Tritium Concentrations in the F- and H-Area Seeplines and Fourmile Branch at SRS: March 1997 and 1989-1997 Trending

by

J. W. Koch II

Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

K. L. Dixon

MASTER

DOE Contract No. **DE-AC09-96SR18500**

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October 27, 1997

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Prepared by:

J. W. Koch II and K. L. Dixon

Environmental Analysis Section

Approved by: _____

J.B. Gladden, Section Manager

Environmental Analysis Section

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ADC &
Reviewing
Officer:

Donna Hedrow
(Name and Title)

Date: *mp. 1/12/98*

Westinghouse Savannah River Company

Savannah River Site

Aiken SC 29808

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Tritium Concentrations in the F- and H-Area Seepines and Fourmile Branch at SRS: March 1997 and 1989-1997 Trending

J.W. Koch II and K.L. Dixon

Abstract

The Environmental Analysis Section (EAS) of the Savannah River Technology Center (SRTC) conducted a quarterly monitoring program of the Fourmile Branch (FMB) stream and its associated seepine located down gradient from the F- and H-Area Seepage Basins from May 1992 to May 1995. The quarterly tritium survey was changed to a semi-annual schedule in 1996. This report presents the results of the first semi-annual event in 1997 and summarizes the tritium data beginning with the baseline 1989 and 1992 sampling events. The primary focus of this program is to measure and track changes in tritium concentrations. Specific electrical conductivity and pH were also measured. The results from this survey (March 1997) exhibited similar trends to data from the previous surveys. The results of this tritium survey and stream monitoring data (Looney et al., 1993) indicated that the tritium plume from the past operation of the seepage basins continues to flush from the seepines and wetlands to Fourmile Branch. The overall summary results indicate that the tritium plumes are surfacing in somewhat localized areas along the F-Area and 643-E seepines.

Executive Summary

In March 1997 the Environmental Analysis Section (EAS) surveyed the Fourmile Branch seepine down gradient from the F- and H-Area Seepage Basins for tritium, specific conductivity, and pH. This survey was the first of two surveys scheduled during FY97 to monitor the movement of contaminants from the basins since closure in 1990. Surface-water samples were collected from 57 locations along the seepines and from three stream locations along Fourmile Branch. The seepine locations included 22 from F Area, 20 from H Area, and 15 from the seepine south of 643-E, which is a decommissioned area in the Solid Waste Disposal Facility. Three of the planned sample locations were dry (two from H and one from F). Forty-four of the locations were sampled in 1989 by the Savannah River Technology Center as part of an extensive characterization study (Haselow et al. 1990). Tritium activities in both F- and H-Area seepines in March 1997 were significantly lower than the activities measured by Haselow et al. (1990). However, there were four locations from the March 1997 survey that showed

an increase in tritium activity over 10% above the March 1989 results. The March 1997 conductivity measurements exhibited the same trends as tritium activities in both F- and H-Area seepines.

The average seepine pH was approximately the same as the last survey that was conducted in September 1996. The results continue to indicate that conditions have somewhat stabilized from extremely acid (pH < 4.5) to slightly acid (combined average pH of 5.5) which is closer to normal for this type of wetland. The chronic screening values for pH are 6.5-9.0 (ecological) and 5.0-9.0 for human health. The seepine south of 643-E, along a tributary of Fourmile Branch, is influenced by tritium migrating from the Burial Ground Complex. The tributary (old F-Area effluent ditch) is a natural drainage that received effluent discharge from F-Area Separations prior to the construction of the engineered effluent canal. The March 1997 tritium concentrations on the east side of the natural drainage ranged from 12 to 438 pCi/ml and on the west side from 87 to 10,800 pCi/ml. The tritium activity measured in the stream of the natural

drainage was 17,300 pCi/ml. These results continue to suggest that the tritium outcrop area has been delineated by the sampling locations established on the west side of the drainage channel. Conductivity and pH measurements taken on both sides of the drainage were similar to those recorded in September 1996, and were within the range of normal values for this wetland. The maximum tritium concentrations have declined from 59,400 pCi/ml at sample location FHB018 to a maximum of 17,300 pCi/ml at sample location FHB012 which is the stream sample location that separates the east and west sides of the ditch. Similar decreases have occurred at the other west side sample locations.

Introduction

The objectives of this report are to present the results from the March 1997 sampling event and to trend the results from the baseline sampling events (1989 and 1992) through the March 1997 sampling event.

Seepage basins in the F and H Areas of SRS received low-level radioactive waste effluent from the chemical separation processes in the General Separation Area, (GSA). The basins retained the effluent and allowed it to be slowly released into the soil. The waste effluent consisted principally of sodium hydroxide, nitric acid, low concentrations of various radionuclides, and some metals (Killian et al., 1985a and 1985b). Discharges of tritiated water to the seepage basins accounted for a majority of the radioactivity (Fenimore and Horton, 1972).

The Savannah River Technology Center conducted an extensive study designed to characterize the shallow groundwater outcropping into Fourmile Branch (FMB) and its associated seepline in 1988 and 1989 (Haselow et al., 1990). As a part of this study, Haselow et al. (1990) analyzed for tritium, and measured pH, and conductivity. Researchers found low pH and elevated conductivity and tritium values along the seeplines and concluded that contaminants leaching from the F- and H-Area Seepage Basins were impacting the wetlands below the basins. SRS discontinued discharges to the seepage basins in 1988 and sealed the basins in 1990

to isolate the contaminants from direct rainfall. Scientists hypothesized that after the elimination of the contaminant source, natural groundwater flow from annual rainfall would flush the remaining contaminant plume out of the shallow groundwater over time. After the contaminant plume in the shallow groundwater is flushed out, the impacted wetland systems immediately down gradient from the basins should recover.

To investigate this hypothesis, a quarterly sampling program was begun in May 1992 and concluded in May 1995. EAS sampled 44 of the seepline locations sampled by Haselow et al. (1990) for tritium, pH, and specific conductivity. The 1997 sampling program was developed to complement sampling of the seepline for selected Appendix IX constituents, Dixon et al. (1995). The Appendix IX program began in July 1992 as a semi-annual program and since 1996 has been conducted annually. The Haselow et al. (1990) results established the baseline to which the results from the quarterly tritium sampling program are compared. These collection points were chosen as the baseline because they are the only data available that were collected before the basin discharges were discontinued. The Haselow et al. (1990) data should be representative of conditions immediately prior to closing the basins.

Later, concern was expressed about the source of tritium and other contaminants that possibly emanate from an area in the southwest corner of 643-E rather than from the closed basins. To investigate this possibility, numerous sampling locations on the H-Area seepline south of 643-E were established and were incorporated into the quarterly sampling plans beginning in March 1993.

Methods

EAS conducted the first of two FY97 sampling events for tritium in March 1997. Sampling locations were the same as those selected in the quarterly tritium surveys. These locations, according to 1989 data, exhibited high and low values for the three variables of concern. Attempts were made to establish an even ground coverage along both

Results of the Tritium Survey of Fourmile Branch and its Seepines in the F and H Areas of SRS: March 1997

seepines. EAS collected 58 samples from the seepines in F and H Area: 22 from the F-Area seepine, 20 from the H-Area seepine, and 14 from the FHB seepine south of 643-E Area. Two of the seepine locations were dry. One sample was collected from the old effluent stream. EAS also collected three stream samples from locations on Fourmile Branch. Figures 1 and 2 approximate these sampling locations.

Prior to sampling for the first quarterly survey in May 1992, the Health Protection Department (HPD) collected soil samples from several locations along both seepines and monitored them for gamma radioactivity. HPD did not detect gamma radiation above concentrations of concern; therefore, EAS selected rubber boots and disposable rubber gloves as protective clothing to prevent skin contact with seepine water during sampling operations.

Seepine sampling locations had been previously marked and labeled with PVC stakes. Samples were collected within a ten foot radius of the PVC stake by boring a hole into the soil with a small soil auger, generally six inches and not more than eighteen inches deep. To collect water for tritium analysis, 25 ml polyethylene sample containers were filled and then capped. The outside of each container was then rinsed with deionized water and sealed in a small polyethylene bag to minimize the possibility of cross contamination. The small bags were then placed in a large polyethylene bag and sealed. General Engineering Laboratories (GEL) performed the tritium analysis for the standard and duplicate samples and the Environmental Monitoring Section (EMS) performed the analysis on split samples and samples with activities exceeding 2000 pCi/ml total counts.

EAS measured specific conductivity and pH *in situ* with conductivity and pH electrodes (WSRC Procedure Manual L14.1, 1992a and 1992b). The electrodes were rinsed with deionized water after each sampling. All sampling equipment was thoroughly rinsed with deionized water at the end of each day.

Results and Observations

Parameters measured at seepine sampling locations fluctuated throughout the year. Seepine measurements were taken on water collected from fixed locations at the initial point of outcropping, or toe, of the contaminant plume in the stream-side wetland. Since the plume is dynamic (i.e. influenced by weather and other activities in the area) seepine monitoring is sensitive to both long term changes and seasonal/transient influences. Climatic and seasonal conditions, especially amounts of rainfall, influence measured concentrations. Groundwater flow paths in F and H Area are complex, as illustrated in Figures 3 and 4. Recharge to the groundwater is primarily due to infiltration of rainwater (rainfall minus runoff and evapotranspiration). Groundwater then moves laterally, down and towards Fourmile Branch and its tributaries.

As the water travels toward the Fourmile Branch, additional infiltration forces up-gradient water deeper. Near Fourmile Branch, the flow lines rise to the surface, emerging between the seepine and the stream (this acts as the groundwater "drain"). This typical vertical trajectory, a path curving downward near the groundwater divide and then upward into draining surface water, is shown as flow lines on Figures 3 and 4.

Figure 3 shows the flow lines without contaminated water from the seepage basins and Figure 4 shows the addition of contaminated flow lines resulting from F and H Area operation of the basins. The theoretical plume geometry was confirmed by the real vertical profile of the F-Area Seepage Basin plume based on the detailed grid wells available in the 1970s (Looney et al., 1993). Changes in the water balance in the area influence the flow velocity and tend to move the plume either deeper or shallower and cause the location of the contaminated water to move. This is particularly important to data interpretation if the "toe" of the plume is shifting relative to the fixed sample locations. Figure 5 summarizes the projected changes in the plume based on a range of transitory activities. Increased rainfall (or other activities that increase infiltration such as harvesting trees) result

in increased plume velocity and movement downward and away from the seepline. This decreases contaminant concentrations at the seepline sampling locations. Less infiltration decreases plume velocity and causes the plume to move upward and outcrop closer to the basins. This results in increased contaminant concentrations as measured at the seepline sampling locations.

Low rainfall for a few months prior to sampling is expected to increase constituent concentrations, and high rainfall decreases constituent concentrations in the shallow groundwater at the seepline intercept. Rainfall measured at the SRS weather station in F Area for November 1996 through February 1997 was 36.0 cm. The average long term rainfall for this same period was 37.0 cm. Thus, rainfall in the sampling area was about average for the few months prior to this sampling event. Figure 6 compares March 1996 to February 1997 rainfall to the long term average (1961 to 1994). It is hypothesized that below average rainfall observed in the area for this period would cause contaminant concentrations to increase at sample locations closer to the basins and to decrease at the more distant locations. Note that the direction of the plume flow always remains the same, only the flow velocity and outcrop location changes relative to the changes in infiltration.

Tritium concentrations at four sample locations were above the March 1989 readings, with these sample locations showing an average tritium activity increase of 919 pCi/ml. Generally, these are the most distant sample location points from the closed basins along Fourmile Branch. Figures 7 through 12 show comparisons of March 1989 with September 1996 and March 1997 tritium, conductivity, and pH measurements for locations on the F- and H-Area seepline. Data for the first fourteen surveys can be found in Dixon, Rogers, and Looney (1992, 1993a, 1993b, 1993c, 1993d and 1993e and 1994), Rogers et al. (1994a, 1994b, and 1994c) and Koch and Dixon (1994, 1995, 1996, and 1997). Figures 13 through 15 show the data for the Fourmile Branch stream locations. Figures 16 through 18 show the data for the sampling locations along the old effluent seepline and include one stream sample from the branch channel south of

643-E. These sampling locations were identified with the prefix FHB.

F- and H-Area Seepline Tritium Measurements

Figures 7 and 8 show tritium activities at F and H Areas for the March 1997 sampling event. Tritium concentrations increased at 10 sample locations, while 26 locations either decreased or were relatively unchanged compared to the September 1996 sampling event. There were two dry sites. Overall, sampling has shown a declining trend in tritium concentrations at the F-and H-Area seeplines (Figures 19 and 20).

It is important to note that total tritium fluxes to the wetlands and FMB have steadily declined since basin closure (Looney et al., 1993) and that overall results of the tritium survey support this finding. Differences in tritium concentrations measured at seepline sampling locations from one sampling event to the next represent seasonal variability and variable rainfall as well as changes due to the plume flushing from the wetland system. Variability may also result from reduction in plume size along margins.

F-Area Seepline

March 1997 tritium values in the F-Area seepline ranged from 15 to 6,770 pCi/ml (Figure 7 and Table 2). None of the 22 sampling locations were dry, and only one sampling location had a tritium activity that exceeded the 1989 baseline measurements by more than ten percent. No sample exceeded the maximum value of 14,000 pCi/ml measured in March 1989 at this seepline.

As with data from previous sampling events, a Wilcoxon signed-rank test was conducted to compare March 1997 tritium activities to March 1989 baseline activities. The Wilcoxon signed-rank test uses the sign and the magnitude of the rank of the differences between pairs of measurements to compare nonparametric data (Daniel, 1978). This test was chosen because it allows comparisons of paired data without assumptions of normality. If the

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P value is less than or equal to 0.05, then the March 1997 tritium concentrations are significantly different from the March 1989 baseline tritium concentrations. The results from this test gave a P value < 0.002 . Consequently, this test shows that the March 1997 concentrations were significantly lower than the 1989 concentrations for this seepine.

H-Area Seepine

Tritium values in the H-Area seepine for March 1997 ranged from 14 to 7,320 pCi/ml (Figure 8 and Table 3). Two of the 22 sampling locations were dry, and three sampling locations had tritium activities that exceeded the 1989 baseline measurements by more than ten percent. These locations, HSP071, HSP097, and HSP103 are among the farthest locations from the closed basins. No sample exceeded the maximum value of 24,000 pCi/ml measured in March 1989 at this seepine.

Figure 22 shows the downward trend of tritium concentrations and the conductivity trends in this area. It presents the mean of the tritium concentrations from each sampling event beginning with the March 1989 baseline event (Table 6). Figure 23 shows the pH trends using the mean pH of each sampling event.

As with data from F Area, a Wilcoxon signed-rank test was conducted to compare March 1997 tritium activities to March 1989 activities. The result shows that the March 1997 concentrations were significantly less ($P < 0.002$) than the 1989 concentrations for this seepine.

F- and H-Area Seepine Conductivity Measurements

F-Area Seepine

Conductivity measurements at the F-Area seepine in March 1997 ranged from 24 to 1649 $\mu\text{S}/\text{cm}$ (Figure 9, Table 2). Due to the variability of conductivity measurements, only differences of 100 $\mu\text{S}/\text{cm}$ or more are considered significant. Of the 22 locations sampled at the F-Area seepine, four of the locations measured more than 100 $\mu\text{S}/\text{cm}$ above the

1989 baseline measurements. A comparison of the results in Figures 7 and 9 suggests that conductivity follows the same general trends as the tritium activities. Using a Spearman rank correlation test for nonparametric data, the probability that tritium and conductivity exhibited independent trends was low, ($P < 0.001$). The Spearman rank correlation coefficient was calculated to be $r_s = 0.82$, suggesting that the two parameters behave dependently. This similarity of trends between conductivity and tritium is consistent with past results. In past tritium surveys, 1992 through 1996, this correlation has been positive and significant. A rank correlation coefficient of 1.0 is a perfect correlation between variables.

H-Area Seepine

Conductivity measurements in March 1997 at the H-Area seepine ranged from 35 to 385 $\mu\text{S}/\text{cm}$ (Figure 10 and Table 3). None of the sampling locations, had a measurement of more than 100 $\mu\text{S}/\text{cm}$ above the 1989 baseline measurements. The Spearman rank correlation test was used to investigate the correlation of tritium activities and conductivity values. The probability that the two parameters exhibited independent trends was low on this seepine also ($P < 0.001$). The rank correlation coefficient ($r_s = 0.71$) was less than that for F Area suggesting a weaker correlation but still dependent behavior between variables. In past tritium surveys, 1992 to 1996, this correlation has been positive and significant.

F- and H-Area Seepine pH Measurements

F-Area seepine pH values ranged from 4.2 to 6.4, with an average value of 5.1 (Figure 11, Table 2). H- Area pH values ranged from 5.1 to 6.6, with an average of 6.0 (Figure 12 and Table 3). The pH for the entire seepine (F and H Areas combined) averaged 5.5. This represents an increase of 0.6 units over the 4.9 average in 1989 and is slightly higher than the overall average for the September 1996 and March 1996 sampling events. An increase in pH will effect the solubility of metals in the soil which should improve the soil water chemistry and

enhance the recovery of wetland vegetation stressed indirectly by low pH.

Aluminum concentrations measured along the seepline in 1989 were high enough to be toxic to plants (Haselow et al., 1990). Increases in pH from an average of 4.9 (in 1989) have likely reduced the amount of aluminum in solution and thereby reduced it as a possible source of plant toxicity. Concentrations of aluminum and other metals measured along the seepline in July 1992 were substantially lower than 1989 concentrations, consistent with the observed pH (Dixon and Rogers, 1993e; Chappell et al, 1995). Field observations have revealed that vegetation in most of the stressed areas is making noticeable recovery (Nelson and Irwin, 1994; Nelson and Rogers, 1995). Studies have also shown that the toxicity of these areas is decreasing, (Nelson and Westbury, 1994; Westbury and Nelson, 1994).

Fourmile Branch Measurements

Figures 13 through 15 show the tritium, conductivity, and pH values for the Fourmile Branch stream sampling locations. Table 4 provides the data used in the figures. Tritium activities at these locations in March 1997 ranged 9 to 329 pCi/ml. These values were slightly lower than previous results and continue to show increases in tritium concentrations downstream as the seepline water enters the channel of Fourmile Branch. Conductivity measurements ranged from 54 to 98 μ S/cm and pH ranged from 6.5 to 7.7.

Solid Waste Disposal Facility (643-E) Seepline Measurements

The graphs in Figures 16 through 18 show tritium, conductivity, and pH values for the seepline and stream sampling locations south of 643-E, which is part of the Solid Waste Disposal Facility. Table 5 provides the data used in the figures. This seepline is along the natural drainage (old F-Area effluent ditch) that was used to discharge effluent from F-Area separations prior to the construction of the engineered effluent canal.

Tritium activities for the locations on the east side of the drainage ranged from 12 to 435 pCi/ml. Activities on the west side of the drainage ranged from 16 to 10,800 pCi/ml. The tritium activity at the stream location in the drainage (FHB012) was 17,300 pCi/ml.

In March 1997, pH values ranged from 4.8 to 6.1, with an average of 5.3. Conductivity measurements on both sides of the drainage were near background at most locations and ranged from 24 to 90 μ S/cm. Conductivity values are typical of the conductivity values being reported in the water table wells in the vicinity of the old F-Area effluent ditch (EMS, 1996). The Spearman rank correlation test showed a significant but weak correlation between conductivity and tritium for these locations ($r_s = 0.40$). This indicates that these two variables behave dependently. Past Spearman rank correlation test results showed no correlation between these variables.

The tritium results were consistent with the Haselow et al. (1990) results for the west side sample locations of the 643-E seepline, particularly near location HSP103. Haselow et al. (1990) found that down gradient from 643-E, conductivity values were near background whereas tritium concentrations were elevated. This finding was attributed to tritiated wastes deposited in 643-E. Tritium activities measured along the seepline down gradient of 643-E (particularly sample points on the west side of the drainage) suggest that tritium migrating from 643-E and outcropping in this area was substantial. The detection of tritium on the west side (as opposed to the east side of the drainage) suggested that soil material placed in the northern reaches of the natural drainage forced the tritium plume to outcrop down gradient. It appears that the groundwater containing tritium is moving below the fill material and outcropping on the west side of the drainage channel. The results suggest that the sampling locations on the west side of the drainage have delineated the tritium plume with the center located at or near FHB018.

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Figure 30 shows the tritium data from all the sampling events for this seepage area beginning with the 1992 sampling event. A majority of the tritium activity measured shows up at four locations, all on the west side of the drainage. These locations are FHB013, 017, 018, and 019.

Overall Trends, and Summary

F-Area Seepage

Figure 19 shows the downward trend of tritium concentrations for the F-Area seepage and the conductivity trends. It shows the mean tritium and conductivity concentrations from each sampling event beginning with the March 1989 baseline event through the March 1997 sampling event (Table 6). Each sampling event since 1989 has shown a statistically significant decrease in tritium concentrations when compared to the 1989 baseline event. Figure 20 shows the pH trends using the mean pH of each sampling event.

Figure 21 shows the tritium concentrations for all the sampling events at the F-Area seepage. It indicates that a majority of the tritium measured appears at eight of the 22 sample locations. These locations, are FSP019, 026, 032, 034, 035, 040, 204, and 213. Very little of the tritium plume has been detected east of sample location FSP040 or south and west of sample location FSP0213. It also appears that two distinct groupings of sample locations delineate the bulk of the tritium plume from the seepage basins. These two groupings are separated by Road C-4.

H-Area Seepage

Figure 22 shows the downward trend of tritium concentrations for the H-Area seepage and the conductivity trends. This figure shows the mean tritium and conductivity concentration from each sampling event beginning with the March 1989 baseline event through the March 1997 sampling event (Table 6). Figure 23 shows the pH trends using the mean pH of each sampling event. Each sampling event since 1989 has shown a statistically

significant decrease in tritium concentrations when compared to the 1989 baseline event.

Figure 24 shows the tritium concentrations from all the sampling events conducted for the H-Area seepage. The sample locations having the highest and lowest tritium values over the entire sampling interval (1989 to 1997) can be seen from examining this figure.

643-E

Figures 25 to 27 summarize the tritium concentrations, conductivity, and pH measurements of each sampling event. The delineation of the contamination is apparent in Figure 25. Figure 27 shows that a majority of the contaminant plume appears at four sample locations. These locations are on the west side of the drainage and are identified as FHB013, 017, 018, and 019.

Fourmile Branch

Figures 28 to 30 show the tritium concentrations, conductivity, and pH measurements for the Fourmile Branch sample locations from 1992 to 1997. Each point represents the actual concentration or reading and is not an average value.

Conclusions

F- and H-Area Seepines, and Fourmile Branch

- Tritium concentrations measured at most locations during March 1997 remained relatively unchanged compared to the previous sampling event yet were significantly lower than the 1989 baseline tritium concentrations.
- Total tritium fluxes to the wetlands and FMB have steadily declined since basin closure (Looney et al., 1993). Overall results from the March 1997 tritium survey support this finding. These findings continue to support the hypothesis that the tritium plume in F and H Area is being flushed from the shallow groundwater.

- A majority of the tritium detected along the F-Area seepage line appeared at two localized areas (i.e., eight of the 22 sample locations). These eight sample locations are FSP019, 026, 032, 034, 035, and 040; FSP204 and 213.
- The difference in tritium concentrations between sampling events is represented by rainfall and seasonal variability as well as changes due to the contaminant plume flushing from the wetland system. Conclusions about tritium fluxes into the wetlands and FMB should consider the complexity of the groundwater system. They should also be based on long-term surface water, seepage line, and groundwater monitoring data and not on quarterly changes in concentrations at seepage line monitoring locations. No correction has been made for tritium decay because of the short time period between sampling events.
- All tritium results from the March 1997 survey were below the current regulatory threshold of 20,000 pCi/ml.

Solid Waste Disposal Facility (643-E) Seepage Line

Data from 16 seepage line locations south of the 643-E Area indicated that tritium migrating from 643-E is outcropping at the F-Area effluent ditch, particularly on the west side of the stream channel. It appeared that sampling locations on the west side of the ditch have delineated the tritium outcrop area with the present climatic and hydrologic conditions.

- Data indicated that the tritium has decreased over the past nine sampling events.
- A major portion of the tritium detected was on the west side of the drainage at four sample locations. These four sample locations are FHB013, 017, 018, and 019.
- The tritium concentrations have steadily decreased at the west side sample locations since sampling began in August 1993.

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Results of the Tritium Survey of Fourmile Branch and
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Figure 1. Location of F-Area Seepage Basins and Seepine Sampling Points.

Figures 2. Location of H-Area Seepage Basins and Seepine Sampling Points and FHB Sampling Points.

Figures 3. Schematic Diagram of Flow Lines in the Shallow Groundwater at the F- and H-Area without Seepage Basins.

Figures 4. Schematic Diagram of Flow Lines in the Shallow Groundwater at the F- and H-Area during Basin Operation.

Results of the Tritium Survey of Fourmile Branch and
its Seepelines in the F and H Areas of SRS: March 1997

Figure 5. Schematic Diagram of the Tritium Plume Migrating from F- and H-Area Seepage Basins

Figure 6. Comparison of March 1996-February 1997 Monthly Rainfall to the Long Term Average (1961-1994) for the F-Area Weather Station.

Figure 7. Comparison of Tritium Concentrations at F-Area Seepline Locations.

Figure 8. Comparison of Tritium Concentrations at H-Area Seepline Locations.

**Results of the Tritium Survey of Fourmile Branch and
its Seepines in the F and H Areas of SRS: March 1997**

Figure 9. Comparison of Specific Electrical Conductivity at F-Area Seepine Locations

Figure 10. Comparison of Specific Electrical Conductivity at H-Area Seepine Locations.

Figure 11. Comparison of pH at F-Area Seepage Locations.

Figure 12. Comparison of pH at H-Area Locations.

Results of the Tritium Survey of Fourmile Branch and
its Seep Lines in the F and H Areas of SRS: March 1997

Figure 13. Comparison of Tritium Concentrations at Fourmile Branch Locations.

Figure 14. Comparison of Specific Electric Conductivity at Fourmile Branch Locations.

Figure 15. Comparison of pH at Fourmile Branch Locations.

Figure 16. Comparison of Tritium Concentrations at Locations on the Seep line South of 643-E.

**Results of the Tritium Survey of Fourmile Branch and
its Seepines in the F and H Areas of SRS: March 1997**

Figure 17. Comparison of Specific Electrical Conductivity at Locations on the Seepine South of 643-E.

Figure 18. Comparison of pH at Locations on the Seepine South of 643-E.

Figure 19. Tritium and Conductivity Trends for F-Area Seepage. Each point represents the mean value of a sampling event.

Figure 20. pH trends for the F-Area Seepage. Each point represents the mean value of a sampling event.

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its Seepines in the F and H Areas of SRS: March 1997

Figure 21. Bar Chart Scatter plot of tritium concentrations for F-Area Seepine (1989-1997)
Plot shows distribution of tritium throughout the entire sampling period.

Figure 22. Tritium and conductivity trends for H-Area Seepine. Each point represents the mean value of a sampling event.

Figure 23. pH trends for the H-Area Seepline. Each point represents the mean pH value of a sampling event.

Figure 24. Bar chart scatter plot of tritium concentrations for the H-Area Seepline (1989-1997). Plot shows distribution of tritium throughout the entire sampling period.

Results of the Tritium Survey of Fourmile Branch and
its Seepelines in the F and H Areas of SRS: March 1997

Figure 29. Tritium, conductivity, and pH sample location FMC001H (Fourmile Branch)

Figure 30. Tritium, conductivity, and pH at sample location FMC002H (Fourmile Branch).

Table 1. Comparison of 1996/1997 Monthly Rainfall to the Long Term Average Rainfall From the F-Area Weather Station

Month	Year	Rainfall (cm), F-Area Weather Station, (March 1996-February 1997)	Longterm Rainfall (cm), F-Area Weather Station, (1961-1994)
Mar	96	18.00	12.62
April	96	4.29	8.01
May	96	6.10	9.31
June	96	11.65	11.77
July	96	14.10	13.97
Aug	96	26.92	14.56
Sept	96	7.98	8.77
Oct	96	5.31	7.80
Nov	96	3.71	7.12
Dec	96	7.54	8.97
Jan	97	10.67	11.14
Feb	97	14.12	10.74

**Results of the Tritium Survey of Fourmile Branch and
its Seepines in the F and H Areas of SRS: March 1997**

Table 2. Comparison of F-Area Seepine Measurements for Tritium, Conductivity, and pH for the March 1989, September 1996, and March 1997 Sampling Events.

Location	Tritium (pCi/ml)			Conductivity (μS/cm)			H(-log H)		
	Mar-89	Sep-96	Mar-97	Mar-89	Sep-96	Mar-97	Mar-89	Sep-96	Mar-97
2	520	779	476	95	90	90	5.6	6.1	6.4
7	3400	1010	1040	681	241	244	5.4	5.5	6.3
12	260	70	44	30	62	50	5.3	4.8	5.7
14	14000	51	17	666	28	24	4.2	5.3	5.2
19	4900	4270	4660	1424	1007	1068	4.2	3.7	4.3
26	4400	3980	6770	1095	884	1649	6.5	3.9	4.5
32	3600	232	73	174	38	37	5.0	4.3	5.4
34	14000	2910	2180	810	585	503	3.8	4.3	4.4
35	11000	7150	5090	1100	1210	989	3.9	3.5	4.4
40	7800	4640	5670	900	940	1382	5.2	5.5	4.5
47	100	20	15	52	63	54	4.7	4.9	5.2
56	19	7	6	34	41	88	4.5	5.1	5.5
204	3000	2880	2400	895	576	487	4.4	3.9	4.6
213	2800	2200	684	860	486	48	4.6	3.9	5.4
220	560	955	505	147	232	220	4.8	5.2	5.0
226	1300	443	758	306	162	251	5.1	6.1	5.5
235	580	176	242	84	134	76	5.7	5.6	5.4
241	560	dry	515	36	154	155	4.7	5.5	5.5
249	580	345	193	84	86	78	4.4	4.7	5.2
256	400	285	80	56	126	58	5.1	5.4	5.4
270	40	42	32	50	39	170	4.1	4.0	4.3
290	35	35	24	49	34	65	3.6	4.3	4.2

Table 3. Comparison of H-Area Seepage Measurements for Tritium, Conductivity, and pH for the March 1989, September 1996, and March 1997 Sampling Events.

Location	Tritium (pCi/ml)			Conductivity ($\mu\text{S}/\text{cm}$)@25deg C			pH (-log H)		
	Mar-89	Sep-96	Mar-97	Mar-89	Sep-96	Mar-97	Mar-89	Sep-96	Mar-97
3	14000	1740	1480	468	170	223	5.2	6.3	6.6
4	11000	386	398	292	198	117	5.8	6.4	6.6
8	24000	1190	1130	556	237	156	5.7	6.7	6.6
11	960	dry	135	80	dry	41	5.1	dry	5.7
13	12000	435	735	592	148	148	6.2	6.3	6.4
15	1000	776	504	82	168	112	5.2	6.0	5.7
20	6500	228	147	183	127	77	6.2	5.9	5.7
25	3300	799	258	135	94	53	4.7	5.9	5.4
29	9200	70	51.2	257	54	56	5.2	5.9	5.4
34	5600	dry	dry	331	dry	dry	5.8	dry	dry
38	6500	dry	dry	227	dry	dry	4.9	dry	dry
43	10000	dry	1840	413	dry	132	5.3	dry	6.5
46	11000	663	494	318	170	171	5.5	6.0	6.1
49	11000	1060	1250	551	112	124	4.4	5.8	6.0
52	20000	1310	7320	699	375	385	4.1	5.9	5.9
57	15000	1080	354	581	120	122	5.5	6.0	6.1
60	21000	dry	1470	473	174	207	5.9	6.1	6.0
64	320	20	13.6	38	22	35	4.7	5.8	5.1
71	450	1160	1070	40	96	115	5.1	6.5	6.5
76	400	410	202	146	74	133	5.7	6.7	6.3
97	1100	1980	1370	37	129	102	4.3	6.3	6.1
103	510	1660	927	43	80	83	4.4	5.6	5.5

Table 4. Comparison Measurements for Tritium, Conductivity, and pH in Fourmile Branch for the March 1996, September 1996, and March 1997 Sampling Events.

Location	Tritium (pCi/ml)			Conductivity ($\mu\text{S}/\text{cm}$)			pH (-log H)		
	Mar-96	Sep-96	Mar-97	Mar-96	Sep-96	Mar-97	Mar-96	Sep-96	Mar-97
1F	456	520	329	30	62	61	6.0	5.4	6.6
1H	29	35	9	38	49	98	6.3	6.1	7.7
2H	88	76	78	42	56	54	5.4	5.9	6.5

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Table 5. Comparison of 643-E Seepine Measurements for Tritium, Conductivity, and pH for the March 1996, September 1996, and March 1997 Sampling Events.

Location	Tritium (pCi/ml)			Conductivity (μS/cm)			pH (-log H)		
	Mar-96	Sep-96	Mar-97	Mar-96	Sep-96	Mar-97	Mar-96	Sep-96	Mar-97
1	102	dry	42	25	dry	47	4.9	dry	5.6
2	15	16	12	36	39	39	4.8	5.7	5.0
3	115	87	101	33	23	33	5.1	5.1	5.2
4	115	247	158	32	27	38	4.7	5.4	5.1
5	406	496	435	41	39	46	5.1	5.6	5.5
6	207	211	213	29	32	42	5.2	5.4	5.6
8	157	200	111	25	186	24	4.9	5.3	5.3
12	15000	18500	17300	35	34	38	5.1	5.4	4.8
13	8120	7190	3050	31	42	33	4.8	5.4	5.0
14	307	209	195	29	31	37	5.0	5.2	5.0
15	dry	dry	dry	dry	dry	dry	dry	dry	dry
16	240	278	87	66	47	66	5.2	5.6	5.7
17	10400	8830	3470	31	61	53	5.2	5.6	5.4
18	20200	19100	10800	106	25	90	5.8	6.1	6.1
19	5630	dry	4960	54	dry	51	4.2	dry	4.9
20	24	22	16	68	37	32	5.6	5.8	6.1

Note: Location 12 is a stream sample location.

Table 6. Average Tritium, Conductivity, and pH values for F and H Area Seepines (March 1989-September 1997).

Sampling Event Date	F Area Seepine-Average Values			H Area Seepine-Average Values		
	tritium (pCi/ml)	Conductivity (μS/cm)	pH	tritium (pCi/ml)	Conductivity (μS/cm)	pH
Mar-89	3357	438	4.8	8402	297	5.2
May-92	1934	335	4.7	4131	183	5.9
Sep-92	1990	352	5.2	2904	182	6.0
Dec-92	1823	300	5.3	3001	165	6.0
Mar-93	1398	293	5.0	2063	124	5.9
Jun-93	1936	330	5.1	2885	157	6.0
Sep-93	2384	404	5.0	2876	205	5.7
Dec-93	1920	415	5.1	2749	181	5.7
Mar-94	1525	371	5.0	1818	140	5.6
Jun-94	1688	344	5.0	2053	153	5.8
Sep-94	1806	381	5.1	1953	159	6.0
Dec-94	1698	366	4.9	2836	179	5.8
May-95	1634	311	5.0	1547	131	5.6
Mar-96	1424	331	4.7	1082	113	5.9
Sep-96	1545	328	4.8	880	142	6.1
Mar-97	1431	354	5.1	1057	130	6.0

Table 7. Average Tritium and Conductivity, values for Seep line below 643-E.

Sampling Event Date	Tritium (all) (pCi/ml)	Tritium (East) (pCi/ml)	Tritium (West) (pCi/ml)	Conductivity (All) (μS/cm)	Conductivity (East) (μS/cm)	Conductivity (West) (μS/cm)
Mar-93	4808	242	8999	62	43	88
Jun-93	7617	389	14779	82	53	122
Sep-93	10924	445	22017	92	57	140
Dec-93	8182	435	15527	68	56	86
Jun-94	8557	324	14557	58	53	68
Sep-94	8065	303	15469	57	53	65
May-95	4323	270	6630	69	64	79
Mar-96	4069	143	7483	43	36	53
Sep-96	4260	183	7121	44	37	54
Mar-97	2730	136	3760	45	38	55

Table 8. Tritium concentrations for Fourmile Branch.

Sample date	Sample ID	Tritium (pCi/ml)	Sample date	Sample ID	Tritium (pCi/ml)
Dec-92	FMC001H	55	Sep-94	FMC001F	567
Dec-92	FMC001F	455	Sep-94	FMC001H	52
Dec-92	FMC002H	2050	Sep-94	FMC002H	93
Apr-93	FMC001H	47	Dec-94	FMC001F	312
Apr-93	FMC001F	425	Dec-94	FMC001H	59
Apr-93	FMC002H	104	Dec-94	FMC002H	113
Sep-93	FMC001H	41	May-95	FMC001F	643
Sep-93	FMC002H	105	May-95	FMC001H	63
Sep-93	FMC001F	503	May-95	FMC002H	97
Dec-93	FMC001H	37	Mar-96	FMC001F	138
Dec-93	FMC001F	567	Mar-96	FMC001H	34
Dec-93	FMC002H	145	Mar-96	FMC002H	65
Mar-94	FMC001H	34	Sep-96	FMC001F	520
Mar-94	FMC001F	375	Sep-96	FMC001H	35
Mar-94	FMC002H	91	Sep-96	FMC002H	76
Jun-94	FMC001F	331	Mar-97	FMC001F	329
Jun-94	FMC001H	42	Mar-97	FMC001H	9
Jun-94	FMC002H	82	Mar-97	FMC002H	78