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WHC-EP-0412

NOV 18 1991

Fate and Transport of Constituents Leaked from Tank 241-A-105

Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management

Westinghouse
Hanford Company Richland, Washington

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

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DISCLM-1 CHP (1-91)

WHC-EP--0412

DE92 002914

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J. A. Caggiano

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October 1991

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	DATE & TRANSPORT OF CONSTITUENTS LEAKED FROM TANK 241-A-105		UC-
	Date of Journal		Impact Level 4
	Grade or Society Sponsoring		
Date(s) of Conference or Meeting		City/State	Will proceedings be published? ☐ Yes ☐ No Will material be handed out? ☐ Yes ☐ No
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CHECKLIST FOR SIGNATORIES

Review Required per WHC-CM-3-1	Yes	No	Reviewer Name (printed)	Signature	Date
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WHC Program	☐	☒		See document Approval page 10	
Communications	☐	☒			10/23/91
DOE-RL Program	☒	☐	M. J. Furman	M. J. Furman	10/15/91
Publications Services	☒	☐	M. S. Kowalski	M. S. Kowalski	10-23-91
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Intended Audience ☐ Internal ☐ Sponsor ☒ External		
Date Received 9/19/91		

Document Title: Fate and Transport of Constituents
Leaked from Tank 241-A-105

Prepared by:

J. A. Caggiano
Principal Scientist

10/3/91
Date

Reviewed by:

D. G. Horton
Manager
Geosciences

10/7/91
Date

Approved by:

R. E. Raymond
Program Manager

10/22/91
Date

ACKNOWLEDGMENTS

J. J. Consort drafted the cross section shown in Figure 2.
N. J. Vermeulen and R. R. Rios provided access to logs of dry wells and laterals as well as reports in files relating to incidents at various tanks.
N. A. Holman provided data on tanks and cribs from Waste Information Data System. J. A. Serkowski and W. A. Jordan provided groundwater monitoring data from the Hanford Ground Water Data Base. A draft of this report was reviewed by K. R. Fecht, D. G. Horton, V. G. Johnson, A. J. Knepp and A. G. Law.
F. J. Ungefug and associates retrieved boxes from archival storage and provided assistance in the Westinghouse Hanford Company Records Holding Area. Gratitude is extended to each for contributing to this report.

WHC-EP-0412

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EXECUTIVE SUMMARY

Following a January 28, 1965 sudden steam release in Tank 241-A-105, the carbon steel liner of the tank was noted to have bulged to a maximum height of about 8.5 feet (2.6 meters). Most of this bulging likely resulted from the January 28, 1965 incident. But available data indicate that some bulging during an earlier leak in 1963 when waste was being added to the tank may have contributed. By March 8, 1965, increases in radiation in the 14-05-03 leak detection lateral indicated that fluids had escaped the tank and that the liner was ruptured. Waste was subsequently transferred from Tank 241-A-105 to other tanks, and liquid levels in Tank 241-A-105 were maintained at about 18 inches to control temperature to prevent deterioration of the concrete. Spray cooling water was added weekly to the tank from February 1971 to December 1978 to maintain liquid levels and temperatures, and some of this fluid is assumed to have leaked from the tank.

This study examined available data to determine, to the extent possible, the distribution of the leaked constituents in surrounding soils and whether they migrated to groundwater. In this assessment, available data from gross gamma logging of dry wells and leak detection laterals as well as data from analyses of groundwater samples were examined throughout the period of interest. Logs of wells and photographs taken during construction of the 241-A-105 Tank Farm were also examined.

Analyses of scintillation logs from dry wells and laterals surrounding Tank 241-A-105 indicate that radionuclides have escaped the tank and entered the soils. The limited number and depth of the dry wells and the depth and distribution of the laterals are not sufficient to map the present location of

all the constituents leaked from the tank. Interpretation of logs of the scintillation (gross gamma) probes run in the dry wells and laterals indicate that the gamma-emitting radionuclides apparently leaked from the seam at the intersection of the side and bottom of the liner and may have penetrated vertically in the soils beyond the 125-foot depth of the dry wells. Some activity was seen in dry wells E25-66 (10-05-10) and E25-68 (10-05-02) at the north end of the tank where, because of the bulge in the south end of the tank, the remaining fluids ponded before escaping the tank. Metal cations tend to sorb and move more slowly than the non-sorbing constituents. The fate of hazardous constituents leaked from the tank is unknown; anions likely moved with the moisture front through the soils. The ultimate fate of these constituents in the soil surrounding Tank 241-A-105 cannot be determined without additional drilling and sampling.

Available records indicate that fluids leaked from Tank 241-A-105 constitute most of the contaminants leaked to the soils from the A Tank Farm. Small leaks have been reported from Tanks 241-A-103 and 241-A-104, but these total less than 10,000 gallons. A break in a two-inch raw water line in February 1978 along the east side of the A Tank Farm leaked approximately 60,000 gallons to the soil and induced some soil collapse between Tanks 241-A-102 and 241-A-105.

Analyses of data from groundwater monitoring wells in and around the A Tank Farm indicate that the groundwater beneath the tank farm was contaminated before the operation of most tanks in the farm and before leaks were reported from any tanks in the farm. Data from wells E25-1 and E25-2 for 1958 reveal contaminants in the groundwater several years before the

1965 steam explosion and subsequent release of fluids from Tank 241-A-105. Available records indicate that the volume of liquids discharged to nearby PUREX cribs, french drains and trenches exceeds 3.6 billion gallons, much more than the estimates of about 50,000 to 950,000 gallons of fluids leaked from Tank 241-A-105. High-density waste discharged to the BY cribs during uranium scavenging operations in the mid 1950's is likely to have penetrated the unconfined aquifer and may have flowed southeastward along the top of basalt toward the area of the A Tank Farm. The waste streams discharged to the PUREX and BY cribs contain many of the same constituents as those discharged to Tank 241-A-105. Because of the volume of fluids discharged to nearby facilities and the similarity (not in terms of their concentration/activity) of the constituents in the waste streams discharged to both facilities, it is not possible to determine from available groundwater monitoring data whether any contaminants leaked from Tank 241-A-105 have descended the 285 feet to reach the water table. The discharges to nearby facilities and the absence of any unique indicators of Tank 241-A-105 waste make it impossible to determine whether fluid leaked from the tank ever reached groundwater. Liquid waste discharges to nearby facilities mask any contribution Tank 241-A-105 may have made to degradation of groundwater quality beneath the A Tank Farm.

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GLOSSARY

Computer Automated Surveillance System (CASS). A computer-based system that records and stores various instrumental data measured within waste storage tanks and that is part of a system used to assess the safety of tanks and contained wastes.

Cladding. The outer jacket of nuclear fuel elements used to prevent corrosion of the fuel and release of fission products into reactor coolants.

Crib. An underground structure designed to receive liquid waste that can percolate into the soil directly and/or after travelling to a connected tile field. Crib designs vary. All liquid disposal facilities bear the number 16 after the area designator; thus, the number 216-A-8 designates a liquid disposal facility in the 200 Area, in this case the 216-A-8 crib. Cribs with "A" as the letter designator received wastes from the 202-A canyon building, sometimes known as "A" plant or by the process that was conducted within, the PUREX process.

Curie. A unit of radioactivity defined as the amount of a radioactive material that has an activity of 3.7^{10} disintegrations per second; one picocurie = 10^{-12} curie.

Dry Well. A borehole constructed of carbon steel (usually 6- or 8-in. diameter) that terminates above the water table and is used as an access port for geophysical logging instruments used to detect characteristics of the soil in the immediate vicinity of the well. Dry wells are a part of the leak-detection system that has been used at tank farms to detect loss of containment. Dry wells around tank farms may be 75 to 150 ft deep. These "wells" are identified by two different numbering schemes: one is an 8- or 9-digit identifier used to number all wells on the Hanford Site; the other is a Tank Farm Surveillance identification number based on relative position on a "clock" (with north as 12 o'clock). For example, well 299-E25-67 in the Hanford well system is a dry well (numbers greater than 50 do not penetrate the water table) located in section 25 of the 200 East Area. Tank Farm Surveillance personnel identify this well as 10-05-02. The number "10" is the CASS system identification number unique for the 241-A tank farm; 05 identifies the well as located adjacent to the 241-A-105 tank; and 02 indicates that it is in the 2 o'clock (or approximately northeast) position.

French Drain. A rock-filled encasement with an open bottom to allow seepage of liquid waste into the ground. Numerical designators are given to french drains in the same manner as stated above for cribs.

Gross Gamma Log. A record from a type of borehole geophysical logging tool obtained from a detector that senses gamma-emitting radionuclides in the medium through which the detector is passed. It detects the cumulative output of gamma radiation emitted by all gamma emitting radionuclides (compared with a Spectral Gamma Log, which records various peaks in a spectrum of gamma radiation and allows identification of specific gamma-emitting radionuclides).

Leak Detection Lateral. A horizontal borehole constructed beneath a single-shell waste storage tank that allows passage of geophysical instruments that detect gamma-emitting radionuclides in the immediate vicinity of the borehole. These are present only beneath the self-boiling tanks in the 241-A and 241-SX Tank Farms. Leak detection laterals were constructed after the tanks were built at a depth of 8 to 10 ft below a tank. There were three leak detection laterals beneath each tank that extended horizontally from a 12-ft-diameter vertical caisson that is 75 ft deep. These laterals are different from others that contained thermocouples and that were designed to sense temperature in the soil immediately below the concrete pad and footings on which the tanks were built.

Reverse Well. An early Hanford liquid disposal waste structure consisting of a well that terminated above or at the water table into which waste solutions were pumped.

FATE AND TRANSPORT OF CONSTITUENTS LEAKED FROM TANK 241-A-105

1.0 INTRODUCTION

The Westinghouse Hanford Company (Westinghouse Hanford) Geosciences Group evaluated available data from dry wells and groundwater monitoring wells to ascertain the spatial distribution of fluids leaked from Tank 241-A-105 and tried to determine whether any leaked fluids reached groundwater. Fluids were reported to have leaked from the tank in 1963 during the initial addition of waste to the tank that began in May 1962. A "severe bump" (steam explosion) in the tank in January 1965 caused a bulging of the steel liner and leaking of additional waste. The addition of cooling water from 1971 to 1978 also contributed to the leak volume. Using temperatures recorded in thermocouples beneath the tank (Jansen et al. 1965) it is estimated that between 5,000 and 15,000 gal leaked from the tank in January 1965. The tank continued to leak during the addition of spray cooling water between 1971 and 1978 to stabilize the in-tank temperature at safe levels that would not further damage the concrete. The volume of water added to the tank from 1971 to 1978 has been difficult to estimate. Different reports indicate that somewhere between 1,000 and 2,000 gal of water were added each week during the 7-yr period. Somewhere between 50,000 and 950,000 gal of cooling water are estimated to have been added to the tank from 1971 to 1978. Water was continually added to maintain in-tank liquid levels, suggesting that some of the water was being lost from the tank. Some water was undoubtedly evaporated and exhausted from the tank through the exhaust system (Allen, 1991). However, the volume of water added seems to exceed the volume that could have evaporated, indicating that some of the fluid escaped the tank and entered the adjacent soils. Increasing counts in the leak detection laterals and dry wells in 1978 indicate that gamma-emitting radionuclides migrated to where they could be detected. There was also an inadvertent addition of excess water to Tank 241-A-105 in 1975 that raised the in-tank liquid levels about 4 in. before the liquid level was corrected.

To conduct this study, data from dry wells and laterals surrounding Tank 241-A-105 and neighboring tanks, as well as data from nearby groundwater monitoring wells, were compiled and evaluated. Some dry well and lateral data were obtained from the Waste Information Data System (WIDS) as well as from records maintained in the Tank Farm Surveillance and Analysis Support Group (TFSAS) and in summary form in some reports (e.g., Stalos and Walker 1978). Groundwater data were obtained from the Hanford Ground Water Data Base (HGWDB). Process records relating volumes and constituents discharged to various liquid effluent disposal facilities in the area of the A Tank Farm were also obtained from WIDS. A search was also made for historic data that are not in WIDS or the current files of TFSAS.

The files of a retired Hanford soil chemist were used for historic information and data that may not be in reports. These files supplied some useful information and data and are housed in the Geosciences technical files.

2.0 WASTE COMPOSITION AND DETECTABILITY

The composition of the waste in Tank 241-A-105 affects the detectability of wastes leaked from the tank and the ability of personnel to determine whether a leak has occurred. Tank 241-A-105 was a self-boiling tank that received wastes primarily from the Plutonium-Uranium Extraction (PUREX) process. The PUREX uses tributyl phosphate in kerosene to recover uranium and plutonium from nitric acid solutions made from irradiated uranium-bearing fuel rods. Most nitric acid is recovered and recycled in the PUREX process, but some residual nitric acid is neutralized before discharge to the waste storage tanks. Initially, cladding (alloys of aluminum for early reactors and zirconium for N Reactor) is dissolved and produces highly metallic waste that is discharged to tanks. The PUREX waste, like most tank waste at the Hanford Site, was modified into an alkaline slurry before it was discharged to tanks to minimize corrosion of the tank carbon steel liners. Through the addition of various sodium compounds, alkalinity (pH of between 9.5 and 12) was maintained, and salt concentration was stabilized at about 7.0M sodium. Like other single-shell tanks (SST), Tank 241-A-105 contains primarily inorganic wastes consisting of sodium hydroxide, sodium salts of nitrate, nitrite, carbonate, aluminate and phosphate and hydrous oxides of iron and manganese. The radioactive components consist of various fission products. Figure 1 gives the original inventory and the likely inventory after decay and actinide elements such as uranium, thorium, plutonium and neptunium. Jansen et al. (1965), from analyses of sludge and supernate, list the principal contents of Tank 241-A-105 as ^{90}Sr , ^{137}Cs , ^{144}Ce , ^{106}Ru , ^{144}Pm and $^{95}\text{Zr-Nb}$. Following decay of short-lived fission products (Figure 1), the principal radionuclides remaining in the tank when the spray cooling water was added were ^{144}Ce , ^{106}Ru , ^{147}Pm , ^{137}Cs and ^{90}Sr . The waste forms in Tank 241-A-105 are principally sludge and salt cake, with minimal interstitial fluid.

The radionuclides most likely detected in soils (i.e., in the dry wells and laterals) using a gross gamma probe are ^{144}Ce , ^{147}Pm and ^{137}Cs (and daughter isotopes in the decay chain). Other gamma-emitting, fission product radionuclides with short half lives are unlikely to be found because they probably would have decayed to a ground state or very low levels within the tank. Radionuclides that decay principally by emission of alpha or beta particles will not penetrate steel casing and would not be detected by a gross gamma probe. Any daughters that also emit gamma energy or decay to an isomer might contribute some gamma energy to the total activity detected by a gamma probe.

Constituents detected in groundwater likely would be those of greatest mobility, i.e., radionuclides and anions not readily sorbed in passing through the soils of the unsaturated zone en route to groundwater (e.g., tritium, NO_3 , SO_4). Most of the metal fission products such as ^{137}Cs and ^{90}Sr are likely to sorb close to their point of origin (Van Luik and Smith 1982). Analyses in the HGWDB indicate the presence of some of these constituents in groundwater shortly after PUREX began operating, suggesting that the reported results may reflect improper techniques of sampling and/or analyses, or that constituents

Figure 1. Tank 241-A-105 Fission Product Inventories
(taken from Jansen et al. 1965).

were transported to groundwater via direct pathways along poorly sealed wells. The annular space in early wells was not sealed, and many of these wells were drilled close to the cribs they were intended to monitor.

Nonradioactive, largely inorganic compounds, while present in the waste, were never sought by detecting probes in the soils. Radionuclides were the principal concern, and the gamma emitters were the easiest to detect. If gamma-emitting radionuclides were detected by gross gamma probes in laterals and dry wells, it is likely that other waste constituents were present. Confirming evidence of the nonradioactive components is lacking.

3.0 REVIEW OF UNSATURATED ZONE DATA

3.1 LEAK DETECTION SYSTEM

Liquid levels were measured in the SSTs so that changes not accounted for by operational or known processes in the tanks could be further investigated as possible leaks and wastes could be removed from leaking tanks. However, liquid levels in the tanks in the 241-A Tank Farm were never static because these were self-boiling tanks. Therefore, it was more difficult to determine whether wastes in the A Farm tanks were being confined within the tanks using liquid level measurements.

In order to confirm tank leaks suspected from measured changes of in-tank fluid levels, a number of shallow boreholes were constructed around each tank in the 241-A Tank Farm to provide access for radiation detection instruments (Figure 2). These shallow boreholes, known as "dry wells," were constructed in 1962 to a depth of 75 ft and in 1978 were deepened to 125 ft around Tank 241-A-105 (Table 1). They are located about 10 ft beyond the edge of Tank 241-A-105 and provide access for instruments that can be used to detect changes in radiation levels in the boreholes. Initially, Geiger-Mueller tubes were to be used to detect changes in activity, but these probes were subsequently replaced by gross gamma logging tools. Gross gamma logging is used to measure changes in radiation above background or some other established baseline. After compiling baseline values, subsequent logging is used to note any changes in the pattern of activity different from that in the baseline. These gross gamma probes can note an increase or decrease in radiation intensity as radioactive contaminants move past a well or decay, or trace the movement of a peak to greater depth and thus movement of gamma-emitting radioactive contaminants. Changes in radiation levels in the dry wells can also indicate that a leak may have "self healed"; i.e., precipitation of salts effectively reduce or eliminate the pathway along which fluids migrate. Loss of hydraulic head from reduction or elimination of fluids in a tank can also result in reduction of activity seen in the logs.

Additionally, three radiation detection lateral lines were constructed in 1962 about 10 ft beneath each tank in A Farm. These extend from one of two 12-ft diameter, 75-ft-deep caissons (Figure 3). Scintillation probes are inserted under pneumatic pressure to the end of the lines. Then the lines are logged as the probes are retrieved. While not calibrated to allow a quantitative interpretation, gross gamma logging nevertheless permits

Figure 2. Dry Wells Around the 241-A Tank Farm.

Table 1. Dry Wells Around Tank 241-A-105.

Well number*	Date	Depth**	Diameter
E25-56 (10-04-04)	6/55	151	8"
E25-62 (10-05-09)	4/62	125 (75)	8"
E25-63 (10-04-05)	4/62	125 (75)	8"
E25-66 (10-05-10)	4/62	130 (125)	6"
E25-67 (10-05-12)	4/62	125 (75)	8"
E25-68 (10-05-02)	5/62	121	4"
E25-69 (10-06-09)	4/64	130 (125)	6"
E25-70 (10-05-05)	4/62	75	8"
E25-71 (10-05-07)	4/62	75	8"
E25-98 (10-05-08)	1/66	56	6"

NOTE: There are 51 dry wells in A Tank Farm. Laterals are also present--3 laterals per tank at about 10 ft below each tank. These laterals extend from two central caissons.

*Number in parentheses is tank farm monitoring number. Number 10 is code number for A Tank Farm; 05 (second part of number) is number of tank; the third part of the number is clock position, with north as 12 o'clock. Thus, well 10-05-09 is a leak detection dry well at the west (9 o'clock) location around the 241-A-105 tank.

**Number in parentheses is the original depth of the well before deepening.

Figure 3. The 241-A Tank Farm Laterals and External Dry Wells.

detection of changes in radiation levels between readings. When recommended in 1961, the system of three radiation detection laterals and seven dry wells for each self-boiling tank was intended to detect any leak of 6,400 gal or more from a tank (Stivers 1961) assuming optimum conditions and the ability to detect gamma-emitting radionuclides up to 7 ft from the borehole.

These probes detect only gamma-emitting radionuclides and indicate only cumulative levels of activity, not the specific isotope(s) producing the activity. Without detailed knowledge of the specific tools, shielding, logging rates, and procedures used to obtain these logs, interpretation is necessarily qualitative. More detailed interpretation might be possible with further investigation into these parameters and how they changed with time. In reporting the data in the ensuing paragraphs, activity is reported in both counts per minute (c/m) and counts per second (c/s) corresponding to the original units recorded. No attempt was made to convert c/m to c/s because the data reported as c/m were taken by different instrument(s) with different sensitivity than those reported as c/s. Without specific calibration, conversion of units is not recommended.

Fully calibrated spectral gamma logging tools are currently being developed that will permit the identification of specific radionuclides producing the activity. After logging and interpretation, the spatial distribution of specific radionuclides in the upper part of the vadose zone around Tank 241-A-105 (and other facilities) will be better understood, which will in turn facilitate modeling to determine the extent of transport of radionuclides that have escaped from Tank 241-A-105. Closure of the SSTs requires data of the spatial distribution, and any changes with time, of radionuclides.

Scintillation logs or summaries of scintillation logs from dry wells listed in Table 1 were studied for the period 1972 to present. Logs from the pre-1972 era are in archival storage and were not retrieved in time for this report. The minutes from meetings held in 1965 in response to the Tank 241-A-105 steam release incident provided some unconfirmed values of lateral logs.

The first leak from Tank 241-A-105 was reported on November 19, 1963, when 17,000 c/m were detected in lateral number 3. Seven days later, the activity had increased to 150,000 c/m in this lateral (Beard et al. 1967). Radiation was detected over only a very short segment of the lateral, indicating a small "finger" of waste from a relatively small leak had encountered the lateral. Radioactivity continued to decrease in this lateral to about 50,000 c/m until March 8, 1965 when it "increased by a factor of 60 and then remained constant. No radiation increases were detected in the other laterals or the vertical wells that indicated leakage. One well was drilled to a depth of 65 ft and terminated at the same depth as the laterals, 10 ft from the high radiation reading in the number 3 lateral. No radioactive contamination was detected in the soil samples removed from the test wells, and the maximum temperature in the test wells was 206 °F. These data indicated the leakage was 'small'" (Beard et al. 1967, p. 15).

Logs of most dry wells around Tank 241-A-105 generally reveal background levels of decay, with no peaks. Logs of dry wells (see Glossary) 10-05-05 (E25-70), 10-05-07 (E25-71), 10-05-09 (E25-62), and 10-05-12 (E25-67) reveal

background values (up to 50 c/s with present instruments) (Figure 4) from surface to total depth (0 to 75 or 0 to 125 ft) for the entire period of record studied. Several wells reveal a shallow peak at a depth of 3 to 8 ft, indicating likely surface contamination from undocumented spills or the effects of fluids in nearby transfer lines that pass very close to the dry wells. Transfer lines are not double contained, and small leaks were likely during use. However, dry well 10-05-02 was deepened in the summer of 1978 because of a peak that appeared at the 75-ft-level (bottom) of the well. The earliest records examined (1/27/75) reveal this peak reading at 75 ft to be 2,800 c/s. This peak persisted at levels between 300 and 900 c/s leading to deepening of the well to better determine the level of activity and depth. Tabulated data for this dry well in Stalos and Walker (1978) indicate that the peak value was 200 c/m, with values exceeding 10,000 c/m at the bottom of the well. With the initiation of a new probe in 1975, values near the bottom of the well changed to 1,684 c/s (January 20, 1975) and declined steadily to 189 c/s in July 1978 just before the well was deepened.

The first log obtained after deepening well 10-05-02 was on July 21, 1978. The log indicated a peak of 1,516 c/s at 100 ft. On August 7, 1978, this well showed a peak of 1,100 c/s at a depth of 95 ft. The peak decayed as revealed by the next two logs on September 4 and October 2, 1978. The October record shows that a single broad peak split into two peaks that are nearly the same depth and are initially identical in counts. The second peak at a depth of 100 to 102 ft appears to decay at a slower rate from October 1978 to July 1979, when only one broad peak is visible on the log. This single broad peak continues to decay until November 1983, at which time it has decayed to background levels (30 to 40 c/s). Selected logs taken in dry well 10-05-02 are shown on Figure 5.

Tabulated data from the leak detection dry well 10-05-10 exhibited a peak of 473 c/s at 60 ft, which declined steadily to a value of less than 50 c/s on November 28, 1977. A bottom reading of up to 1,070 c/s was noted in October 1973 and April 1974.

Elevated counts were also reported in dry well 10-05-10 just after the well was deepened in 1978. Only background values were noted on this log immediately before deepening the well except for an increase in counts at the base of the 75-ft well. Because counts were increasing at 75 ft and had not reached a peak, the well was deepened to determine the full extent of this peak. Two broad peaks showed in the first logs taken after deepening of dry well 10-05-10, and these peaks persisted through 1990, although with some reduction in intensity (Figure 6). The broad peak that first appeared after deepening the dry well to 125 ft appeared at a depth of about 25 to 50 ft. At about 25 ft, counts increased to about 60 to 75 c/s and decreased from about 100 c/s to background at about 50 ft. Peak values within this broad peak generally reached between about 120 and 135 c/s. Because this peak appeared in the first log after deepening of the well at an interval at which only background values appeared, it is assumed that this peak is somehow related to the deepening of the well. A handwritten note in the files of R. C. Routson, retired Principal Soil Scientist and long-time tank farm researcher, indicates that the casing of well E25-66 was pulled during deepening of the well to investigate the corrosion of casing of tank farm dry wells. The original casing was heavily corroded between the 60- and 70-ft depths, and the casing facing the tank had corroded completely through. Pulling the original casing

Figure 4. Logs of 241-A Tank Farm Dry Wells.

Figure 5. Selected Logs Taken in Dry Well 10-05-02.

Figure 6. Logs of 241-A Tank Farm Dry Well 10-05-10.

and driving replacement casing to deepen the well could have led to the broad peak between 25 and 50 ft, presumably by introduction and driving of some contamination during construction.

The second peak revealed the extent of the increase barely sensed at the base of the 75-ft well. Counts increased to 150 c/s at 75 to 80 ft, decreased to below 100 c/s and then increased to a second 125 c/s peak on this broad "double peak" at 80 ft before declining to background values. While this double peak persisted through 1990, it slowly declined in intensity, perhaps because of radioactive decay, passage of the plume past the dry well, sealing of the opening through which fluids passed, or reduction of the volume of fluids leaking from the tank.

In-tank photographs and contouring of the tank bottom indicate that bulging of the liner in the southern half of the tank led to ponding of fluids in the northern part of the tank. In-tank photographs indicate that the tank bottom was not smooth, but rippled, allowing fluids to accumulate preferentially in low points. Fluids were apparently directed toward dry wells 10-05-02 and 10-05-10 either by the accumulation in low points at these locations, or by movement to these locations where fractures in the tank wall or footings near these dry wells allowed the fluids to escape the tank.

Early reports indicate that contaminants leaking from Tank 241-A-105 were first detected in the laterals, not in the dry wells. Minutes of a meeting held on March 19, 1965 indicate readings of 220,000 to 260,000 c/m in lateral number 3, but do not specify a location for these values. Readings were taken at least once per shift for the next several months and remained at about 220,000 c/m or above until June when a new probe was introduced. With the introduction of a new probe, counts per minute dropped to 200,000. Minutes from a November 8, 1965 meeting indicated that only lateral number 3 showed elevated readings near previous levels, with readings from an unshielded probe used to log the other laterals revealing "nothing significant." Meeting minutes from December 17, 1965 indicate a possible downward trend in the readings in lateral number 3, with a similar notation in the minutes of a March 28, 1966 meeting.

Tabulated data in Stalos and Walker (1985) indicate clearly that radioactivity has been consistently highest in lateral number 3, with a gradual and progressive decline in values for the period September 1972 to October 1984. Radiation levels in the number 1 lateral are the lowest readings for any one date of survey, with intermediate values for the number 2 lateral. Readings for September 11, 1972 in the number 3 lateral are 580,000 c/m at a distance of 17 ft from the end of the lateral and decline progressively as indicated in Table 2.

Occurrence report 78-49 (May 15, 1978) noted a major increase in the counts detected in leak detection lateral 14-05-03 from 8,600 c/s on May 8, 1978 to 18,000 c/s 61 ft from the end of the lateral on May 15, 1978. Two possible explanations were offered for this increase: (1) water added to Tank 241-A-105 to control the in-tank temperature, and (2) a spill of "raw water" on February 23, 1978 along the east side of the tank farm. Shortly after the spill of raw water, water was discovered in the base of the caisson

Table 2. Lateral Data from Stalos and Walker (1985).
(sheet 1 of 2)

Lateral number	Date	Peak reading (c/m)	Distance from end (ft)	Comments
1. N-77-01'-W (14-05-01)	9/13/72	16,600	12	Red probe
	4/26/74	11,550	12	" "
	1/03/75	4,350	12	" "
	5/12/75	3,900	12	" "
	8/15/75	6,200	12	" "
	1/07/76	6,300	15	" "
	6/04/76	5,750	16	" "
	9/10/76	7,500	16	New red probe
	12/06/76	7,715	16	" "
	3/28/77	7,300	16	
	6/17/77	400 c/s	154	New monitoring
	9/05/77	445 c/s	155	equipment c/m to c/s
	12/09/77	430 c/s	155	distance from top
	6/09/78	380 c/s	155	
	12/20/78	430 c/s	155	
	12/25/79	390 c/s	158	
	12/16/80	240 c/s	158*	New measurement
	12/28/81	301 c/s	158	method
	12/15/82	373 c/s	158	
	11/18/83	158 c/s	160	
	10/15/84	160 c/s	160	
2. N-58-15'-W (14-05-02)	9/08/72	198,000	80	
	4/26/74	175,000	80	Red probe
	1/06/75	76,999	90	" "
	5/12/75	51,000	75	" "
	8/15/75	54,000	88	" "
	1/21/76	54,000	88	
	8/30/76	79,300	89	New red probe
	12/08/76	82,000	89	" "
	3/28/77	80,700	89	
	6/17/77	3,250 c/s	101	New monitoring
	9/05/77	3,000 c/s	94	equipment c/m to c/s
	12/09/77	2,700 c/s	94	distance from top
	6/05/78	3,000 c/s	94	
	12/25/79	2,300 c/s	94	
	12/16/80	2,266 c/s	104	
	12/16/80	2,266 c/s	94*	New measurement
	10/28/81	2,656 c/s	94	method
	12/15/82	2,481 c/s	93	
	11/18/83	2,204 c/s	96	
	10/15/84	2,449 c/s	97	

Table 2. Lateral Data from Stalos and Walker (1985).
(sheet 2 of 2)

Lateral number	Date	Peak reading (c/m)	Distance from end (ft)	Comments
3. N-39°-30'-W (14-05-03)	9/11/72	580,000	17	Red probe
	4/26/74	485,000	17	
	1/10/75	192,000	17	Red probe
	6/02/75	202,500	17	" "
	8/18/75	199,500	17	" "
	1/05/76	198,000	14	
	8/30/76	273,000	16	New red probe
	10/04/76	347,000	16	" "
	12/08/76	356,000	17	" "
	3/28/77	310,000	17	
	6/16/77	12,000 c/s	163	New monitoring
	9/05/77	10,800 c/s	161	equipment c/m to c/s
	12/09/77	9,500 c/s	161	distance from top
	3/29/78	6,450 c/s	161	
	6/26/78	13,500 c/s	161	
	9/27/78	11,000	161	
	12/20/78	14,500	161	
	12/25/79	3,200	162	
	12/16/80	3,696	154*	New measurement
	10/28/81	7,237	153	method
	12/15/82	6,633	153	
	11/18/83	3,933	154	
	10/15/84	6,661	154	

*See page 10-05-14, paragraph 2.

from which these leak detection laterals extend. As a result of this occurrence, it was recommended that spray irrigation water no longer be added to Tank 241-A-105.

The pattern of high counts in the lateral lines (Figure 7) suggests that the leaks occurred near the periphery of the tank and developed from failure of the liner at or near the intersection of the sides and bottom. The timing of the failure likely coincides with the steam explosion in Tank 241-A-105 in 1965, because 37 days after the steam explosion, the number 3 lateral line reportedly began to show increasing levels of radiation. There was a small leak detected in one of the laterals shortly after the tank first received waste in 1963, but apparently it was small. Decreasing activity in the laterals indicated that the 1963 leak may have "self healed" by precipitation of salts. However, because of the need for storage volume, the tank was filled in December 1964.

3.2 OTHER SOURCES OF FLUID

Two other tanks in the 241-A Tank Farm are assumed leakers: Tanks 241-A-104 and 241-A-103. A small leak from Tank 241-A-104, discovered in April 1975, was estimated at up to 2,500 gal. Tank 241-A-104 was reduced to 28,000 gal total waste and interim stabilized in September 1978. The leak in Tank 241-A-104 was discovered by increased radiation in the leak-detection laterals beneath the tank, as was the leak at the adjacent Tank 241-A-105 (see Figure 3 for a map of leak detection lateral lines). Scintillation log data for seven dry wells for this tank through 1984 indicate only background levels of radiation. In March 1975, increases began to appear in lateral number 2 beneath Tank 241-A-104 (see Figure 3 for a map of laterals beneath tanks in the 241-A Tank Farm). A new peak of 105 c/m was identified in March 1975, 25 ft from the end of the line. In April 1975, a second peak at 220 c/m was identified 73 ft from the end of the line. Both peaks continued to increase over the next several weeks until maxima were recorded: 7,550 c/m 23 ft from the end of the line on October 6, 1975, and 1,200 c/m 73 ft from the end of the line on May 1, 1975. Both peaks continued to decline steadily over the next few years. In March 1977, new monitoring equipment was introduced, and distances were then recorded from the top of the lateral. For the first logs using the new equipment, three peaks were noted: 250 c/s at 161 ft, 60 c/s at 151 ft, and 40 c/s at 107 ft. These peaks continued to decline to background levels by 1981.

A new peak of 105 c/m in lateral number 1 beneath Tank 241-A-104 was noted in April 1975 at a point 76 ft from the end of the line. This peak continued to increase in intensity to a peak of 6,450 c/m on June 9, 1975, from which it continued to decline. A second new peak of 650 c/m was recorded 64 ft from the end of the line on May 19, 1975. The value for this second peak quickly reached a maximum value on October 6, 1975, at which time it continued to decline. A third new peak of 450 c/m was noted 55 ft from the end of lateral number 1 on March 2, 1976 and continued to increase through March 1977 up to 1,260 c/m. As with the 14-04-02 lateral, a new system of monitoring equipment was introduced in the spring of 1977. The first logs taken after this change reveal three peaks of 120, 74 and 57 c/s at distances of 125, 118 and 107 ft from the top of the lateral. These values continued to decline to background by 1980.

Figure 7. Inferred Zone of Contaminated Sediments
Beneath Tank 241-A-105.

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Lateral number 3 also showed a new peak of 205 c/m on April 22, 1975 14 ft from the end of the line. This peak increased to a maximum of 325 c/m in May 1975, declined through October and then increased to a second peak of 330 c/m in January 1976 from which it continued a steady decline. When the new instruments were introduced in March 1977, two peaks of 60 and 17 c/s at 143 and 88 ft from the top appeared. These peaks declined steadily to background values in 1980. The readings in the 241-A-104 laterals are assumed to reflect a leak that occurred in 1975 and not the spread of contaminants leaked from the adjacent Tank 241-A-105. However, contaminants leaked from Tank 241-A-105 may have contributed to these recorded peaks beneath Tank 241-A-104.

In 1987, up to 5,500 gal of waste were estimated to have leaked from Tank 241-A-103. Changes of in-tank liquid levels over a period of several years preceding June 1987 led to the convening of a committee of five engineers to evaluate the data to determine with 95% confidence, whether the tank could be declared sound. Two of five members felt that they could not declare the tank sound with 95% confidence, and therefore Tank 241-A-103 was declared an "assumed leaker." This designation was made despite the absence of any changes in the profile of radioactivity seen in the scintillation logs taken in both the dry wells and laterals. There has been no increase above background in these dry wells and laterals since the designation of "assumed leaker" has been applied to this tank. Nevertheless, Tank 241-A-103 was interim stabilized in August 1988, and its contents were reduced to 370,000 gal of waste.

Two additional dry wells, 10-01-16 and 10-01-28, were constructed southeast of Tank 241-A-101 in 1981 and 1984, respectively. When dry well 10-01-16 was first logged in February 1981, two peaks were detected: 1,304 c/s at 34 ft and 725 c/s at 29 ft. By May 1983, these two peaks had merged at about 36 ft and increased to 6,203 c/s, from which the intensity continued to decline through at least November 1986 to 3,420 c/s. When dry well 10-01-28 was first logged in January 1984, a peak of 13,295 c/s was found at 30 ft. Through several readings thereafter, the peak continued to decline to about 10,789 in November 1986 while remaining fixed at about the 30-ft depth. Nearby dry well 10-01-04 began showing a rise in counts at a depth of 38 ft about 2 yr after the well was deepened to 125 ft in September 1978. The rise continued until the counts peaked at 1,343 in May 1983 when counts continued to decline to 729 c/s by November 1986. No changes were noted in any readings in dry well 10-01-05 during this interval of time, with readings continually at background levels. Occurrence report OR-81-03 was issued on January 13, 1981 after the initial increase in activity in dry well 10-01-04. The assumed cause of this increase in observed activity was leakage of water from an unknown source that mobilized Cs-137 and Ru-106 present in the soil around a nearby sluice pit. Counts in dry well 10-01-04 at the 40-ft depth stabilized in 1983 and have slowly declined with time to 510 c/s on February 21, 1989. Peaks in dry wells 10-01-16 and 10-01-28 at 36 ft and 32 ft, respectively, have been on the decline since 1985 and have reached values of 1,260 and 9,000 c/s on February 27, 1989. All this activity occurred on the southeast side of Tank 241-A-101, with no activity noted in any laterals or dry wells toward Tank 241-A-105. Therefore, the activity in the dry wells surrounding Tank 241-A-101 does not appear to be related to any leak or spreading from a source in Tank 241-A-105.

Both Tank 241-AX-102 and Tank 241-AX-104 in the adjacent tank farm immediately north of the 241-A Tank Farm are assumed leakers. Leak detection in the AX Farm is performed by in-tank measurements of liquid levels, by dry wells and by a collection system between the carbon steel liner and the concrete. (Several drains collect any fluid accumulating in the space between the liner and the concrete and direct the fluid to a sump.) Leak-detection laterals are not present beneath tanks in the AX Tank Farm. Tank 241-AX-104 was assigned "Questionable Integrity" status in November 1977 because of increasing activity in several dry wells. A radiation peak that appeared initially at the 60-ft depth in dry well 11-04-08 in May 1976 had quadrupled in intensity by March 1977. After investigation, the increasing activity in several dry wells was believed by some to result from the 20-in. vapor line and the tie line to the 24-in. vessel vent header. Tank 241-AX-104 was interim stabilized in August 1981 at which time the total waste volume was reduced to 7,000 gal. Up to 8,000 gal may have leaked from Tank 241-AX-104.

A peer review panel convened in August 1988 to evaluate the status of Tank 241-AX-102. When the integrity of the tank could not be determined with 95% confidence, the tank was declared a leaker on August 17, 1988 despite the absence of any change in the background levels of radiation detected in the dry wells surrounding the tank and the absence of any indication of a leak from the leak detection pit beneath the tank. Tank 241-AX-102 was interim stabilized in September 1988 based on an assumed leak of 3,000 gal. Tank 241-AX-102 currently contains 39,000 gal of waste after interim stabilization.

Between the morning of February 22, 1978 and 5:30 pm February 23, 1978, approximately 60,000 gal of uncontaminated "raw water" leaked to the ground from a broken 2-in. pipe along the east side of the 241-A Tank Farm (Occurrence Report 78-24). The water was found ponded in a 6- to 8-ft-dia. hole of unknown depth. At the edge of the hole radiation readings of 1,000 mrem/h were recorded. A cave-in was discovered on the morning of February 24, 1978 between Tanks 241-A-102 and 241-A-105. The leak was attributed to the rupture of the M5a line approximately 30 ft southeast of the 501 Valve Pit building. The soil subsidence between Tanks 241-A-102 and 241-A-105 was attributed to subterranean flow of water along a pipe, which resulted in subterranean erosion that led to sinking of the ground surface. Neutron-neutron logs were run in some nearby dry wells, but no moisture could be definitely detected. Between February 21, 1978 and February 24, 1978, the counts jumped from about 15 c/s to about 130 c/s in all three laterals beneath Tank 241-A-103 about 60 to 70 ft from the top of the lateral. This peak has remained at about the same intensity to date. The rapid appearance of this leaked water in the laterals indicates high transmissivity of the sediments surrounding and beneath the tank and the mobilization of gamma-emitting contaminants that were detected by scintillation logging. Other leaks of water lines may have occurred, but no documentation could be found to substantiate such leaks.

Minutes from a March 1, 1965 meeting state "Well number 2 near the 104-A tank increased to greater than 1,000,000 counts at about seven feet below ground level. This increase was very likely due to the back-up in the new line which drained out into the excavation near the well." There is no further explanation of this occurrence, but it does indicate a leak from a

"new line" that must have contained some waste destined for Tank 241-A-104 (or other) tank. No other documentation of this event was found.

Several other liquid waste disposal facilities are present within a 1,000-ft radius of Tank 241-A-105, including reverse wells and cribs (see Glossary for definitions). The cumulative volume of liquid effluent added to these facilities greatly exceeds the estimates of water added to Tank 241-A-105. More than 3.6 billion gal of liquid effluent have been disposed to the soil from 1955 to the present in various cribs, french drains, etc., that received wastes from PUREX and that are listed on Table 3. Most, but not all, of these discharges occurred during times when PUREX was operating (1956 to 1972 and 1982 to 1988). Note that the contaminants in the liquids disposed include essentially the same constituents disposed to Tank 241-A-105 and that the list includes only radionuclides for which there are records of disposal. Nitrate is the only nonradioactive contaminant listed in this table, although there were very likely unknown quantities of various chemicals disposed to these facilities, constituents that are currently listed as dangerous waste but that were not monitored before the initiation of the Resource Conservation and Recovery Act (RCRA) groundwater monitoring.

3.3 ANALYSIS OF AVAILABLE DATA

Process and historical records, along with data from logging of the dry wells and leak detection laterals beneath Tank 241-A-105, suggest that fluids have escaped from the tank and spread into the soils. However, with the limited number, distribution, and depth of wells and laterals in the unsaturated zone, it is not possible to map a plume to determine the present distribution of these leaked fluids. The general absence of activity shown on scintillation logs in the dry wells suggests that gamma-emitting radionuclides leaked from the tanks along the ruptured seam of the side and bottom of the liner and have probably penetrated vertically downward in the soils below the 125-ft depth of the dry wells. The general absence of activity in the dry wells suggests no significant lateral spreading immediately below the tank. Little can be interpreted concerning the fate of alpha- and beta-emitting radionuclides or hazardous wastes in the soils for which there are no data. The gamma-emitting radionuclides are tracers of leaked waste, so it is reasonable to assume that other alpha- and beta-emitting radionuclides as well as nonradioactive components are also present in the soils. However, there are no definitive data to indicate their distribution in the soils.

4.0 REVIEW OF GROUNDWATER DATA

4.1 HYDROGEOLOGY OF THE 241-A TANK FARM

Groundwater occurs in the unconfined aquifer at a depth of about 285 ft beneath Tank 241-A-105 in unconsolidated sediments of the Hanford or Ringold Formation (Price and Fecht 1976). In the 200 East Area, recharge to the unconfined aquifer occurs mostly by discharge of liquid to unlined ponds, trenches and cribs, perhaps supplemented minimally by natural precipitation

Table 3. Liquid Effluent Facilities Close to 241-A Tank Farm.* (sheet 1 of 3)

Facility	Type	Dates of operation	Volume (gals)	Waste type	Radionuclides
216-A-1	Crib	11-12/55	25,997	Uranium from PUREX startup	Co-60, Cs-137, Sr-90, Pu-239, Pu-240, U-238
216-A-6	Crib	11/55-1/61 3/66-1/70	898,282,695	Steam condensate, floor and door drainage, basin overflow from PUREX	Cs-137, Ru-106, Sr-90, Pu, alpha, beta, U, nitrate
216-A-7	Crib	1/56-7/59	87,186	Catch tank and sump waste from 241-A-152 diversion box	Pu, beta, Sr-90, Ru-106, Cs-137, Co-60, U-238
216-A-8	Crib	11/55-5/58 1/66-4/76 1/78-4/78 10/83-3/84	242,969,644	A, AX, AY & AZ Tank Farm tank condensate	Pu, beta, Sr-90, Ru-106, Cs-137, Co-60, U
216-A-9	Crib	3/56-2/58 4/66-10/66 8/69	259,180,978	PUREX fractionator condensate and N Reactor decon waste	Cs-137, Sr-90, Pu, alpha, beta, U
216-A-15	French drain	12/55-1972	2,642,008	216-A-10 process condensate	Beta, nitric acid
216-A-16	French drain	1/56-3/69	32,232	Floor and stack drainage from 241-A-431 building	Nitrate, beta
216-A-17	French drain	1/56-3/69	15,852	s/a	Nitrate, beta
216-A-19	Trench	11/55-1/56	290,621	Condenser cooling water from 241-A-431 building and depleted U waste from cold startup at PUREX	Cs-137, Ru-106, Sr-90, Pu, alpha, beta, U, nitrate

Table 3. Liquid Effluent Facilities Close to 241-A Tank Farm.* (sheet 2 of 3)

Facility	Type	Dates of operation	Volume (gals)	Waste type	Radionuclides
216-A-20	Trench	11/55-1/56	253,897	s/a 216-A-19	
216-A-22	French drain	3/56-12/58	2,642	203-A building drainage and sump waste	
216-A-24	Crib	5/58-1/66	216,644,649	Condensate from A and AX Tank Farms	Pu, beta, Sr-90, Ru-106, Cs-137, Co-60, U
216-A-30	Crib	1/61-	1,878,467,635	Steam condensate, drainage and over-flow from PUREX	Am-241, Cs-137, H-3, Pm-147, Pu-239, Ru-106, Sn-113, Sr-90, Pu, alpha, beta, U
216-A-32	Crib	1/59-1972	1,057	Drainage from floor, sink and shower of PUREX crane maintenance shop	Beta
216-A-37-1	Crib	3/77-	99,603,699	Process condensate from 242-A evaporator	Am-241, Cs-137, H-3, I-129, Pm-147, Pu-239, Ru-106, Sr-90, alpha, beta, U
216-A-37-2	Crib	1983	287,978,864	PUREX steam condensate	Am-241, Cs-137, H-3, Pm-147, Pu-239, Ru-106, Sn-113, Sr-90, alpha, beta, U
216-A-39	Crib	6/66-6/66	5.3	241-AX-801-B floor drainage	

Table 3. Liquid Effluent Facilities Close to 241-A Tank Farm.* (sheet 3 of 3)

Facility	Type	Dates of operation	Volume (gals)	Waste type	Radionuclides
216-A-40	Trench	1/68-5/79	249,934	244-AR vault cooling water and steam condensate	Nitrate
216-A-41	Crib	1/68-1974	2,642	296-A-13 stack drainage	Nitrate, beta
			3,896,732,237		

*Data compiled from Waste Information Data System and from Maxfield (1979).

PUREX = Plutonium-Uranium Extraction

s/a = same as

(mean annual precipitation at Hanford is 6.25 in.). Artificial recharge from liquid disposal facilities in the Separations Areas on the Hanford Site greatly exceeds natural recharge, if any, to the unconfined aquifer (Routson and Johnson 1990). Some natural recharge may occur in areas where the ground surface consists of gravel and is unvegetated (Gee and Kirkham 1984). Since 1944 when Hanford operations began, liquid effluent discharges have raised the water table several tens of feet and resulted in mounds beneath the 216-B-3, 216-U-10, and 216-A-25 (Gable Mountain) ponds. These mounds have also affected the direction and rate of flow of groundwater as can be seen by comparing a 1988 water table map of the Hanford Site (Figure 8) with a hindcast map for 1944 (Figure 9).

Sediments underlying Tank 241-A-105 are mostly medium to coarse sand containing various percentages of pebble and cobble gravel. Figure 10 (a northeast trending cross section) shows the degree of lateral variability in the fluvially deposited sediments of the Hanford formation. Note that there is a finer grained horizon at the top of the Ringold Formation at and just above the water table. These unconsolidated sediments of the Hanford formation have relatively high permeability. In places, the clasts are dominant and the material becomes a sandy gravel or gravel rather than the usual gravelly sand. Thin, laterally discontinuous units of silt or silty fine sand may be interbedded in the section. While volumetrically insignificant, these thin units may be hydrogeologically significant in that they may serve to laterally disperse downward percolating fluids. Photographs taken during construction of the 241-A Tank Farm in 1954-55 reveal stratification in the sideslopes of the excavation. Interbedded fine sand and silt units such as these would enhance lateral transport of fluids. Similar strata are likely within the sediments between the base of the tanks and the water table and would thus facilitate the lateral dispersal of fluids leaked from the tanks. Thin, discontinuous units can be seen in several cross sections beneath the A Tank Farm in Price and Fecht (1976). Similar units were encountered in drilling RCRA groundwater monitoring wells around the A Tank Farm in 1989.

In a stratigraphically layered (heterogeneous) system like that beneath Tank 241-A-105, the variations in permeability of the various strata affect the degree of lateral spreading of downward percolating fluids and thus the volume of voids that could become saturated by fluids leaking from Tank 241-A-105. The larger the volume of sediment affected by downward percolating fluid, the larger the total volume of voids for the fluids to occupy and thus the greater quantity of fluid that can be accepted and held by the sediments before draining by gravity to groundwater. The volume of fluid that can be retained in a column of soil without draining to groundwater is termed the field capacity. The greater the lateral spreading of fluids beneath a leak (source), the larger the volume of fluid that will be retained. Samples analyzed for moisture content during drilling of RCRA groundwater monitoring wells in 1989 indicate less than 5% moisture (by weight) is typically present in the sand and gravel around the A Tank Farm. Samples from thin, finer-grained units containing some silt have yielded moisture contents of up to 26% (by weight). The three groundwater monitoring wells constructed in 1989 are in upgradient and downgradient locations just beyond the perimeter fence of the A Tank Farm. These finer-grained units must become saturated before fluids will drain through to underlying strata. Because the voids in

Figure 8. 1988 Water Table Map of the Hanford Site.

Figure 9. Estimated Water Table Map of the Hanford Site for 1944.

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the sediments have to become saturated before fluid will infiltrate downward, the measured moisture contents suggest that the sediments could hold substantially more fluids; i.e., the fluids in the sediments generally do not exceed the field capacity of the soils. The difference between the moisture content and the field capacity is the water that can be stored in the soil.

The groundwater mound beneath B Pond has resulted in a very low groundwater gradient in the 200 East Area, with the most likely flow of groundwater beneath the A Tank Farm being toward the west to southwest (see Figures 8 and 9). Little difference in the elevation of the water table has been measured recently between wells on the upgradient (east) side of the tank farm and wells on the downgradient (west) side (Table 4). The low groundwater gradient beneath the 200 East Area is attributable to the high transmissivity of the sediments constituting the unconfined aquifer. Because of this low gradient and high transmissivity, large volumes of water disposed to the soil column and percolating to groundwater are unlikely to result in a persistent groundwater mound unless the volume of waste discharged overwhelms and saturates much of the unsaturated zone (as at B Pond).

Water levels in the 200 East Area have risen and fluctuated with time. A hindcast map of the water table at the Hanford Site suggests that the elevation of the water table in the eastern part of the 200 East Area where the A Tank Farm is located was about 380 ft in 1944 (see Figure 9). Water level elevations beneath the A Tank Farm are presently about 403 to 404 ft above sea level (see Figures 8 and 11).

Several wells have a long-term record of water level change in the vicinity of the A Tank Farm, including E25-2 (an upgradient well). Hydrographs of some of these wells are shown on Figure 12. Water level elevation from 1956 to 1969 in this well increased from about 395 ft to about 407 ft; from 1970 to 1973, the water level declined about a foot. No measurements were made from 1973 to 1990. In well E24-4, located a few hundred feet west of the A Tank Farm adjacent to the 216-A-9 crib, the water level elevation was 401.9 ft in September 1960. By May 1973, the water level elevation in this well had increased to 404.01 ft and has remained within 1 ft of this elevation through May 1990. In well E25-4, located several hundred feet northeast of the A Tank Farm adjacent to the 216-A-8 crib, the water level elevation in May 1956 was 399.06 ft. By September 1960, the water level in this well had risen to 402.5 ft and by May 1973, had reached 404.43 ft. In December 1983, water level had risen to 406.13 ft and reached 407.34 ft in December 1985. Since then, water levels have been declining to 402.76 ft in June 1990. The rise of water table elevation in 1983 corresponded to re-use of this crib, which was out of service from 1976 to 1983. In well E26-4, located adjacent to the 216-A-24 crib, water level elevation was 400.69 ft in December 1958. By August 1965, water level elevation in this well had increased to 405.5 ft and has remained essentially within a foot of this value through more than 20 measurements until June 1990. In well E27-3, located several hundred feet northwest of the A Tank Farm, water level elevation in September 1960 was 402.0 ft. By August 1965, water level had reached 404.49 ft in this well and increased slowly to a maximum elevation of 406.32 in April 1969 from where it has declined slowly. The most recent water level measurement was taken in December 1982 when the water level elevation was 400.69 ft.

Table 4. Groundwater Elevations in Wells Around 241-A Tank Farm.

Well number	WMA	Date	Depth to water	Well elevation	Water level elevation
E24-13	A-AX	6/28/90	286.87	691.13	404.26
		11/26/90	287.43		403.70
E24-19R	A-AX	6/28/90	289.54	693.65	404.11
		11/26/90	289.97		403.68
E25-1	A-AX	6/28/90	286.29	690.57	404.28
		11/26/90	286.76		403.81
E25-2	A-AX	6/27/90	271.06	675.45	404.39
		11/27/90	271.44		404.01
E25-13	A-AX	6/28/90	278.15	682.43	404.28
		11/26/90	278.60		403.83
E25-15	A-AX	6/28/90	285.46	689.73	404.27
		11/26/90	285.93		403.80
E25-40R	A-AX	6/28/90	261.42	665.71	404.29
		11/26/90	261.79		403.92
E25-41R	A-AX	6/28/90	266.91	671.26	404.35
		11/26/90	267.28		403.98

R indicates that the well is a Resource Conservation and Recovery Act groundwater monitoring well that meets the construction specifications in WAC 173-160.

Although drilled during different years, all wells were resurveyed to the same datum in September 1990 so that water level data are consistent and comparable.

WMA = Waste Management Area.

Figure 11. June 1990 Water Table Map of the 200 East Area.

Figure 12. Hydrographs of Wells Near the 241-A Tank Farm.

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An April 1966 water table map for the Hanford Site indicates that the elevation of the water table beneath B Pond was greater than 415 ft, within a few feet of present elevation. However, maps of groundwater contamination in the early 1950's suggest that before the beginning of PUREX operations and the discharge of large volumes of effluent to cribs in the vicinity of that plant, the flow of groundwater from the northern part of the 200 East Area was southeast toward PUREX. Before the startup of PUREX, the annual volumes of liquid discharged to B Pond were less than 500 million gal (compared with discharges of several billion gallons in the 1960's to present). Large discharges to cribs and discharges to reverse wells in the area of B Plant in the 1940's and early 1950's, along with a significantly lower water table near the present A Tank Farm because of the low discharges to PUREX cribs and B Pond in the early 1950's, may have created a sufficient head to direct groundwater flow from the area of the BY cribs toward the A Tank Farm. The saturated thickness of the unconfined aquifer in the area of the BY cribs in 1990 is between 15 and 20 ft. Sediments of the Hanford formation in this area rest directly on southward dipping basalts of the Columbia River Basalt Group along the flanks of the Cold Creek syncline. The axis of the Cold Creek syncline plunges southeast.

Although water level elevations have changed with time, the dominance of the B Pond mound and its control of water level elevations and direction of flow in the area of the A Tank Farm was established by the 1960's. However, an earlier groundwater flow regime before the large volumes of effluent discharged to PUREX cribs and B Pond caused groundwater to flow southeastward from the area of the BY cribs. The high volume of high-salt liquid wastes discharged to the BY cribs and trenches during uranium scavenging operations (approximately 45.7 million gal) in the early to mid 1950's most likely would have sunk to the bottom of the unconfined aquifer because of high density and may have flowed southeastward along the top of the basalt toward the area currently occupied by the 241-A Tank Farm and PUREX. Once high-salt wastes sank to the base of the unconfined aquifer, control of flow was determined by the interplay of the groundwater velocity and by the sloping top of basalt. This contrasts with shallow flow in the unconfined aquifer where flow is controlled by head differences in the unconfined aquifer.

Water levels beneath the 200 East Area (and thus A Tank Farm) are anticipated to be on a long-term decline with decrease in the volume of liquid effluents discharged to B Pond and nearby cribs. However, water levels measured recently in wells suggest that there may be some slight seasonal fluctuation of groundwater levels.

4.2 MONITORING WELLS

Six wells constructed between 1955 and 1969 were used to monitor the unconfined aquifer in and around the 241-A Tank Farm before initiation of RCRA groundwater monitoring in 1989. Some of these wells located outside the tank farm proper were located to monitor nearby cribs. The older wells were constructed of carbon steel, with the casing perforated at various intervals in the unconfined aquifer. Note that casing liners were installed in these wells in the mid 1970's. Initially, the annulus between the casing and the formation was open and provided direct access to groundwater along the casing. Any surface spills or caved portions of the formation containing contaminants

potentially could have reached groundwater directly between the time the wells were constructed and the time that the liner was installed and grout was added as a sealant.

Three RCRA Standard groundwater monitoring wells that conform with construction specifications in WAC 173-160 for resource protection wells were added to this network in August 1989. These wells are constructed using annular seals in accordance with the requirements of WAC 173-160. The new wells monitor Waste Management Area (WMA) A-AX, one of several RCRA waste management units at the SSTs on the Hanford Site. These groundwater monitoring wells are listed in Table 5 and shown on Figure 13. Summary as-built diagrams of the nine wells are included in Appendix A. Additional RCRA Standard monitoring wells may be installed at WMA A-AX in the future depending on the efficiency of the existing groundwater network determined by the Monitoring Efficiency Model (MEMO) (see following section).

4.3 THE MONITORING EFFICIENCY MODEL

The likelihood of detecting any contaminants leaked to groundwater from Tank 241-A-105 is related to the number and location of groundwater monitoring wells that could detect contaminants in the groundwater. Without a suitable number and location of wells, any contaminants reaching groundwater could go undetected, thus giving a false sense of environmental consequences of any leak/spill. These wells must also be sampled at the proper times, and the samples must be analyzed for the proper constituents to fully assess the impact of a leak or spill.

The MEMO (Jackson et al. 1991) was run for the 241-A Tank Farm to ascertain the likelihood of intercepting a plume of contaminants leaked to groundwater from Tank 241-A-105. Given certain input, the model generates a hypothetical plume from a continuously leaking source, allows the plume to migrate and spread, and determines the likelihood that a network of groundwater monitoring wells would intercept the hypothetical plume. The plume generation model is basically the two-dimensional analytical transport model of Domenico and Robbins (1985). The MEMO inputs include data on the characteristics of the sediments (soils), the volume and rate of leaking of contaminants, the direction of groundwater flow and the coordinates of wells used to monitor the facility. As output, the model provides a map showing where releases from the facility would and would not likely be detected by monitoring wells under the known constraints assumed for the analysis. Cumulatively, MEMO calculates an efficiency for the groundwater monitoring network, which is basically the probability (expressed as a percentage) of a plume being detected by the network of groundwater monitoring wells.

The MEMO was run for the 241-A Tank Farm using the perimeter fence as the boundary of the tank farm and an assumed southwest direction of groundwater flow because of the B Pond mound. An April 1966 water table map for the Hanford Site shows the B Pond mound at nearly its current elevation; therefore, the current direction of groundwater flow approximates the past directions of flow when contaminants may have leaked to groundwater.

Table 5. Groundwater Monitoring Wells Surrounding the A-AX Tank Farms.

	Depth	Casing(s)	Open interval	Date ^a	Sampled by
Upgradient					
E25-2	375	8", 6"	276-316 ft ^b	3/55 (1/82)	Bailer
E25-13	317	8", 6"	265-316	10/63 (9/76)	Bailer
E25-40 ^c	274	4"	252-273	9/89	Hydrostar
E25-41 ^c	279	4"	255-276	9/89	Hydrostar
Downgradient					
E24-13	340	6", 4"	270-308	9/69 (6/75)	Bailer
E25-16	340	6", 4"	270-307	7/69 (10/76)	Bailer
E25-1	322	8", 4"	280-310	2/55 (10/76)	Bailer
E25-15	340	6", 4"	270-338	7/69 (10/76)	Bailer
E24-19 ^c	303	4"	279-300	9/89	Hydrostar

NOTE: E24-20 is currently being completed.

^aDates of modification (liner installation) given in parentheses.

^bBlank casing from 316 to 375 ft--top of basalt at about 365 ft.

^cResource Conservation and Recovery Act Groundwater Monitoring Wells (comply with WAC 173-160).

Figure 13. Groundwater Monitoring Wells Around the 241-A Tank Farm.

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The MEMO is designed to determine the efficiency of monitoring with a given set of wells; nonetheless, the model can be used to estimate whether contaminants leaked from Tank 241-A-105 to groundwater might be detected. The network of groundwater monitoring wells in existence in 1970 had a 78% likelihood of detecting any contaminants leaked to groundwater from tanks in the A Tank Farm. The areas where contaminants leaked to groundwater from the A Tank Farm would most likely not be detected are along the western margin and the southeast corner of the tank farm. The likelihood of detecting any contaminants leaked to groundwater from the area of Tank 241-A-105 is considerably higher. With the addition of two groundwater monitoring wells in 1989 and 1990 (E24-19 and E24-20), the efficiency of the present groundwater monitoring network increases to about 97%.

4.4 SAMPLING AND ANALYSES OF GROUNDWATER

The six wells that existed during the period of water addition to Tank 241-A-105 have been sampled intermittently by bailer and analyzed for a limited list of constituents. Before 1987, all analyses were for radionuclides only, with a few anions analyzed because of their association with processing facilities and their mobility in soils and groundwater (e.g., NO_3 , SO_4). Constituents and dates of sampling are given in Table 6. Some of these wells were originally located to monitor other facilities (e.g., E25-2 was located to monitor the 216-A-8 crib). Therefore, many of the analytes in past groundwater analyses were chosen to monitor discharges to other liquid disposal facilities and were not chosen to check for constituents discharged to and then leaked from the 241-A-105 (and/or any other) tank. While the data are limited, they do permit some interpretation of constituents reaching groundwater.

Some of the liquids discharged to SSTs were allowed to settle for a short period so that certain short-lived fission products would decay to lower levels of activity and to permit settling/precipitation of dense constituents. After curing and settling, the remaining supernatant was frequently discharged to nearby cribs to make more room in the tanks. This practice was followed in the 1950's when wastes from the BY Tank Farm were discharged to the BY cribs. No records are available to suggest that this practice was followed at A Tank Farm. Through the use of transfer lines, wastes from various plants were routed to different tank farms. Thus, distinction of sources from which contaminants in groundwater may have been derived is complicated by past waste management practices and discharges.

Groundwater analyses results available in the HGWDB are summarized in Table 6. Note that the number and frequency of analyses vary from well to well and that there are periods during which no analyses are reported. For example, gross beta was analyzed weekly in 1957 in well E25-2 during periods of discharge to nearby liquid disposal facilities. Monthly or bi-monthly analyses for gross beta were continued through 1958 and 1959, but there are no data for this well for gross beta between 1959 and 1971, when monthly sampling was resumed. Some data are obviously spurious. For example, an analysis for gross beta is shown for 1951 in well E25-1; however, the well was not drilled until 1955 shortly after construction of the A Tank Farm was completed. Some values are very high compared to others and may represent analytical error.

Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 1 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E24-13	Cesium-137	PCI/L	20.0	4/02/87	< -1.0
				9/02/87	< -.3
				3/10/88	< -2.7
				7/28/88	< 1.4
				6/08/89	< 0.0
	Cobalt-60	PCI/L	22.5	4/02/87	< -9.6
				9/02/87	< 2.3
				3/10/88	< -5.3
				7/28/88	< -.4
				6/08/89	8.7
	Gross beta	PCI/L	8.0	1/14/71	180.0
				2/09/71	150.0
				3/29/71	150.0
				4/22/71	230.0
				3/18/71	170.0
				6/16/71	170.0
				7/08/71	220.0
				8/17/71	240.0
				9/24/71	150.0
				10/25/71	260.0
				11/11/71	280.0
				12/14/71	230.0
				1/13/72	600.0
				2/08/72	410.0
				3/09/72	340.0
				4/18/72	350.0
				5/22/72	370.0
				6/14/72	410.0
				7/20/72	430.0
				8/16/72	370.0
				2/15/73	270.0
				3/21/73	170.0
				4/18/73	220.0
				5/16/73	80.0
				6/20/73	75.0
				7/19/73	75.0
				8/16/73	130.0
				9/13/73	80.0
				10/18/73	90.0
				11/14/73	75.0
				12/14/73	75.0
				1/23/74	75.0

Note: Data are unofficial and should not be referenced without permission from the Geosciences Group

Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 2 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E24-13	Gross beta	PCI/L	8.0	2/14/74	75.0
				3/11/74	85.0
				4/18/74	110.0
				5/14/74	75.0
				6/19/74	85.0
				7/18/74	75.0
				8/14/74	75.0
				9/17/74	80.0
				10/17/74	75.0
				11/13/74	80.0
				12/12/74	80.0
				1/17/75	80.0
				2/11/75	80.0
				3/12/75	80.0
				4/16/75	75.0
				5/21/75	75.0
				6/11/75	75.0
				7/16/75	80.0
				5/09/77	75.0
				8/10/77	75.0
				11/14/77	75.0
				2/06/78	75.0
				5/02/78	75.0
				7/25/78	75.0
				11/13/78	75.0
				5/07/79	75.0
				7/27/79	75.0
				10/23/79	75.0
				11/15/79	75.0
				2/11/80	75.0
				8/22/80	100.0
				3/10/81	340.0
				6/16/81	18.0
				9/09/81	14.0
				11/13/81	17.0
				3/05/82	13.0
				5/27/82	1.0
				8/23/82	8.8
				3/09/83	10.4
				6/01/83	13.5
				8/24/83	11.1
				11/15/83	25.0

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 3 of 29)

WELL	CONSTITUENT			RESULT	
	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E24-13	Gross beta	PCI/L	8.0	3/08/84	27.8
				5/21/84	13.7
				8/07/84	40.6
				11/21/84	6.1
				2/13/85	5.3
				4/10/85	3.5
				2/28/86	5.7
				5/05/86	6.3
				8/14/86	7.7
				11/04/86	6.6
				4/02/87	8.0
				6/29/87	6.9
				9/02/87	9.4
				10/28/87	8.4
				3/10/88	5.8
				5/12/88	6.6
				7/28/88	5.6
				10/26/88	6.7
				2/07/89	5.7
				6/09/89	9.0
	Iodine-129 (Drinking Water Sta	PCI/L	1.0	7/28/88	2.6
				6/08/89	2.2
	Nitrate	PPB	500.0	11/04/86	3010.0
				4/02/87	2950.0
	Nitrate, High Detection Level	PPB	2500.0	6/29/87	4210.0
				9/02/87	2640.0
				10/28/87	2750.0
				3/10/88	< 2500.0
				5/12/88	< 2500.0
				7/28/88	< 2500.0
				10/26/88	< 2500.0
	Nitrate, Phenodisulfonic Acid	MG/L	.5	2/07/89	4300.0
				2/13/85	2.4
				4/10/85	42.3
				2/28/86	3.1
				5/05/86	2.5
	Ruthenium-106	PCI/L	172.5	8/14/86	2.6
				4/02/87	84.0
				9/02/87	< 15.2
				3/10/88	< -18.5
				7/28/88	71.8
				6/08/89	< 15.7

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 4 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E26-13	Strontium-90	PCI/L	5.0	4/02/87	< .2
				9/02/87	< .5
				3/10/88	< .0
				7/28/88	< .7
				6/08/89	< .6
	Tritium	PCI/L	500.0	4/02/87	22200.0
				9/02/87	8430.0
				3/10/88	6390.0
				7/28/88	6120.0
				6/08/89	6310.0
2-E25-1	Cesium-137	PCI/L	20.0	10/07/51	740.0
				7/02/57	740.0
				7/23/57	740.0
				7/30/57	740.0
				8/06/57	740.0
				8/13/57	740.0
				8/19/57	740.0
				8/27/57	740.0
				9/04/57	740.0
				9/10/57	740.0
				9/17/57	740.0
				9/25/57	740.0
				9/30/57	740.0
				10/07/57	740.0
				10/14/57	740.0
				10/22/57	740.0
				10/29/57	740.0
				11/06/57	740.0
				11/11/57	740.0
				11/18/57	740.0
				11/25/57	740.0
				12/02/57	740.0
				12/09/57	740.0
				12/16/57	740.0
				12/30/57	740.0
				1/27/58	740.0
				2/03/58	740.0
				2/24/58	740.0
				3/03/58	740.0
				3/24/58	740.0
				3/31/58	740.0

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 5 of 29)

WELL		CONSTITUENT		RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-1	Cesium-137	PCI/L	20.0	4/21/58	740.0
				4/28/58	740.0
				5/26/58	740.0
				6/02/58	740.0
				6/23/58	740.0
				6/30/58	740.0
				7/28/58	740.0
				8/04/58	740.0
				8/25/58	740.0
				9/02/58	740.0
				9/22/58	740.0
				9/29/58	740.0
				12/01/58	740.0
	Chemical sodium by AA	MG/L	1.0	6/23/53	58.0
				7/28/58	83.0
				9/22/58	34.0
	Cobalt-60	PCI/L	22.5	3/25/57	440000.0
				12/01/58	740.0
	Gross beta	PCI/L	8.0	10/07/51	140000.0
				3/25/57	28000000.0
				7/02/57	58000.0
				7/23/57	97000.0
				7/30/57	100000.0
				8/06/57	120000.0
				8/13/57	98000.0
				8/14/57	93000.0
				8/19/57	93000.0
				8/27/57	110000.0
				9/04/57	110000.0
				9/10/57	120000.0
				9/17/57	120000.0
				9/25/57	130000.0
				9/30/57	140000.0
				10/07/57	140000.0
				10/14/57	210000.0
				10/22/57	120000.0
				10/29/57	110000.0
				11/06/57	120000.0
				11/11/57	120000.0
				11/18/57	120000.0
				11/25/57	140000.0
				12/02/57	110000.0

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 6 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-1	Gross beta	PCI/L	8.0	12/09/57	150000.0
				12/16/57	100000.0
				12/23/57	100000.0
				12/30/57	94000.0
				1/27/58	85000.0
				2/03/58	220000.0
				2/24/58	63000.0
				3/03/58	54000.0
				3/24/58	56000.0
				3/31/58	56000.0
				4/21/58	53000.0
				4/28/58	51000.0
				5/26/58	64000.0
				6/02/58	67000.0
				6/23/58	65000.0
				6/30/58	65000.0
				7/28/58	64000.0
				8/04/58	52000.0
				8/25/58	34000.0
				9/02/58	40000.0
				9/22/58	44000.0
				9/29/58	79000.0
				10/13/58	100000.0
				12/01/58	48000.0
				1/26/59	82000.0
				2/02/59	120000.0
				2/23/59	100000.0
				3/02/59	97000.0
				3/24/59	110000.0
				3/30/59	100000.0
				4/02/59	32000.0
				4/27/59	88000.0
				5/04/59	120000.0
				6/22/59	150000.0
				6/29/59	160000.0
				8/03/59	160000.0
				8/24/59	160000.0
				8/25/59	160000.0
				8/31/59	150000.0
				9/28/59	130000.0
				10/05/59	120000.0
				1/14/71	420.0

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 7 of 29)

WELL	CONSTITUENT			RESULT	
	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-1	Gross beta	PCI/L	8.0	2/09/71	350.0
				3/29/71	260.0
				4/22/71	430.0
				5/18/71	220.0
				6/16/71	350.0
				7/08/71	360.0
				8/17/71	290.0
				9/24/71	370.0
				10/25/71	340.0
				11/11/71	400.0
				12/14/71	530.0
				1/13/72	2200.0
				2/08/72	450.0
				3/09/72	340.0
				4/18/72	350.0
				5/22/72	460.0
				6/14/72	450.0
				7/20/72	540.0
				8/16/72	570.0
				2/15/73	280.0
				3/21/73	310.0
				4/18/73	230.0
				5/16/73	90.0
				6/20/73	90.0
				7/19/73	110.0
				8/16/73	99.0
				9/13/73	75.0
				10/16/73	90.0
				11/14/73	75.0
				12/14/73	75.0
				1/23/74	75.0
				2/14/74	75.0
				3/11/74	85.0
				4/18/74	75.0
				5/14/74	75.0
				6/19/74	75.0
				7/18/74	80.0
				8/14/74	75.0
				9/17/74	80.0
				10/17/74	75.0
				11/13/74	80.0
				12/12/74	80.0

Note: Data are unofficial and should not be referenced without permission from the Geosciences Group

Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 8 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-1	Gross beta	PCI/L	8.0	1/17/75	75.0
				3/12/75	75.0
				4/16/75	75.0
				5/21/75	75.0
				6/11/75	75.0
				8/26/57	33.0
	Nitrate, Phenedisulfonic Acid	MG/L	.5	9/03/57	5.0
				9/24/57	71.0
				9/30/57	4.0
				10/14/57	73.0
				10/21/57	4.0
				11/25/57	100.0
				12/23/57	4.5
				1/27/58	17.0
				2/24/58	64.0
				3/24/58	150.0
				4/21/58	97.0
				5/26/58	170.0
				6/23/58	110.0
				7/28/58	25.0
				8/25/58	140.0
				9/22/58	160.0
				9/24/62	19.0
				7/01/63	17.0
	ORGANIC Plutonium	MG/L	.1	8/17/67	.1
		PCI/L		9/04/57	110.0
				9/30/57	110.0
				10/29/57	110.0
	Strontium-90	PCI/L	5.0	12/09/57	110.0
				7/02/57	200.0
				7/23/57	200.0
				7/30/57	200.0
				8/06/57	200.0
				8/13/57	200.0
				8/19/57	200.0
				8/27/57	200.0
				9/04/57	200.0
				9/10/57	200.0
				9/17/57	200.0
				9/25/57	200.0
				9/30/57	200.0
				10/07/57	200.0

Note: Data are unofficial and should not be referenced without permission from the Geosciences Group

Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 9 of 29)

WELL	CONSTITUENT			RESULT	
	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-1	Strontium-90	PCI/L	5.0	10/14/57	200.0
				10/15/57	200.0
				10/22/57	200.0
				10/29/57	200.0
				11/06/57	200.0
				11/11/57	200.0
				11/18/57	200.0
				11/25/57	200.0
				12/02/57	200.0
				12/09/57	200.0
				12/16/57	200.0
				12/30/57	200.0
				1/27/58	200.0
				2/03/58	200.0
				2/24/58	200.0
				3/03/58	200.0
				3/18/58	200.0
				3/24/58	200.0
				3/31/58	200.0
				4/21/58	200.0
				4/28/58	200.0
				5/26/58	70.0
				6/03/58	70.0
				6/23/58	70.0
				6/30/58	70.0
				7/28/58	70.0
				8/04/58	70.0
				8/25/58	70.0
				9/02/58	70.0
				9/08/58	70.0
				9/22/58	70.0
				9/29/58	70.0
				12/01/58	70.0
				3/01/59	70.0
				1/25/60	70.0
				5/02/60	70.0
				7/05/60	70.0
				7/26/60	70.0
				10/24/60	70.0
				10/31/60	70.0
				1/23/61	70.0
				4/03/61	55.0

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 10 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-1	Strontium-90	PCI/L	5.0	4/11/61	55.0
				4/24/61	55.0
				7/24/61	56.0
				7/31/61	56.0
2-E25-13	1,1,1-trichloroethane	PPB	5.0	3/22/90	< 5.0
	1,1,2-trichloroethane	PPB	5.0	3/22/90	< 5.0
	1,1-dichloroethane	PPB	5.0	3/22/90	< 5.0
	1,2-dichloroethane	PPB	5.0	3/22/90	< 5.0
	Acetone by VOA	PPB	10.0	3/22/90	< 10.0
	Alpha, High Detection Level	PCI/L	4.0	3/22/90	2.7
	Benzene	PPB	5.0	3/22/90	< 5.0
	Bromide	PPB	1000.0	3/22/90	< 1000.0
	Carbon Tetrachloride by GC/MS	PPB	5.0	3/22/90	< 5.0
	Chloride	PPB	500.0	3/22/90	29900.0
	Chloroform	PPB	5.0	3/22/90	< 5.0
	Conductivity, Laboratory	UMHO	1.0	3/22/90	1490.0
	Fluoride	PPB	500.0	3/22/90	500.0
	Gross beta	PCI/L	8.0	4/29/71	150.0
				5/18/71	150.0
				6/16/71	240.0
				7/08/71	150.0
				8/17/71	500.0
				9/24/71	150.0
				10/25/71	160.0
				11/11/71	160.0
				12/14/71	580.0
				1/13/72	190.0
				2/08/72	260.0
				3/09/72	210.0
				4/18/72	150.0
				5/22/72	170.0
				6/14/72	430.0
				7/20/72	500.0
				8/16/72	340.0
				2/15/73	150.0
				3/21/73	150.0
				4/18/73	150.0
				5/16/73	75.0
				6/20/73	75.0
				7/19/73	75.0
				8/16/73	75.0

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 11 of 29)

WELL	CONSTITUENT			RESULT	
	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-13	Gross beta	PCI/L	8.0	9/13/73	80.0
				10/18/73	75.0
				11/14/73	75.0
				12/14/73	75.0
				1/23/74	75.0
				2/14/74	75.0
				3/11/74	75.0
				4/18/74	80.0
				5/14/74	75.0
				6/19/74	75.0
				7/18/74	80.0
				8/14/74	75.0
				9/17/74	75.0
				10/17/74	75.0
				11/13/74	80.0
				12/12/74	80.0
				1/17/75	75.0
				2/11/75	80.0
				3/12/75	75.0
				4/16/75	80.0
				5/21/75	75.0
				6/11/75	80.0
				7/16/75	140.0
				8/13/75	80.0
				3/17/77	75.0
				6/17/77	75.0
				12/12/77	75.0
				8/24/78	75.0
				6/05/79	75.0
				8/29/79	75.0
				11/15/79	75.0
				12/11/79	75.0
				3/06/80	75.0
				6/02/80	75.0
				3/10/81	8.0
				6/16/81	.8
				9/09/81	10.0
				11/13/81	38.0
				3/05/82	13.0
				5/27/82	16.0
				8/23/82	12.0
				3/09/83	8.1

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 12 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-13	Gross beta	PCI/L	8.0	6/01/83	6.0
				8/24/83	9.4
				11/15/83	178.0
				3/08/84	16.5
				5/21/84	16.1
				8/07/84	-5.8
				11/21/84	11.9
				2/13/85	12.9
				4/10/85	13.7
				8/30/85	10.4
				2/28/86	11.4
				5/05/86	11.1
				8/14/86	8.7
				11/04/86	7.5
				4/02/87	11.1
				6/29/87	10.8
				9/02/87	7.8
				10/28/87	9.1
				3/09/88	8.7
				5/11/88	6.8
				7/28/88	6.7
				10/27/88	9.0
				2/10/89	12.4
				3/22/90	15.2
	Methyl Isobutyl Ketone	PPB	10.0	3/22/90	< 10.0
	Methyl ethyl ketone	PPB	10.0	3/22/90	< 10.0
	Methylene Chloride	PPB	5.0	3/22/90	< 5.0
	Nitrate	PPB	500.0	11/04/86	314000.0
				4/02/87	390000.0
				3/22/90	370000.0
				6/29/87	128000.0
				9/02/87	443000.0
	Nitrate, High Detection Level	PPB	2500.0	10/28/87	327000.0
				3/09/88	96400.0
				5/11/88	68200.0
				7/28/88	95900.0
				10/27/88	129000.0
	Nitrate, Phenodisulfonic Acid	MG/L	.5	2/10/89	237000.0
				12/08/60	.2
				1/19/61	8.4
				3/13/61	6.7
				3/20/61	4.1

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 13 of 29)

WELL	CONSTITUENT			RESULT	
	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-13	Nitrate, Phenodisulfonic Acid	MG/L	.5	4/10/61	1.3
				4/17/61	.4
				5/15/61	1.3
				6/19/61	12.0
				7/17/61	9.9
				8/14/61	16.0
				9/11/61	7.3
				9/18/61	8.4
				11/13/61	9.3
				2/13/85	280.0
				4/10/85	133.0
				8/30/85	208.0
				2/28/86	478.0
				5/05/86	509.0
				8/14/86	258.0
	Nitrite	PPB	1000.0	3/22/90	< 1000.0
	Phosphate	PPB	1000.0	3/22/90	< 1000.0
	Specific conductance	UMHO	1.0	3/22/90	1409.0
	Sulfate	PPB	500.0	3/22/90	306000.0
	Tetrachloroethylene	PPB	5.0	3/22/90	< 5.0
	Tetrahydrofuran	PPB	10.0	3/22/90	< 10.0
	Toluene	PPB	5.0	3/22/90	< 5.0
	Total Organic Halogen, Low Det	PPB	10.0	3/22/90	< 6.0
	Trans-1,2-dichloroethene	PPB	5.0	3/22/90	< 5.0
	Trichloroethylene	PPB	5.0	3/22/90	< 5.0
	Tritium	PCI/L	500.0	3/22/90	36000.0
	Vinyl chloride	PPB	10.0	3/22/90	< 10.0
	Xylene-m	PPB	5.0	3/22/90	< 5.0
	Xylene-o,p	PPB	5.0	3/22/90	< 5.0
	p-Dichlorobenzene	PPB	5.0	3/22/90	< 5.0
	pH, Field Measurement		.1	3/22/90	7.7
	pH, Laboratory Measurement		.0	3/22/90	7.6
2-E25-15	Gross beta	PCI/L	8.0	1/14/71	420.0
				2/10/71	390.0
				3/29/71	390.0
				4/22/71	400.0
				5/18/71	270.0
				6/16/71	330.0
				7/08/71	370.0
				8/17/71	260.0
				9/24/71	380.0

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 14 of 29)

WELL	CONSTITUENT			RESULT	
	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-15	Gross beta	PCI/L	8.0	10/25/71	350.0
				11/11/71	880.0
				12/14/71	340.0
				1/13/72	360.0
				2/08/72	430.0
				3/09/72	370.0
				4/18/72	270.0
				5/25/72	350.0
				6/14/72	430.0
				7/20/72	560.0
				8/16/72	550.0
				2/15/73	350.0
				3/21/73	190.0
				4/18/73	250.0
				5/16/73	130.0
				6/20/73	75.0
				7/19/73	75.0
				8/16/73	90.0
				9/13/73	75.0
				10/18/73	90.0
				11/14/73	75.0
				12/14/73	75.0
				1/23/74	75.0
				2/14/74	90.0
				3/11/74	80.0
				4/18/74	80.0
				5/14/74	75.0
				6/19/74	90.0
				7/18/74	75.0
				8/14/74	75.0
				9/17/74	75.0
				10/17/74	80.0
				11/13/74	80.0
				12/12/74	75.0
				1/17/75	75.0
				2/11/75	75.0
				3/12/75	80.0
				4/16/75	75.0
				5/21/75	80.0
				6/11/75	75.0
				5/10/76	75.0

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 15 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-16	Gross beta	PCI/L	8.0	7/08/71	330.0
				8/17/71	390.0
				9/24/71	340.0
				10/25/71	670.0
				11/11/71	320.0
				12/14/71	790.0
				1/13/72	410.0
				2/08/72	460.0
				3/09/72	400.0
				4/18/72	430.0
				5/22/72	440.0
				6/14/72	330.0
				7/20/72	490.0
				8/16/72	150.0
				2/15/73	300.0
				3/21/73	150.0
				4/18/73	220.0
				5/16/73	120.0
				6/20/73	75.0
				7/19/73	120.0
				8/16/73	80.0
				9/13/73	75.0
				10/18/73	100.0
				11/14/73	95.0
				12/14/73	90.0
				1/23/74	75.0
				2/14/74	75.0
				3/11/74	85.0
				4/18/74	150.0
				5/14/74	75.0
				6/19/74	75.0
				7/18/74	130.0
				8/14/74	75.0
				9/17/74	80.0
				10/17/74	80.0
				11/13/74	80.0
				12/12/74	75.0
				1/17/75	80.0
				5/10/76	75.0
2-E25-2	Alpha, High Detection Level	PCI/L	4.0	4/27/90	4.6
				5/21/90	1.3

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 16 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-2	Bromide	PPB	1000.0	4/27/90	< 1000.0
				5/21/90	< 1000.0
	Cesium-137	PCI/L	20.0	10/07/51	740.0
				4/01/57	740.0
				5/06/57	750.0
				5/17/57	920.0
				6/03/57	740.0
				6/04/57	.0
				7/02/57	740.0
				7/09/57	740.0
				7/15/57	740.0
				7/23/57	740.0
				7/30/57	740.0
				8/06/57	740.0
				8/13/57	740.0
				8/19/57	740.0
				8/27/57	740.0
				9/04/57	740.0
				9/10/57	740.0
				9/17/57	740.0
				9/25/57	740.0
				9/30/57	740.0
				10/07/57	740.0
				10/14/57	740.0
				10/22/57	740.0
				10/29/57	740.0
				11/06/57	740.0
				11/11/57	740.0
				11/18/57	740.0
				11/25/57	740.0
				12/02/57	740.0
				12/09/57	740.0
				12/16/57	740.0
				12/30/57	740.0
				1/27/58	740.0
				2/03/58	740.0
				2/24/58	740.0
				3/03/58	740.0
				3/24/58	740.0
				3/31/58	740.0
				4/21/58	740.0
				4/28/58	740.0

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 17 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-2	Cesium-137	PCI/L	20.0	5/26/58	740.0
				6/02/58	740.0
				6/23/58	740.0
				6/30/58	740.0
				7/28/58	740.0
				8/04/58	740.0
				8/25/58	740.0
				9/02/58	740.0
				9/22/58	740.0
				9/29/58	740.0
				10/28/58	740.0
				11/03/58	740.0
				11/24/58	740.0
				12/01/58	740.0
				1/12/59	740.0
				1/19/59	740.0
				2/09/59	740.0
				2/19/59	740.0
				3/03/59	500.0
				3/09/59	500.0
				3/16/59	500.0
				4/06/59	500.0
				5/01/59	500.0
				5/11/59	500.0
				5/22/59	500.0
				6/01/59	500.0
				6/08/59	500.0
				6/15/59	500.0
				7/06/59	500.0
				7/13/59	500.0
				8/10/59	500.0
				8/17/59	500.0
				9/08/59	500.0
				9/14/59	500.0
				10/10/60	500.0
				7/01/63	50.0
				5/17/71	16.0
				7/08/71	26.0
				9/23/71	7.3
				11/11/71	13.0
				1/13/72	7.0
				3/13/72	14.0

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 18 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-2	Cesium-137	PCI/L	20.0	5/22/72	12.0
				7/19/72	7.5
				3/20/73	10.0
				5/15/73	10.0
				7/18/73	32.0
				9/12/73	20.0
				11/13/73	23.0
				1/22/74	20.0
				3/12/74	22.0
				5/15/74	23.0
				7/17/74	31.0
				9/18/74	27.0
				3/30/87	< 2.3
				9/03/87	< -6.7
				2/01/88	< 1.1
				9/01/88	< 5.4
				6/01/89	< 1.8
	Chemical sodium by AA	MG/L	1.0	12/23/57	37.0
				5/26/58	50.0
	Chloride	PPB	500.0	4/27/90	3300.0
				5/21/90	3100.0
	Cobalt-60	PCI/L	22.5	12/01/58	740.0
				6/03/63	1200.0
				11/11/71	69.0
				3/13/72	13.0
				7/17/74	45.0
				7/27/79	20.0
				4/20/83	3.5
				7/20/83	5.3
				10/17/83	11.0
				2/07/84	-1.8
				5/03/84	2.0
				7/06/84	-5
				10/24/84	-1.2
				2/13/85	4.5
				4/10/85	-1.0
				10/16/85	4.0
				4/29/86	< -1.0
				7/08/86	< 20.0
				3/30/87	< -3.0
				9/03/87	< -9.2
				2/01/88	< -1.8

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 19 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-2	Cobalt-60	PCI/L	22.5	9/01/88	< -4.0
				6/01/89	< .4
	Conductivity, Laboratory	UMHO	1.0	4/27/90	244.0
				5/21/90	242.0
	Fluoride	PPB	500.0	4/27/90	< 500.0
				5/21/90	< 500.0
	Gross beta	PCI/L	8.0	10/07/51	160000.0
				3/20/57	16000.0
				3/25/57	35000.0
				4/01/57	32000.0
				4/08/57	45000.0
				4/15/57	50000.0
				4/22/57	45000.0
				4/22/57	50000.0
				4/29/57	50000.0
				5/06/57	75000.0
				5/13/57	77000.0
				5/17/57	76000.0
				5/20/57	76000.0
				5/31/57	84000.0
				6/03/57	100000.0
				6/11/57	100000.0
				6/18/57	110000.0
				6/26/57	110000.0
				7/02/57	140000.0
				7/09/57	150000.0
				7/15/57	150000.0
				7/23/57	140000.0
				7/30/57	150000.0
				8/06/57	140000.0
				8/13/57	170000.0
				8/19/57	180000.0
				8/27/57	160000.0
				9/04/57	170000.0
				9/10/57	20000.0
				9/17/57	150000.0
				9/25/57	150000.0
				9/30/57	180000.0
				10/07/57	160000.0
				10/14/57	210000.0
				10/22/57	180000.0
				10/29/57	160000.0

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 20 of 29)

WELL	CONSTITUENT			RESULT	
	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-2	Gross beta	PCI/L	8.0	11/06/57	180000.0
				11/11/57	150000.0
				11/18/57	160000.0
				11/25/57	190000.0
				12/02/57	160000.0
				12/09/57	170000.0
				12/16/57	160000.0
				12/23/57	150000.0
				12/30/57	160000.0
				1/27/58	100000.0
				2/03/58	590000.0
				2/24/58	77000.0
				3/03/58	75000.0
				3/24/58	94000.0
				3/31/58	92000.0
				4/21/58	100000.0
				4/28/58	100000.0
				5/19/58	180000.0
				5/26/58	150000.0
				6/02/58	160000.0
				6/23/58	130000.0
				6/30/58	140000.0
				7/28/58	180000.0
				8/04/58	110000.0
				8/25/58	86000.0
				9/02/58	85000.0
				9/22/58	85000.0
				9/29/58	83000.0
				10/28/58	87000.0
				11/03/58	74000.0
				11/24/58	68000.0
				12/01/58	71000.0
				1/12/59	58000.0
				1/19/59	50000.0
				2/09/59	84000.0
				2/19/59	94000.0
				3/09/59	86000.0
				3/16/59	93000.0
				4/06/59	120000.0
				5/11/59	130000.0
				5/22/59	110000.0
				6/08/59	130000.0

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 21 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-2	Gross beta	PCI/L	8.0	6/15/59	140000.0
				7/06/59	140000.0
				7/13/59	260000.0
				8/10/59	130000.0
				8/17/59	120000.0
				9/08/59	120000.0
				9/14/59	110000.0
				10/12/59	110000.0
				3/25/69	150.0
				4/30/69	160.0
				5/27/69	120.0
				6/24/69	170.0
				7/08/69	170.0
				8/08/69	160.0
				9/16/69	380.0
				10/27/69	160.0
				11/21/69	160.0
				1/14/71	290.0
				2/09/71	220.0
				3/26/71	290.0
				4/22/71	150.0
				5/17/71	150.0
				6/16/71	210.0
				7/08/71	290.0
				8/17/71	300.0
				9/23/71	230.0
				10/25/71	230.0
				11/11/71	300.0
				12/14/71	270.0
				1/13/72	150.0
				2/08/72	340.0
				3/13/72	270.0
				4/18/72	160.0
				5/22/72	770.0
				6/14/72	310.0
				7/19/72	270.0
				8/15/72	280.0
				2/14/73	150.0
				3/20/73	150.0
				4/17/73	150.0
				5/15/73	75.0
				6/19/73	75.0

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 22 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-2	Gross beta	PCI/L	8.0	7/18/73	75.0
				8/15/73	76.0
				9/12/73	75.0
				10/16/73	75.0
				11/13/73	75.0
				12/11/73	75.0
				1/22/74	75.0
				2/12/74	75.0
				3/12/74	80.0
				4/17/74	130.0
				5/15/74	75.0
				6/18/74	80.0
				7/17/74	75.0
				8/13/74	75.0
				9/18/74	75.0
				12/09/76	75.0
				3/14/77	75.0
				5/09/77	75.0
				6/10/77	75.0
				9/12/77	75.0
				10/18/77	75.0
				12/07/77	75.0
				2/06/78	75.0
				4/04/78	75.0
				5/01/78	75.0
				7/18/78	75.0
				9/26/78	75.0
				10/11/78	75.0
				2/05/79	75.0
				3/28/79	75.0
				5/07/79	75.0
				7/27/79	75.0
				9/20/79	75.0
				10/15/79	75.0
				4/29/81	20.0
				4/29/81	75.0
				10/13/81	1.8
				10/14/81	75.0
				3/09/82	75.0
				4/28/82	28.0
				10/14/82	11.1
				4/20/83	12.1

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 23 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-2	Gross beta	PCI/L	8.0	10/17/83	10.7
				5/03/84	33.4
				10/24/84	16.1
				4/03/85	4.8
				9/06/85	5.8
				3/31/87	3.8
				9/03/87	4.4
				2/01/88	5.1
				9/01/88	4.3
				3/22/89	8.7
	Nitrate	PPB	500.0	4/27/90	6.3
				5/21/90	3.4
				3/31/87	1580.0
				3/31/87	1650.0
				4/27/90	1400.0
	Nitrate, High Detection Level	PPB	2500.0	5/21/90	1200.0
				9/03/87	< 2500.0
				2/01/88	< 2500.0
	Nitrate, Phenodisulfonic Acid	MG/L	.5	9/01/88	< 2500.0
				3/22/89	< 2500.0
				9/03/57	3.0
				9/09/57	4.0
				9/16/57	4.0
				9/24/57	4.0
				10/07/57	45.0
				10/14/57	27.0
				10/21/57	61.0
				10/28/57	430.0
				11/25/57	150.0
				12/23/57	5.6
				1/27/58	59.0
				2/24/58	340.0
				3/24/58	170.0
				4/21/58	150.0
				5/26/58	240.0
				6/23/58	800.0
				7/28/58	1500.0
				8/25/58	540.0
				9/22/58	1500.0
				10/28/58	430.0
				12/18/61	1.3
				1/16/62	1.1

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 24 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-2	Nitrate, Phenodisulfonic Acid	MG/L	.5	7/02/62	.9
				7/30/62	12.0
				12/17/62	31.0
				2/04/63	11.0
				4/01/63	2.8
				6/03/63	7.1
				7/01/63	50.0
				12/09/76	2.6
				3/14/77	2.8
				5/09/77	2.9
				6/10/77	1.9
				9/12/77	1.4
				10/18/77	1.6
				12/07/77	1.4
				2/06/78	2.8
				4/04/78	1.8
				5/01/78	2.1
				7/18/78	3.1
				9/26/78	2.8
				10/11/78	5.7
				2/05/79	2.4
				3/28/79	5.0
				5/07/79	4.5
				7/27/79	8.2
				9/20/79	7.6
				10/15/79	7.4
				4/29/81	7.0
				4/29/81	8.3
				10/13/81	.3
				10/14/81	.5
				3/09/82	5.9
				4/28/82	6.9
				4/28/82	8.6
				7/22/82	8.1
				10/14/82	4.3
				1/07/83	4.7
				2/02/83	5.3
				4/20/83	5.6
				4/20/83	6.1
				10/17/83	6.6
				2/07/84	4.1
				5/03/84	3.4

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 25 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-2	Nitrate, Phenodisulfonic Acid	MG/L	.5	10/24/84	4.3
				4/03/85	.3
				9/06/85	4.8
	Nitrate-Ion	MG/L	.5	7/20/83	20.0
				5/03/84	12.0
				7/06/84	7.2
				10/24/84	10.0
				2/13/85	8.6
				4/10/85	7.3
				10/16/85	16.0
	Nitrite	PPB	1000.0	4/29/86	4.9
				4/27/90	< 1000.0
				5/21/90	< 1000.0
	ORGANIC Phosphate	MG/L	1000.0	8/18/87	.1
				4/27/90	< 1000.0
	Plutonium	PCI/L	.1	5/21/90	< 1000.0
				6/04/57	220.0
				9/04/57	110.0
	Ruthenium-106	PCI/L	172.5	9/30/57	110.0
				10/29/57	110.0
				12/09/57	110.0
				8/17/71	130.0
				9/23/71	130.0
				1/13/72	120.0
				3/13/72	95.0
				5/22/72	83.0
				7/19/72	120.0
				9/12/72	110.0
				3/30/87	38.2
				9/03/87	27.8
	Specific conductance	UMHO	1.0	2/01/88	< 0.0
				9/01/88	< 1.0
				6/01/89	< -20.8
				4/27/90	368.0
	Strontium-90	PCI/L	5.0	5/21/90	250.0
				4/01/57	200.0
				4/22/57	50000.0
				5/06/57	200.0
				6/03/57	200.0
				6/04/57	200.0
				7/02/57	200.0
				7/09/57	200.0

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 26 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-2	Strontium-90	PCI/L	5.0	7/15/57	200.0
				7/23/57	200.0
				7/30/57	200.0
				8/06/57	200.0
				8/13/57	200.0
				8/19/57	200.0
				8/27/57	200.0
				9/04/57	200.0
				9/10/57	200.0
				9/17/57	200.0
				9/25/57	200.0
				9/30/57	200.0
				10/07/57	200.0
				10/14/57	200.0
				10/15/57	200.0
				10/22/57	200.0
				10/29/57	200.0
				11/06/57	200.0
				11/11/57	200.0
				11/18/57	200.0
				11/25/57	200.0
				12/02/57	200.0
				12/09/57	200.0
				12/16/57	200.0
				12/30/57	200.0
				1/27/58	200.0
				2/03/58	200.0
				2/24/58	200.0
				3/03/58	200.0
				3/18/58	200.0
				3/24/58	200.0
				3/31/58	200.0
				4/21/58	200.0
				4/28/58	200.0
				5/26/58	70.0
				6/03/58	70.0
				6/23/58	70.0
				6/30/58	70.0
				7/28/58	70.0
				8/04/58	70.0
				8/25/58	70.0
				9/02/58	70.0

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 27 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-F25-2	Strontium-90	PCI/L	5.0	9/08/58	70.0
				9/22/58	70.0
				9/29/58	70.0
				10/28/58	70.0
				11/03/58	70.0
				11/24/58	70.0
				12/01/58	70.0
				1/12/59	70.0
				1/19/59	70.0
				2/01/59	70.0
				2/09/59	70.0
				2/19/59	70.0
				3/01/59	70.0
				3/09/59	70.0
				3/16/59	70.0
				4/01/59	70.0
				4/06/59	70.0
				5/01/59	70.0
				5/11/59	70.0
				5/22/59	70.0
				6/01/59	70.0
				6/08/59	70.0
				6/15/59	70.0
				7/01/59	70.0
				7/06/59	70.0
				7/13/59	70.0
				8/10/59	70.0
				8/17/59	70.0
				9/08/59	70.0
				9/14/59	70.0
				10/12/59	70.0
				10/19/59	70.0
				11/09/59	70.0
				11/16/59	70.0
				1/11/60	70.0
				1/18/60	70.0
				4/11/60	70.0
				4/18/60	70.0
				6/20/60	20.0
				7/11/60	70.0
				7/22/60	70.0
				10/17/60	70.0

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 28 of 29)

WELL	CONSTITUENT			RESULT	
Name	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-2	Strontium-90	PCI/L	5.0	1/09/61	70.0
				1/16/61	70.0
				3/20/61	55.0
				4/10/61	55.0
				6/19/61	56.0
				9/18/61	56.0
				1/07/63	70.0
				2/04/63	70.0
				3/04/63	70.0
				4/01/63	70.0
				5/06/63	70.0
				7/01/63	70.0
				10/01/63	70.0
				3/30/87	5.0
				9/03/87	< .1
				2/01/88	< .2
				9/01/88	< .5
				6/01/89	< .1
	Sulfate	PPB	500.0	4/27/90	16400.0
				5/21/90	16100.0
	Total Organic Halogen, Low Det	PPB	10.0	5/21/90	< 3.0
	Tritium	PCI/L	500.0	12/21/66	880000.0
				12/09/76	290000.0
				3/14/77	230000.0
				5/09/77	280000.0
				6/10/77	270000.0
				9/12/77	230000.0
				10/18/77	230000.0
				12/07/77	210000.0
				2/06/78	210000.0
				4/04/78	210000.0
				5/01/78	200000.0
				7/18/78	180000.0
				9/26/78	170000.0
				10/11/78	160000.0
				2/05/79	150000.0
				3/28/79	120000.0
				5/07/79	120000.0
				9/20/79	120000.0
				10/15/79	110000.0
				4/29/81	46000.0
				4/29/81	51000.0

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Table 6. Constituents from the A-AX Groundwater Monitoring Wells.
(sheet 29 of 29)

WELL	CONSTITUENT			RESULT	
	Name	Units	Detection Limit	Sample Date	Analysis Value
2-E25-2	Tritium	PCI/L	500.0	10/13/81	69000.0
				10/14/81	65000.0
				3/09/82	51000.0
				4/28/82	52000.0
				4/28/82	81000.0
				7/22/82	47000.0
				10/14/82	36200.0
				1/07/83	38000.0
				2/02/83	77000.0
				4/20/83	27500.0
				4/20/83	34000.0
				7/20/83	35000.0
				10/17/83	32700.0
				2/07/84	41000.0
				5/03/84	28500.0
				7/06/84	35000.0
				10/24/84	136000.0
				2/13/85	14000.0
				4/03/85	19100.0
				4/10/85	12000.0
				9/06/85	15100.0
				10/16/85	13000.0
				4/29/86	11000.0
				7/08/86	9600.0
				3/30/87	7660.0
				3/31/87	8660.0
				9/03/87	7190.0
				2/01/88	5940.0
				9/01/88	6210.0
				3/22/89	9650.0
	pH, Field Measurement		.1	4/27/90	6.5
				5/21/90	6.6
	pH, Laboratory Measurement		.0	4/27/90	7.6
				5/21/90	7.8

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that is difficult, if not impossible, to substantiate. Limits of detection generally improved with time as analytical capability improved. Nonetheless, the data taken in toto do reveal some past management practices and discharges that affected groundwater.

A search was initiated to determine if any analyses of groundwater samples were classified, but no data were located. A conversation with J. R. Raymond, a scientist involved in groundwater monitoring at the Hanford Site for several decades, indicated that data from the 1950's are generally not classified now. The data either were never classified or, if classified, were subsequently declassified. It is possible that there are some groundwater monitoring data that are classified; only titles of classified documents can be retrieved, and these must be scanned to determine whether any relevant data are contained within--a lengthy process. However, data from special studies not taken as part of routine monitoring may not have been entered into the HGWDB. A search could be made for possible data that were never entered into the database or that were lost from the database during conversion from one computer system to another, but that is beyond the scope of this study and could require a lengthy, intensive effort. Gaps in the data likely represent times when samples were not collected and analyzed.

The oldest monitoring well in the A Tank Farm is 299-E25-1, which was constructed in October 1955 between but slightly south of Tanks 241-A-101 and 241-A-102 shortly after completion of construction of the A Tank Farm. The earliest constituent data from this well are for 1957 (aside from the spurious 1951 record). In March 1957, Co-60 at 440,000 pCi/L and gross beta at 2,800,000 pCi/L were detected from this well just 14 months after Tank 241-A-101 and 12 months after Tank 241-A-102 were first put into service. (Tank 241-A-105 was put into service in 1963 and was the last tank put into service in the 241-A Tank Farm.) These were the second and third tanks to be used in the A Tank Farm (241-A-103 was the first). All available data from in-tank liquid levels and the logging of dry wells and laterals indicate that Tanks 241-A-101 and 241-A-102 are still sound and have never leaked. Therefore, the elevated values obtained for Co-60 and gross beta must be from another liquid disposal site. Values for Pu and Sr-90 for September 1957 and July 1957, respectively, for this well are 110 pCi/L and 200 pCi/L. Assuming the analytical data are valid, the implication of these results is that groundwater beneath the A Tank Farm was contaminated before the time that Tank 241-A-105 was put into service. As can be seen from Table 3, many of the liquid effluent disposal facilities near the A Tank Farm were put into service before the first sampling from well E25-1, including some of the larger cribs, which received high liquid volumes (e.g., the 216-A-8 crib).

Well E25-2, an upgradient well a few hundred feet east of Tank 241-A-105, was sampled regularly in 1957 and analyzed for gross beta through October 1959, as well as later dates in the late 1960's and early 1970's. From an initial value of 10,000 pCi/L on March 20, 1957, the values for gross beta escalated regularly to 180,000 pCi/L on August 19, 1957 and remained at or close to this level through 18 subsequent analyses until late December 1957. Analyses were also run for Sr-90 (and other constituents) on E25-2, with Sr-90 values generally at 200 pCi/L throughout all of 1957 (except for one seemingly spurious value of 50,000 pCi/L on April 22, 1957). The number of 200 pCi/L values suggest that this may have been a detection limit at the time. The appearance of Sr-90 in groundwater just a few years after

the initiation of PUREX operations is unusual because Sr-90 generally sorbs in soils within 10 to 20 m of the source and would not be expected to have reached groundwater from discharges to cribs. The appearance of Sr-90 in groundwater suggests some lack of quality control on the sampling/analytical process as well as the possibility that this radionuclide was transported directly to groundwater along a poorly sealed well. The proximity of this well to the 216-A-8 crib and the dates of operation of this crib suggest that the groundwater upgradient of the A Tank Farm had already been contaminated before the use of Tank 241-A-105. The likely source of this contamination is the 216-A-8 crib.

The limited data from wells E25-1 and E25-2 suggest that groundwater upgradient in the vicinity of the A Tank Farm and beneath the southwestern part of the A Tank Farm was contaminated by discharges to liquid effluent disposal facilities before Tank 241-A-105 was placed into service. Because many liquid disposal facilities continued to operate during the period Tank 241-A-105 was receiving wastes and the period spray irrigation water was being added to the tank to control the in-tank temperature, the likelihood of detecting contaminants that were specifically derived from Tank 241-A-105 is impossible with the available data.

Three groundwater monitoring wells were constructed in the southwest corner of the A Tank Farm to supplement E25-1 in 1969: E24-13, E25-15 and E25-16. All three were constructed in the summer of 1969, which coincides with events at Tank 241-A-105. All three monitor the upper part of the unconfined aquifer, but E25-15 has a longer perforated interval. Sampling and analyses began in 1971 at all three of these wells. Only gross beta was analyzed regularly for E24-13, and most of these values are less than 500 pCi/L, except for a reading of 600 pCi/L on January 13, 1972. All values for gross beta are less than 100 pCi/L after 1974 except for a reading of 100 pCi/L on August 22, 1980 and 340 pCi/L on March 3, 1981. Other constituents were not analyzed until 1985, and most of these values for nitrate and other radionuclides are below current established regulatory limits. Values for gross beta generally correlate between wells E24-13 and E25-1, which are separated by about 100 ft.

Only gross beta was analyzed for samples from well E25-13 for the period 1971 through 1976. The maximum value was 420 pCi/L for the first analysis in January 1971 and declined steadily through 1976 to 75 pCi/L until analyses were terminated in May 1976.

Similar to well E25-15, well E25-16 was analyzed only for gross beta between 1971 and 1976. The maximum recorded value of 670 pCi/L was recorded on October 25, 1971. The minimum value of 75 pCi/L was recorded on May 10, 1976.

Well E25-13 was constructed in October 1963 and is located in the southwest corner of the AX Tank Farm, which was constructed in 1963-64. Well E25-13 is completed in the top of the unconfined aquifer and has a long open interval extending from 265 to 316 ft depth. From April 1971 to the present, gross beta was analyzed at least once each year, and in most years, several times. The maximum value for gross beta for this well is 580 pCi/L on

December 14, 1971. Values from 1973 to the present are generally less than 100 pCi/L except for two values: 140 pCi/L on July 16, 1975 and 178 pCi/L on November 15, 1983. Some hazardous waste constituents were analyzed in March 1990 and are generally within regulatory limits. Nitrate was analyzed from 1986 to the present and has consistently exceeded the 45,000 ppb Secondary Maximum Contaminant Limit. Several values for nitrate in 1960 and 1961 are considered spurious because E25-13 was not constructed until 1963.

4.5 ANALYSES OF DATA FROM NEARBY CRIB MONITORING WELLS

Groundwater monitoring wells adjacent to nearby cribs (Figure 14) were sampled and analyzed for some constituents in the 1960's and 1970's. Most of these wells were analyzed for gross beta and tritium, but some samples were analyzed for specific radionuclides. Values for gross beta, Co-60, Cs-137 and Sr-90 exceeded current regulatory standards in 1969 in well E24-4, which monitors the nearby 216-A-9 crib. Analyses for gross beta in this well were done several times per year in subsequent years. The preponderance of 75 pCi/L values suggest that this was likely the detection limit for gross beta during the 1970's. Tritium analyses for this well began in 1972, and for several analyses done from 1972 to 1976, the values greatly exceeded the current regulatory standard of 20,000 pCi/L. A similar pattern for constituents for the same period was also noted in well E24-5, which also monitors the 216-A-9 crib, except that tritium analyses were not performed on samples from this well. While the 216-A-9 crib is located downgradient of the 216-A-9 crib, it illustrates that groundwater in the vicinity of the A Tank Farm was receiving constituents above current regulatory limits during times of operation of the tank farm.

The 216-A-8 and 216-A-24 cribs are located upgradient of the A Tank Farm, and data from wells monitoring these facilities were evaluated as an indication of constituents reaching groundwater upgradient of the A Tank Farm. Values for Cs-137, Co-60, and Sr-90 from 1960 and 1961 in well E25-4 exceed current regulatory standards. Gross beta as well as tritium values for the 1960's also exceed current regulatory standards¹. Values for Cs-137, Co-60, gross beta, Sr-90 and a single value for tritium obtained during the 1960's and 1970's from well E25-5 similarly exceed current regulatory standards. Numerous analyses of groundwater samples from well E25-6 indicate a similar pattern of crib discharges reaching groundwater. Values for Cs-137 from this well exceed current regulatory limits for several analyses done in 1969, but numerous analyses for this isotope performed in the 1970's indicate that Cs-137 was below current regulatory standards of 200 pCi/L. All analyses for Co-60 from this well in the 1970's are below the current regulatory standard of 100 pCi/L except for one value of 100 pCi/L in September 1974. Values for gross beta for numerous analyses done in the period March 1969

¹Although there were no federally mandated limits for various constituents in the 1960's, guidelines for activity/concentration were established in Table I of the Report of Committee II (ICRP 1959), and these limits were subsequently incorporated into the Derived Concentration Guidelines that are now included in DOE Order 5480.11. These earlier values for radionuclides may differ from those established by current regulations/standards for groundwater or drinking water.

Figure 14. Groundwater Monitoring Wells Adjacent to Cribs.

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through November 1980 all exceed the current regulatory standard of 50 pCi/L; however, many values of 75 pCi/L suggest that this was probably the limit of detection for this constituent during this period. All values for Ru-106 during the 1970's for this well exceed current regulatory standards of 30 pCi/L, but two values for analyses in October and November 1980 are below this standard. Many analyses for Sr-90 in 1960 and 1961 exceed the current regulatory limit of 8 pCi/L. All but one of numerous values for tritium greatly exceed the current regulatory limit of 20,000 pCi/L for well E25-6. For well E25-7, all values for Cs-137 in the period March 1963 through October 1969 exceed the current regulatory standard of 200 pCi/L, although two values for this constituent from early 1971 are below the standard. Gross gamma logging and subsequent spectral gamma logging in wells at the 216-A-8 crib suggest that Cs-137 has penetrated only 30 m beneath this crib after more than 20 yr of active use and discharges of more than 200 million gal of wastewater (Environmental Division 1990). Similar results from logging beneath the 216-S-1 and 216-S-2 cribs indicate that Cs-137 sorbed within 10 m of the crib, but Cs-137 in groundwater resulted from a casing failure in a groundwater monitoring well (Van Luik and Smith 1982). Thus, the presence of Cs-137 in groundwater suggests improper sampling/analytical control or movement of Cs-137 directly to groundwater along a poorly sealed well.

All the gross beta analyses done during 1969 exceed the current regulatory standard, but three analyses done in 1971 do not. All values for Sr-90 analyses done in 1960, 1961 and 1963 exceed the current regulatory limit. Tritium analyses for March 1963 through April 1964 for well E25-7 greatly exceed the current regulatory standard, although one value for January 1963 is only 500 pCi/L. Values for Sr-90 analyses in well E25-8 for the period January 1960 to October 1963 exceed the current regulatory standard, although the frequent occurrence of the value 70 pCi/L suggests that this may have been the limit of detection for this constituent at this time. For well E25-9, values for gross beta for the period April 1971 to July 1980 all exceed current regulatory standards. The Sr-90 values from January 1960 through August 1962 for this well all exceed current limits for this constituent. One analysis of tritium for this well done in February 1963 is well below the regulatory limit, but four done in 1975 and 1976 exceed the current regulatory limit. Liquids discharged to the 216-A-8 crib have contributed to groundwater contamination upgradient of the A Tank Farm during the period in question.

Several wells monitor the 216-A-24 crib located northeast and upgradient of the A Tank Farm: E26-2, E26-3, E26-4, E26-5 and E26-7. Gross beta values for the period November 1974 through August 1980 for well E26-2 all exceed the current regulatory standard. The preponderance of 75 pCi/L values suggests that this may have been the detection limit for this constituent at the time. Values for Sr-90 done in 1960 and 1961 for this well all exceed the current regulatory standard. Six analyses for tritium in 1974-76 all exceed the current regulatory limit for tritium. The Cs-137 exceeded the current regulatory standard in the first analysis in well E26-3 in 1965, but subsequent analyses in 1971 and 1980 indicated that Cs-137 was well below the current standard. All four values for Co-60 analyzed in 1971, 1979, and two in 1980, were below the current regulatory standard. For numerous analyses,

gross beta exceeded the current standard between 1971 and July 1980 in this well, with many values of 75 pCi/L. An analysis in October 1980 for gross beta was well below the standard in well E26-3. Analyses for Ru-106 and Sr-90 in 1971 and 1980, and 1960 and 1961, respectively, were above current regulatory standards, with numerous values for 70 pCi/L for Sr-90 suggesting that this may have been the limit of detection for this period. Tritium analyses for E26-3 in 1977, 1978, 1979 and 1980 all exceeded the current regulatory standard. Numerous analyses were run for Cs-137 in the 1960's and 1970's on samples from well E26-4. One analysis was run in January 1961, and several were run in 1964-65. All were at or above the 200 pCi/L regulatory limit. Numerous analyses were run for this isotope from July 1971 to February 1977. All but three analyses were below the regulatory limit: 1,100 pCi/L were reported on August 15, 1972; 330 pCi/L were reported on June 18, 1974; and 400 pCi/L were reported on September 17, 1974. One analysis for Co-60 exceeded the limit in 1960 in well E26-4; all others in the 1970's were below the 100 pCi/L limit. Numerous analyses were run for gross beta in this well, the first several of which were in 1967. Values generally declined from a maximum of 4,600 pCi/L (except for one seemingly spurious value of 31,000 pCi/L on March 31, 1967) to numerous values of 75 pCi/L in the period 1976 through 1980. Another seemingly spurious value of 12,000 pCi/L was noted in September 1974. All values for Ru-106 performed from 1971 through 1975 exceeded the current regulatory limit in E26-4. Except for three values for Sr-90 in 1967, all analyses for this isotope exceeded the current regulatory limit. All of many values for tritium for this well greatly exceeded the current regulatory limit for this isotope. Numerous analyses were run for Cs-137 and Co-60 in well E26-5. All of many values from the 1960's exceeded the current regulatory limit; all values from the 1970's are below the current limits. However, there are significant gaps in the data from the late 1960's. Gross beta values for E26-5 for the period 1971 through 1977 exceed the current regulatory limit, with many reported values of 75 pCi/L. All values for Ru-106 from 1971-1975 exceed current limits. Data for Sr-90 from 1960 through 1963 all exceed current limits, with many values of 70 pCi/L (a likely detection limit). All values for Cs-137, Ru-106, gross beta, and tritium in well E26-7 exceed current regulatory limits for these constituents. The data are all from the early to mid 1970's. The few values from the early 1970's for this well for Co-60 are all below current regulatory limits.

All the analyses summarized above come from wells that are adjacent to and that monitor groundwater beneath cribs. These analyses clearly demonstrate that the cribs have contributed significantly to the degradation of groundwater quality in the area of the A Tank Farm. Analyses for wells monitoring the 216-A-8 and 216-A-24 cribs clearly indicate that groundwater upgradient of the A Tank Farm had been contaminated by discharges to cribs before the operation of the A Tank Farm and the reported releases from Tank 241-A-105. The constituents used to assess contamination are the same as those measured in wells in the monitoring network for the A Tank Farm. The wastes discharged to the tanks in A Tank Farm are similar in composition (although not concentration/activity) as those discharged to the nearby upgradient cribs. Therefore, any constituents from Tank 241-A-105 that may have reached groundwater would have been more than masked by the overwhelming volume of liquid wastes discharged to nearby cribs.

4.6 ANALYSES OF GROUNDWATER DATA

The available data from chemical analyses of groundwater sampled from wells in and near the 241-A Tank Farm as well as from wells at nearby PUREX cribs indicate that groundwater both upgradient and downgradient of the 241-A Tank Farm was contaminated before operation of Tank 241-A-105 and before any tanks in the 241-A Tank Farm leaked. Analytical data for 1958 from wells E25-1 and E25-2 indicate that the groundwater beneath the A Tank Farm was contaminated before the reported tank leaks in the A Tank Farm and several years before the 1965 steam explosion in Tank 241-A-105. Before the mid 1980's, most of the groundwater sample data are for radionuclides or indicators of radionuclide contamination. Only nitrate and/or sulfate of the nonradioactive constituents were analyzed before this time. The available data indicate that contamination precedes the leaking of cooling water from Tank 241-A-105 and likely derives from liquid effluents discharged to nearby PUREX cribs, french drains and trenches. The total volume of liquid discharged to these facilities exceeds 3,600,000 gal, as shown in available records.

Southeastward flow of groundwater from the area of the BY cribs and reverse wells before the initiation of PUREX operations also may have contributed to the contamination of groundwater in the area of the A Tank Farm before use of tanks in the farm. Uranium scavenging operations in the early to mid 1950's led to the discharge of large volumes of high-salt wastes derived from tanks to the BY and BC cribs and specific retention trenches. A density greater than one might cause these constituents to flow from the BY cribs to the southeast along the top of the basalt, which would direct their flow beneath the area of the present A Tank Farm.

Because the constituents in the waste streams discharged to liquid disposal facilities are similar to those discharged to the SSTs and because supernatant was discharged from the tanks to the BY cribs after cooling and precipitation in the tanks, the ability to detect any constituents discharged to groundwater arising from Tank 241-A-105 is severely hampered. The discharges to cribs that have reached groundwater clearly mask any constituents that may have reached groundwater from Tank 241-A-105. No clear indicators are known that would allow one to confirm that constituents leaked from Tank 241-A-105 have reached groundwater.

While the concentration/activity of radioactive and hazardous constituents discharged to cribs is likely less than those discharged to tanks, the available data do not allow one to conclude affirmatively that wastes discharged to Tank 241-A-105 have reached groundwater. Many of the radionuclides discharged to cribs and that have leaked from tanks are metals, which typically sorb/precipitate in soils and would thus not be available for transport to the groundwater. However, sorption can be significantly reduced if the heavy metals are complexed with other compounds, especially organics. The net result would be greater mobility and a more rapid rate of transport through the soils to groundwater. Poorly sealed groundwater monitoring wells such as at the 216-S-1 and 216-S-2 cribs (Van Luik and Smith 1982) may have also contributed to groundwater contamination by providing direct pathways to groundwater.

Data from the wells monitoring nearby PUREX cribs clearly indicate that many constituents common to the waste streams discharged to cribs and the tanks have reached groundwater. It is indeterminate whether transport to groundwater occurs because of complexing with other constituents, because the volume of fluids disposed to the cribs exceeds the specific retention of the soils, or because of poorly sealed groundwater monitoring wells. Discharges to cribs surrounding the A Tank Farm and cribs around the BY Tank Farm are the likely source of contaminants in groundwater and mask any contribution that may have arisen from Tank 241-A-105.

5.0 SEARCH FOR HISTORIC DATA ON TANK 241-A-105

As part of the assessment of the fate of fluids leaked from Tank 241-A-105, historic data and records of logging and construction of the dry wells and laterals as well as any records of earlier investigations of the leaking tank were sought. Contact with the Tank Farm Information Center and the Surveillance Analysis and Support Group led to the discovery of photographs of the A Tank Farm under construction in 1954-55, three boxes of data that were subsequently retrieved from archival storage containing original strip chart records of dry wells and laterals (Box #101711 and Box #61274), draft reports, in-tank photographs and personal files of correspondence, calculations, etc. (Box #84879). Personal files of a retired soil scientist on file in the Geosciences Group were also perused. Correspondence and some data relating to Tank 241-A-105 and 241-A-104 were found in these files.

Black and white photographs with original U.S. Atomic Energy Commission (AEC) numbers were located, and copies of these prints were ordered from Boeing Computer Services Richland, Inc. Photography. Boeing Computer Services Richland, Inc. was unable to locate the original negatives using the AEC numbers so the prints were taken to the laboratory where new negatives were made and current numbers assigned to the photos. These photos can now be requested from Boeing Computer Services Richland, Inc. using the current numbers that have been transmitted to the Tank Farm Information Center.

A box of original strip chart records proved to be useless because the charts are not labeled so the reader can determine which variables are being plotted. Wells are numbered using an older scheme. With interpretation by someone familiar with early Hanford Site logging, these records may reveal some potentially useful data.

Personal files of G. J. Jensen pertaining to Tank 241-A-105 were found in one of the retrieved boxes and contained minutes of meetings held shortly after the Tank 241-A-105 steam explosion. The minutes reveal some data about leak detection and temperature laterals and data obtained from them.

A number of in-tank photographs, both black and white and color, dating from the 1970's, were found but were not pertinent to the subject study, so little attention was devoted to them.

6.0 CONCLUSIONS

1. Analysis of scintillation (gross gamma) logs from dry wells and laterals surrounding Tank 241-A-105 indicate that radionuclides have escaped the tank and entered the soils.
2. Only the cumulative activity generated by gamma-emitting radionuclides (and daughter isotopes) such as Cs-137, Sr-90 and Pm-144 is detected by the gross gamma probes that have been run in the dry wells and laterals surrounding Tank 241-A-105. The nonradioactive, hazardous and alpha- and beta-emitting components of the waste have not been detected, and their distribution in the soils cannot be determined using only these tools.
3. Without further research into the specific tools, shielding, logging rates and procedures employed during past logging and changes in these parameters with time, the conclusions reached during this study are necessarily qualitative.
4. It is not possible to map the present distribution of the leaked wastes in the soils. Metals such as Cs-137 and Sr-90, which typically sorb in Hanford Site soils within 10 to 20 m of a source, likely have not been transported through the soils to groundwater from the Tank 241-A-105 leak and are likely the source of the persistent activity seen in dry wells and laterals. The presence of these constituents in groundwater monitoring wells in and near the A Tank Farm suggests other routes for direct transmission of these constituents to groundwater. Non-sorbing constituents have likely spread farther from Tank 241-A-105 than the sorbed metals and, given certain conditions as assumed in some transport models, may have even reached groundwater.
5. The present southwesterly direction of groundwater flow beneath the A Tank Farm that is established by flow from the B Pond mound was established by the 1960's, if not earlier. An earlier groundwater flow direction to the southeast from the area of the BY cribs likely occurred before the large volumes of water discharged to PUREX cribs and the increased discharges to B Pond in the late 1950's and thereafter.
6. High-salt wastes with density greater than one, such as those discharged to the BY cribs in the mid 1950's, likely would have sunk to the bottom of the unconfined aquifer and may have flowed southeastward along the top of basalt toward the A Tank Farm.
7. The network of groundwater monitoring wells in existence around the 241-A Tank Farm in 1970 had a 78% efficiency according to the MEMO. Thus, the network had a high probability of intercepting any plume of waste reaching groundwater if it was of sufficient concentration to be detected during analyses.

8. Groundwater upgradient of the 241-A Tank Farm was contaminated by discharges to PUREX cribs, french drains and trenches before Tank 241-A-105 was put into service. The similarity of constituents discharged to liquid disposal facilities and tanks makes detecting contaminants in groundwater specifically derived from Tank 241-A-105 nearly impossible using the available data. The volume of liquid effluents discharged to nearby PUREX liquid disposal facilities masks any contribution to groundwater contamination by leakage from Tank 241-A-105.
9. No unique indicators are known that would allow identification of specific constituents in groundwater that derive from Tank 241-A-105.
10. The areal distribution in soils of constituents leaked from Tank 241-A-105 cannot be determined without further intrusive field investigations. Logging of existing single-cased dry wells and groundwater monitoring wells with the spectral gamma logging system would allow better definition of the distribution of radionuclides in the soils.

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APPENDIX A

**AS-BUILT DIAGRAMS OF GROUNDWATER MONITORING WELLS
AROUND THE A TANK FARM**

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299-E24-13

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299-E25-1

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299-E25-16

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WHC-EP-0412

WELL NAME	299-E24-19	TOTAL DEPTH DATE	08/09/89
CASING ELEV.	693.65 Feet		
WELL DEPTH	300.68 Feet	DEPTH TO WATER	285.6 Feet
DRILL DEPTH	303.19 Feet		
COORDINATES	N-S 41075.8 P		
	E-W -47821.4 P		
		PAGE	1 of 1

WELL NAME	299-E25-40	TOTAL DEPTH DATE	08/07/88
CASING ELEV.	665.71 Feet		
WELL DEPTH	273.00 Feet	DEPTH TO WATER	257.4 Feet
DRILL DEPTH	274.00 Feet		
COORDINATES	N-S 41759.6 P		
	E-W -47334.8 P		
		PAGE	1 of 1

WELL NAME	299-E25-41	TOTAL DEPTH DATE	08/08/89
CASING ELEV.	671.26 Feet		
WELL DEPTH	276.00 Feet	DEPTH TO WATER	262.24 Feet
DRILL DEPTH	279.00 Feet		
COORDINATES	N-S 41541.8 P		
	E-W -47330.9 P		
		PAGE	1 of 1

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