Letter, D. A. Dodd to K. G. Carothers, "Analyses of 241-C-103 Tank," September 24, 1987.
- (2) Letter, G. G. Meade to F. E. Boyd, "241C Tank Farm - 103C Exhauster," August 3, 1987.
- (3) External Letter, C. H. St. John to G. G. Meade, "Evaluation of Tank 103-C, 200-E Area Exhaust Gases," July 17, 1987.

The waste stored in the 241-C-103 tank presents a potential, but as yet unidentified, biological hazard to workers in the 241-C Tank Farm. This became apparent when two Westinghouse Hanford Company (WHC) employees experienced impaired respiratory function after becoming exposed to non-filterable irritating vapors while working on equipment installed on tank 103-C. A total of 20+ weeks of time off from work are directly attributed to the exposure induced occupational injury of the involved workers.

Characterization of gases contained in tank 103-C began immediately, following a report of the worker exposure incident, in an attempt to identify any potentially hazardous and/or irritating constituents. This characterization included air samples of the work space surrounding tank 103-C, gas samples taken from the stack of the idled portable exhauster connected to the tank, gas samples taken directly from the tank head space, and a liquid surface sample. Hanford Environmental Health Foundation (HEHF), Pacific Northwest Laboratory (PNL), U.S. Testing, Industrial Hygiene and Hazardous Materials (IH&HM), and numerous other WHC organizations have been involved in various phases of the sampling and/or analyses.

Current plans call for continuing the tank 103-C characterization in order to state definitively what average concentrations of constituents were representative of the tank vapor at the time of the worker exposure incident. This continued effort is based on the results from the exploratory sampling completed to date. The purpose of this memo is to report the current findings of the characterization and to describe future actions directed at identifying potential health hazards associated with the waste stored in the tank.

Distribution
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January 20, 1988

13331-88-018

SUMMARY OF EXPLORATORY SAMPLING

Vapor space samples and a liquid surface sample were taken from tank 103-C during the week of September 14, 1987. The samples were analyzed for various constituents in order to identify any potential biological hazards associated with the gases exhausted from the tank. The constituents or general class of compounds analyzed in the vapor space samples included ammonia, cyanide, oxides of nitrogen, acid gases, and volatile organics. Volatile and extractable organics were target constituents in the liquid sample.

Ammonia, acid gases, and volatile organics were detected in the vapor space samples. Ammonia was the most prevalent of the constituents found. However, all constituents found, including ammonia, were present at very low levels. The results contradict both field experience and the initial sampling results obtained by HEHF and IH&HM. Orders of magnitude higher concentrations than those observed were expected from the direct sampling.

The low vapor space concentrations measured are attributed to two probable causes. First, operation of the portable exhaustor connected to tank 103-C following the worker exposure incident is estimated to have resulted in over a hundredfold dilution of gases in the tank head space before the sampling took place. Secondly, an unknown dilution likely occurred during the sampling from air leaking into the sampling train.

Determining the composition of the gases at the time of the worker exposure is further complicated by the cascaded tank configuration of the tank farm. A low capacity filter initially installed on the tank would have restricted the inlet air flow during exhaustor operations just prior to the exposure incident. This restriction most likely caused vapors from tanks 101-C and/or 102-C to be drawn into tank 103-C and out the exhaustor. Therefore, uncertainty exists as to the origin of the gas breathed by the workers and sampled by HEHF.

Because of conflicting sample results and the uncertainty caused by the exhaustor operations, questionable sample equipment integrity, and the cascaded tank design, continued characterization of tank 103-C and related tanks is recommended. Tank 103-C must first be isolated to allow any gases generated to accumulate undisturbed. Tanks 101-C and 102-C also may require isolation depending on the results of initial exploratory vapor space sampling. Periodic and/or final verification vapor space samples will then be taken from those tanks identified as containing potentially hazardous and/or irritating gaseous species in order to definitively state what the average concentrations of constituents were at the time of the exposure incident.

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RESULTS FROM DIRECT VAPOR SPACE AND LIQUID SAMPLES

Vapor Space Sample Results

Exploratory vapor space samples were taken from tank 103-C on September 14, 1987, in order to determine any causes for biological hazards associated with gases exhausted from the tank. Samples were withdrawn from the tank head space by vacuum through a section of poly tubing positioned such that the inlet was half the distance from the liquid surface to the tank dome. During the sampling, various sampling devices were sequentially placed in the sampling train to collect specific constituents contained in a measured quantity of gas. Figure 1 presents a diagram of the sampling train. The target constituents included ammonia, cyanide, oxides of nitrogen, acid gases, and volatile organics.

The measured concentrations of the various compounds found in the tank vapor space samples were considerably lower than those measured shortly after the worker exposure incident. Concentrations of ammonia measured in the exhaust stack by HEHF several days following the incident were at least 12 ppm and could have been as high as 60 parts per million (ppm) by volume [Reference (3)]. HEHF also monitored organic vapors and measured 70-90 ppm. During exhauster operations that commenced on July 23, 1987, IH&HM measured upwards of 10 ppm ammonia at the portable exhauster continuous air monitor pump exhaust [Reference (2)].

One probable cause of the lower vapor space concentrations is dilution of the samples taken during the sampling procedure. While attempting to take subsequent gas samples, it was discovered that the existing double-shell tank vapor space sampler used to draw vapors out of the tank and into the various sample collection devices had significant air inleakage. Therefore, the actual volume of sample collected is unknown and the sample analyses can not be quantified. However, valuable qualitative information can be deduced from the sample results and is presented in this section.

The overall results of the direct sample analyses are that ammonia, acid gases, and volatile organics were found in the tank 103-C vapor space [Reference (1)]. Table 1 presents a summary of the constituents identified and their respective TLV. Ammonia was present in sufficient quantity such that it most likely would have exceeded its eight hour time weighted average threshold limit value (TLV) after accounting for the sample dilution. Environmental Protection Agency (EPA) priority pollutant volatile organic species were also detected. These species were present at such extremely low concentrations [less than 1 part per billion (ppb)] that, despite the sample dilution that may have occurred, these species would not be expected to exceed their respective TLV in the tank vapor space at the time of sampling. The TLVs for these species are very high, ranging from 10-1000 ppm. Cation and anion analysis of the trapping solution used for collecting acid gases strongly suggests the presence of a fluoride compound. Fluoride anion concentration was relatively high despite the possible dilution that may have

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occurred during the sampling. However, this fluoride anion concentration accounted for less than 3% of the sodium hydroxide neutralized during the sampling. No other anions found appeared significant. Therefore, further analysis and verification of the acid gas and related cation/anion data are required before a level of concern can be assigned to fluoride or any other inorganic acid gas.

Other volatile organic species, which are not EPA targeted compounds, were also tentatively detected in the vapor space samples. Table 2 lists these organic compounds and the TLV range for those species where values have been assigned. Verification of the identity and quantity of these species would require calibration of the gas chromatograph/mass spectroscopy instrumentation using standards prepared for each species. These standards are not presently available. The tentative identification was made by comparing the mass spectrum for the sample with the mass spectrum of compounds found in a data base. However, irrespective of the identity of the species, qualitatively it can be roughly stated that all of these species were present at concentrations less than those measured for the EPA priority pollutants found (i.e., < 1 ppb). Given the high TLV for most organics, the level of concern for these compounds is therefore expected to prove minimal.

In addition to the sample dilution that likely occurred during the sampling, a second contributing factor to the low concentrations of compounds found in the tank vapor space is operation of the portable exhauster that was connected to the tank. The tank was extensively exhausted towards the end of July 1987, in order to complete a scheduled surveillance photographic mission. A large inlet filter, normal rated capacity at 1000 CFM flow, was installed on a tank riser in support of this tank ventilation. Over a hundredfold dilution of the vapor space gases could have occurred given the length of time the exhauster operated. Similarly, the exhauster was run for 30 - 40 minutes every two weeks while it was installed on tank 103-C in order to dioctylphthalate (DOP) test the tank inlet high efficiency particulate filter. A twofold dilution of the tank vapor space gases could have occurred each time the filter was tested. Operation of the exhauster for about 20 hours just prior to the worker exposure incident most likely resulted in over a tenfold dilution of the vapor space gases as well. However, this lower dilution level partially explains why the vapors from the tank may have been more concentrated at the time of the worker exposure incident and during subsequent initial sampling.

A second complicating factor in interpreting the vapor space sample data is that tank 103-C is coupled with tanks 102-C and 101-C through 3 inch cascade lines buried underground. Some of the vapors from these cascade tanks may have been drawn into tank 103-C during either the initial ventilation period before the worker exposure incident, or the following ventilation that occurred at the end of July 1987, and biweekly during exhauster DOP testing. It is unlikely that this cross flow occurred to any appreciable extent during the ventilation periods except for the initial period before the incident.

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The small inlet filter (160 CFM normal capacity) installed on the tank at that time would have caused vapors to be drawn into tank I03-C from the cascaded tanks because of the inlet air flow restriction.

Liquid Surface Sample Results

An exploratory liquid surface sample was taken from tank I03-C on September 15, 1987, and shipped to PNL for analysis. The sample was obtained using the standard bottle-on-a-string sampling method. Packaging, transport, and storage of the sample followed EPA protocol to the extent possible. Volatile and acid/base/neutral extractable organic analyses were requested on the sample.

No EPA priority pollutant volatile organics were detected in the liquid sample. Other nontargeted volatile organics were found though. Table 3 presents the tentative list of the organics present. Again, standards would be required to positively identify and quantify the species indicated. However, the types of compounds identified have such high TLV that they would not be expected to present a health problem. The analysis for extractable organics is not yet complete and will be reported separately if any significant constituents are found.

CONCLUSIONS AND FUTURE ACTIONS

The results from the direct sampling contradict the measurements made by HEHF and IH&HM immediately following the worker exposure incident. Concentrations of ammonia and organic vapors detected during the initial sampling of the work space surrounding tank I03-C and the residual gases in the stack of the idled exhauster were orders of magnitude higher than the direct sampling results.

The sample results are complicated by three factors, each of which precludes either direct determination or indirect projection of the vapor space composition and concentrations at the time of the incident. Operation of the portable exhauster connected to the tank prior to and following the exposure incident caused an unknown and variable dilution of vapor space gases. Air leakage into the sampling train during the direct sampling likewise caused an unknown dilution of each sample collected. Finally, the complexity introduced by the cascaded tank arrangement causes uncertainty regarding the origin of the gases breathed by the workers.

Because of the uncertainty in the sample results caused by past tank operations, the cascaded tank configuration, unknown waste chemistry, and questionable integrity of the sampling equipment, the one remaining major issue is still, "What average concentrations of constituents are representative of the tank vapor at the time of the worker exposure?" In order to provide hard evidence, the approach recommended in answering this

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question is to isolate tank 103-C and tanks 101-C and 102-C, if appropriate, in order to allow gases to accumulate over time, followed by direct sampling of vapor space gases. The major tasks of the continued characterization project are:

- o Complete a transaction history of the 241-C tank farm to determine if any other tanks, either in C Farm or source tanks in other farms, are similar enough to tank 103-C to justify sampling. Proceed to sample the vapor spaces and/or supernatants of those tanks which could prove helpful in assessing the potential hazards associated with tank 103-C waste.
- o Sample the vapor spaces of the cascade tanks, tank 101-C and tank 102-C, to identify any causes for biological hazards associated with gases that may have been drawn into tank 103-C during exhaust operations.
- o Sample tank 101-C, 102-C, and 103-C vapor spaces periodically and/or after about one year isolation to determine equilibrium vapor space composition and concentrations at the time of the worker exposure incident.

K. G. Carothers, Principal Engineer
Tank Farms Plant Engineering

CMC

Attachment

Figure 1. Vapor Space Sampler System.

**TABLE 1
TANK 103-C VAPOR SPACE
PRELIMINARY SAMPLE RESULTS
(VALUES IN MG/M³)**

<u>COMPOUND DETECTED</u>	<u>TLV*</u>	<u>OTV**</u>
NH ₃	18	4
EPA PRIORITY POLLUTANT		
VOLATILE ORGANICS		
TRICHLOROFLUOROMETHANE	5600	-
1,1 - DICHLOROETHENE	810	13
1,1,1 - TRICHLOROETHANE	1900	600
BENZENE	30	17
TOLUENE	375	20
ACID GASES; AS NEUTRALIZED NaOH	-	-
NON-EPA PRIORITY POLLUTANT		
VOLATILE ORGANICS	-	-

* THRESHOLD LIMIT VALUE

** ODOR THRESHOLD VALUE

TABLE 2
TANK 103-C VAPOR SPACE
NON-EPA PRIORITY POLLUTANT
VOLATILE ORGANICS

<u>COMPOUND</u>	<u>TLV*</u>
N-HEPTANE, N-OCTANE, PENTANE, BUTANE, ACETONE, HEXANE, METHYLCYCLOHEXANE	180 - 1900
BUTENE, 2-PENTENE, PENTANE ISOMER, CYCLOPENTANE, METHYLCYCLOPENTANE, 2-METHYLPENTANE, 1-HEXENE, HEPTENE ISOMER, 3-METHYLHEXANE	-

* THRESHOLD LIMIT VALUE (MG/M³)

TABLE 3
TANK 103-C LIQUID SURFACE SAMPLE
PRELIMINARY SAMPLE RESULTS

<u>COMPOUND</u>	<u>CONCENTRATION</u>	<u>TLV*</u>
EPA PRIORITY POLLUTANT VOLATILE ORGANICS	NONE	-
NON-EPA PRIORITY POLLUTANT VOLATILE ORGANICS		
- BUTANOL, N-HEPTANE, N-OCTANE, PENTANE, 2-BUTANONE	QUALITATIVE ONLY	150 - 1800
- BUTANE ISOMER, PROPANENITRILE, 3-METHYLBUTANONE, HEPTANE ISOMER, OCTANONE	QUALITATIVE ONLY	-
EXTRACTABLE ORGANICS	TBD**	TBD**

* THRESHOLD LIMIT VALUE (MG/M³)

** TO BE DETERMINED

RL--WHC-TANKFARM-1992-0069

10 Day Report
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OCCURRENCE REPORT

Tank Farms

(Name of Facility)

Remediation Activities

(Facility Function Involved)

HANFORD SITE

(Name of Laboratory, Site or Organization)

Name: Garrett, Mark S.
Title: Plant Engineer
Telephone No.: (509)373-9191 (FTS)-----

(Facility Manager/Designee)

Name: D. A. Moore
Title: Shift Supervisor
Telephone No.: (509)373-2689 (FTS)373-2689

(Originator)

1. OCCURRENCE REPORT NUMBER: RL--WHC-TANKFARM-1992-0069

2. REPORT TYPE AND DATE:	Date	Time
☐ Notification Report	09/22/92	1207 (MTZ)
☒ 10 Day Report	10/05/92	
☐ 10 Day Update (latest)		
☐ Final Report		

3. OCCURRENCE CATEGORY :

☐ Emergency
☒ Unusual
☐ Off-Normal

4. DIVISION OR PROJECT :

Waste Tank Project

5. DOE PROGRAM OFFICE :

EM - Environmental Restoration

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6. SYSTEM, BLDG., OR EQUIPMENT : 7. UCNI? : 8. PLANT AREA :
241-C Tank Farm No 200 East

9. DATE AND TIME DISCOVERED : 10. DATE AND TIME CATEGORIZED :
09/21/92 1750 09/21/92 1830

11. DOE NOTIFICATION :
09/21/92 2001 Duty Officer DOE-HQ

12. OTHER NOTIFICATIONS :
09/21/92 1935 Duty Officer WHC-ONC
09/21/92 1942 Abu Zaman WHC-SAF
09/21/92 1830 Doug Hamrick WHC-TFO
09/21/92 1940 Charlotte Zaccone DOE-RL

13. SUBJECT OR TITLE OF OCCURRENCE :

FLOATING LIQUID ORGANIC LAYER IN SINGLE-SHELL TANK 241-C-103 DETERMINED
TO BE AN UNREVIEWED SAFETY QUESTION (USQ)

14. NATURE OF OCCURRENCE :

- 9) Cross-Category Items
D. Potential Concerns/Issues

15. DESCRIPTION OF OCCURRENCE :

The Plant Review Committee (PRC) has determined that a rapid organic reaction in Single-Shell Tanks (SST)s is not adequately addressed in the Safety Analysis Reports (SAR)s.

SAR SD-WM-SAR-034 states that a nitrate compound explosion was incredible. The basis for this statement was a series of studies conducted on salt cake and organic mixtures which indicated that nitrated compound explosions would not occur at organic concentrations less than 3 weight percent equivalent Total Organic Carbon (TOC). At concentrations above 3% TOC, extremely high temperature (>220 Degrees C) and very low moisture content are required for the reaction to proceed.

The PRC reviewed the eight single shell tanks containing more than 3% TOC against this basis. The PRC determined that although seven of the SSTs contain more than 3% TOC, they do not constitute an USQ because the high temperatures

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and low moisture content required to cause the reaction were not a credible accident.

However, the PRC determined that these studies and the SAR did not adequately address Tank C-103 which is known to have a floating organic layer covering the surface. The conditions under which a reaction in this floating organic layer may be different than those identified in these studies. As a result, the SAR statement of incredibility is not supported.

The USQ is that the SAR did not address a floating organic layer chemical reaction. The PRC did determine that adequate controls are in place to prevent a rapid organic reaction from occurring. These controls are located in operating specifications for watch list tanks, Operational Specification Document (OSD) T-151-00030.

16. OPERATING CONDITIONS OF FACILITY AT TIME OF OCCURRENCE :

Normal operating conditions

17. ACTIVITY CATEGORY :

Normal Operations

18. IMMEDIATE ACTIONS TAKEN AND RESULTS :

On 9/21/92 the Plant Review Committee determined that adequate controls are in place to prevent an organic reaction from occurring. These controls are located in OSD T-151-00030.

On 9/21/92 at 1750 hours, the shift office was notified of the USQ.

On 9/21/92 at 1830 hours, the occurrence was classified as an Unusual Occurrence per group 1 C 2c and the On Call Manager was notified of classification.

On 9/21/92 all notifications were completed.

19. DIRECT CAUSE :

1992/10/05

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- 2) Procedure Problem
 - A. Defective or Inadequate Procedure

20. CONTRIBUTING CAUSE(S) :

- 2) Procedure Problem
 - A. Defective or Inadequate Procedure

21. ROOT CAUSE :

- 6) Management Problem
 - A. Inadequate Administrative Control

22. DESCRIPTION OF CAUSE :

Tank 102-C had a floating organic layer in the 1960's. In late 1975, the supernate in Tank 102-C was pumped into 103-C, as allowed by safety documentation. The SAR did not adequately address a floating organic layer covering the aqueous surface of the waste.

23. EVALUATION : (By Facility Manager/Designee)

No known effect on tank structure.

24. IS FURTHER EVALUATION REQUIRED? : Yes [X] No []
- IF YES - BEFORE FURTHER OPERATION? : Yes [] No [X]

BY WHOM? : See Block 25

BY WHEN? : 10/05/92

25. CORRECTIVE ACTIONS :

(* = Date added/revised since final report was signed off)

- 1) The Organic Tanks Stabilization Program will identify corrective actions which are approved and monitored by DOE-HQ.

TARGET COMPLETION DATE: 10/05/92

COMPLETION DATE: 10/05/92

26. IMPACT ON ENVIRONMENT, SAFETY AND HEALTH :

1992/10/05

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The declaration of a USQ does not mean that an imminent safety hazard exists regarding Tank 103-C. Comprehensive controls have been in place related to work in and around this tank since July 1990, when the tank was placed on the Organic Tanks Watch List.

27. PROGRAMMATIC IMPACT :

The declaration of a USQ on the tank increases the preparation time and level of review required for intrusive activities, sometimes doubling, tripling or quadrupling the time required to perform an activity. For example, preparing safety assessments will be much more complex, and readiness reviews for intrusive activities will be conducted by DOE-HQ, rather than at the local level.

The USQ impedes progress on two programs aimed at resolving safety problems involving tank 103-C: the Tank Vapor and the Organic Tank Stabilization Programs. The Tank Vapor Program is centered on 103-C and requires characterizing the tank's vapors. Vapor and liquid samplings scheduled under that program for the immediate future have been delayed until a Justification for Continued Operation (JCO) can be prepared, submitted and approved. Once the JCO is approved, these samplings will be further delayed, since the existence of a USQ makes the preparation for intrusive activities more complex, and hence, more time-consuming. On the Organic Program, core sampling of 103-C will also be slowed, as will other activities throughout the duration of the program.

28. IMPACT UPON CODES AND STANDARDS :

None

29. FINAL EVALUATION AND LESSONS LEARNED :

Corrective action will be taken as part of the Organic Tanks Stabilization Program. The program plan, currently under revision, will include short- and long-term corrective action.

As part of the program, the US Bureaus of Mines (USBM) has been contracted to test surrogate organic wastes to determine their energetics (reaction energy, explosivity, etc.). The results from these tests will be input to a

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(Submitted)

technical group refining the criteria (total-organic-carbon content, energy content, etc.) for putting tanks on the organic watch list. These items will proceed in series. Meanwhile, the USBM energetics data will be input to a separate effort specifically addressing the USQ question.

The program plan will address the long-term solution to the problem, including treatment of tank contents if needed.

30. SIMILAR OCCURRENCE REPORT NUMBERS :

None

31. DOE FACILITY REPRESENTATIVE INPUT :

Entered by:

Date: --/--/--

APPENDIX D

METRIC CONVERSIONS

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To Convert	Multiply By	To Convert	Multiply By
LINEAR MEASURE (LENGTH)			
inches to millimeters	25.4	millimeters to inches	0.0394
inches to centimeters	2.54	centimeters to inches	0.394
feet to meters	0.305	meters to feet	3.281
yards to meters	0.914	meters to yards	1.094
miles to kilometers	1.609	kilometers to miles	0.621
SQUARE MEASURE (AREA)			
square inches to square centimeters	6.452	square centimeters to square inches	0.155
sq feet to sq meters	0.0929	sq meters to sq feet	10.764
sq yards to sq meters	0.836	sq meters to sq yards	1.196
acres to hectares	0.405	hectares to acres	2.471
CUBIC MEASURE (VOLUME)			
cubic inches to cubic centimeters	16.387	cubic centimeters to cubic inches	0.0610
cu feet to cu meters	0.0283	cu meters to cu feet	35.315
cu yards to cu meters	0.765	cu meters to cu yards	1.308
LIQUID MEASURE (CAPACITY)			
fluid ounces to liters	0.0296	liters to fluid ounces	33.814
quarts to liters	0.946	liters to quarts	1.057
gallons to liters	3.785	liters to gallons	0.264
imperial gallons to liters	4.546	liters to imperial gallons	0.220
WEIGHTS (MASS)			
ounces avoirdupois to grams	28.35	grams to ounces avoirdupois	0.0353
pounds avoirdupois to kilograms	0.454	kilograms to pounds avoirdupois	2.205
tons to metric tons	0.907	metric tons to tons	1.102
TEMPERATURE			
32 °F (freezing point of water)		0 °C	
212 °F (boiling point of water)		100 °C	
98.6 °F (body temperature)		37 °C	
To find degrees Celsius, subtract 32 degrees Fahrenheit and divide by 1.8. To find degrees Fahrenheit, multiply degrees Celsius by 1.8 and add 32.			

To convert from >> to <<	to >> To convert from <<	multiply by divide by
PRESSURE and STRESS		
pounds force per square inch (lbf/in ² or psi)	kilopascals (kPa)	6.895
thousand pounds force per square inch (kip/in ² or ksi)	megapascals (MPa)	6.895
inches of water (60 °F)	pascals (Pa)	248.8
millimeters of mercury (0 °C)	pascals (Pa)	133.3
ENERGY and WORK		
British thermal units (Btu), International Table	kilojoules (kJ)	1.055
Calories (kilocalories), Int'l	kilojoules (kJ)	4.187
electronvolts (eV)	joules (J)	1.602×10^{-19}
kilowatt hours (kW·h)	megajoules (MJ)	3.600
POWER		
British thermal units (Int'l) per hour (Btu/h)	watts (W)	0.293
horsepower (electric)	watts (W)	746.0
horsepower (boiler)	kilowatts (kW)	9.81
tons of refrigeration	kilowatts (kW)	3.517
TORQUE and BENDING MOMENT		
ounce force inches (ozf·in) ("inch-ounces")	millinewton meters (mN·m)	7.062
pound force inches (lbf·in) ("inch-pounds")	newton meters (N·m)	0.113
pound force feet (lbf·ft) ("foot-pounds")	newton meters (N·m)	1.356
FLOW RATES		
cubic feet per minute (ft ³ /min or cfm)	liters per second (L/s)	0.472
cubic feet per minute (ft ³ /min or cfm) [flow > 20,000 cfm]	cubic meters per second (m ³ /s)	0.000 472
gallons per minute (gpm) [flow rate < 30 gpm]	milliliters per second (mL/s)	63.1
gallons per minute (gpm)	liters per second (L/s)	0.063 1
pounds mass per hour (lbm/h)	kilograms per second (kg/s)	0.000 126

To convert from >> to <<	to >> To convert from <<	multiply by divide by
NUCLEAR and RADIATION UNITS		
barns (b) [neutron absorption cross-section]	square meters (m ²)	1.00 x 10 ⁻²⁸
curies (Ci)	becquerels (Bq)	3.70 x 10 ¹⁰
microcuries (μCi)	becquerels (Bq)	3.70 x 10 ⁴
picocuries (pCi)	becquerels (Bq)	0.037 0
rad *	gray (Gy) ^	0.010 0
rad ^	centigray (cGy) ^	1.000
millirad (mrad) ^	microgray (μGy) ^	10.000
rem *	sievert (Sv) *	0.010 0
rem *	millisievert (mSv) ^	10.0
millirem (mrem) ^	millisievert (mSv) ^	0.010 0
millirem (mrem) ^	microsievert (μSv) *	10.000
roentgen (R) *	coulombs per kilogram ^ (C/kg)	0.000 258
milliroentgen (mR) *	microcoulombs per. kilogram (μC/kg) *	0.258
^ The same "per unit time" (e.g., per hour, per year) may be added to obtain rate units with the same multipliers. For example, 1 rem <i>per year</i> is equal to 10 millisieverts <i>per year</i> .		
ELECTRICITY and MAGNETISM		
NOTE: The following units of electricity and magnetism, including their multiples and submultiples, are SI units needing no conversion.		
ampere (A)		
candela (cd) [1 cd = 1 candlepower]		
coulomb (C)		
farad (F)		
henry (H)		
hertz (Hz) [1 Hz = 1 cycle per second]		
lumen (lm)		
ohm (Ω)		
siemens (S) [1 S = 1 mho]		
tesla (T)		
volt (V)		
watt (W)		
weber (Wb)		

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Distribution	J. W. Fassett	Date 12/04/95
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WHC-SD-EN-TI-299, Assessment of Vadose Zone Radionuclide Contamination Around Single Shell Tank 241-C-103, Rev 0		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./Appendix Only	EDT/ECN Only
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