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**TRITIUM IN THE SAVANNAH RIVER ENVIRONMENT
ADDENDUM TO WSRC-RP-90-424-1, REV 1 (U)**

by

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SAVANNAH RIVER SITE

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ABSTRACT

This document is an addendum to "Tritium in the Savannah River Site Environment," WSRC-RP-90-424-1, released in May of 1991. The purpose of this report is to update the information found in WSRC-RP-90-424-1 for the four year period 1987-1990. Some data has also been included from 1991. The report includes summaries of atmospheric and aqueous monitoring of tritium and estimates of the dose to the population surrounding the Savannah River Site.

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INTRODUCTION

The first in a series of radionuclide assessment volumes was published by the Savannah River Site (SRS) in May of 1991. These volumes are designed to reflect our understanding of the impact of specific radionuclides in the SRS environment. The first volume, WSRC-91-424-1 (Murphy et al. 1991), addressed tritium because this radionuclide, a product of SRS operations, has been shown to have the greatest potential impact on public health of the surrounding population of any radionuclide released by SRS. Since publication, tritium at the SRS has continued to be a source of concern for some citizen groups. This addendum is designed to summarize information collected since compilation of the first document on tritium in the environment of the SRS. The tritium volume and the remaining volumes in the radionuclide assessment series are intended to be living documents that will be updated at intervals. This addendum is intended to provide information in the period between the original publication and the first updating of the tritium volume.

ATMOSPHERIC TRITIUM CONCENTRATIONS

Air Concentrations

The concentration of tritium, and selected other radionuclides, is routinely measured at and in the vicinity of the Savannah River Site (SRS). The

number of monitoring stations has varied during the existence of the SRS. The monitoring locations were designed to surround the site with two concentric rings of samplers. In 1990, the inner ring consists of fourteen samplers located along the plant perimeter. The outer ring includes twelve samplers located at approximately 25 miles from the center of the site. Five additional sampling locations are located within the SRS boundary. Air moisture samples are collected on silica gel. The silica gel is collected every two weeks, returned to the Environmental Measurement Section laboratory for separation and counting. Similar sampling is done quarterly for stations at Columbia, SC; Greenville, SC; Macon, GA; and Savannah, GA (see Cummins et al. 1991 for more detail).

The primary sources of atmospheric tritium at the SRS are the Tritium Separations Area and the Reactor Areas. During the four year period, 1987-1990, C-, P-, and R-Reactor Areas have had little to no tritium releases. Only K- and L-Reactor Areas have had activities related to restart of these facilities. Most of the tritium releases from the Reactor Areas is in the form of tritiated water (HTO). Tritium releases from the Separations Areas contain significant amounts of tritiated hydrogen gas (HT) which is not detected by the silica gel samplers.

Figure 1 Isopeths of Tritium Concentration in Air in the Vicinity of SRS.

The patterns of tritium concentration in the atmosphere in the vicinity of SRS continue to follow those presented in WSRC-90-424-1. The concentration decreases with distance from the center of the site. The concentration decrease can be represented by a straight line when plotted on logarithmic coordinate graphs. This is consistent with theoretical prediction of the effect of increasing dilution as the tritium is carried away from the source by the atmosphere. Figure 1. illustrates the isopeths of tritium concentration averaged for the four years, 1987, 1988, 1989, and 1990. The steeper drop in concentration to the southeast and north of the SRS is related to the predominant wind directions at the site. The location of the isopeths are similar to those shown in WSRC-90-424-1 for the previous five year period. This is consistent with similar quantities of tritium released to the atmosphere under similar climatic conditions.

Rainwater Concentrations

Before 1987, rainwater was collected at many of the same sampling locations as air concentrations. Since 1987, measurements have been made on only the rainwater from a few locations inside SRS, one 25-mile sampling location, and the four sampling locations at Columbia, SC; Greenville, SC; Macon, GA; and Savannah, GA. The justification for the decrease in sampling intensity was the high correlation between atmospheric moisture and rainwater tritium concentrations (Murphy et al. 1991).

The results are shown in Table 1. for the years 1987, 1988, 1989, and 1990. As suggested previously, the atmospheric moisture and rainwater concentrations are similar. The rainwater concentration averages about 60% of the atmospheric concentration during this period. This conversion factor will be used later in this report when ground and surface water is compared to rainwater.

VEGETATION TRITIUM CONCENTRATIONS

The concentration of tritium in vegetation water is measured quarterly at some of the same monitoring stations where the air concentrations are measured. Water was extracted in the laboratory by freeze-drying and counted by liquid scintillation. In 1990, only four of the 25-mile ring stations were measured. Because of the decreased sampling density it was difficult to map the tritium vegetation concentration isopleths as was done in WSRC-91-424-1. Because the source for the tritium in the off-site vegetation is uptake of rainwater from the soil and vapor exchange with atmospheric moisture, the tritium concentrations are similar to the atmospheric moisture concentrations at the same locations. Figure 2. shows the relationship between the air moisture and vegetation moisture tritium concentrations.

Figure 2 The concentration of Tritium in Vegetation Moisture around SRS

Table 1 Tritium Concentration in Rainwater in the Vicinity of SRS (pCi/mL).

<u>Location</u>	<u>Year</u>	<u>Min</u> <u>Rain</u>	<u>Max</u> <u>Rain</u>	<u>Mean</u> <u>Rain</u>	<u>Mean</u> <u>Air</u>	<u>Mean</u> <u>Rain/Air</u>
Darkhorse	1987	-7.70	85.00	4.60	7.09	0.65
Columbia	1987	0.09	0.28	0.19	0.89	0.21
Greenville	1987	-0.26	0.46	0.19	0.65	0.29
Macon	1987	-0.10	0.49	0.15	1.45	0.10
Savannah	1987	-0.08	0.05	0.01	0.59	0.02
Darkhorse	1988	-0.46	6.70	1.70	4.55	0.37
Columbia	1988	-0.09	0.32	0.12	2.18	0.06
Greenville	1988	-0.33	0.22	0.04	0.87	0.05
Macon	1988	0.04	0.17	0.08	1.27	0.06
Savannah	1988	0.00	0.31	0.16	0.09	1.76
Darkhorse	1989	0.10	12.00	1.30	3.09	0.42
Columbia	1989	-0.06	0.18	0.06	1.27	0.05
Greenville	1989	-0.28	0.11	-0.17	1.55	-0.11
Macon	1989	-0.28	0.39	0.00	0.16	0.00
Savannah	1989	-0.02	0.32	0.13	0.14	0.95
Darkhorse	1990	0.05	10.60	1.20	2.36	0.51
Columbia	1990	0.08	0.16	0.10	1.09	0.09
Greenville	1990	-0.05	0.20	0.11	0.49	0.22
Macon	1990	-0.11	0.19	0.02	1.18	0.02
Savannah	1990	-0.19	0.13	0.01	0.53	0.02

Mean — — 0.29

TRITIUM IN SURFACE WATERS

Four Mile Branch

Tritium in the water of Four Mile Branch is derived from two types of sources, direct discharge from industrial processes in the Separations Areas and migration of contaminated water originally discharged to earthen-lined seepage basins. By far, the largest source is the migration of seepage basin water. Discharges to the seepage basins were stopped in 1988. Since that time the seepage basins have been covered with a clay cap to decrease infiltration into the groundwater. The effects of these actions can be seen in figure 3. Sampling station FMC-2 is upstream of the entrance of migration of seepage basin water. The relatively low tritium concentration is the result of direct discharges. Location FMC-2B and FMC-A7 are, respectively, below the entrance of migration from

the H-Area and F-Area seepage basins. It is evident from the decreasing tritium concentration that closure of the basins has limited migration to Four Mile Branch. At the present time it is difficult to forecast when the tritium concentration in Four Mile Branch will return to background. However, it is clear that the seepage basin closure has met its goal of decreasing releases to the stream and ultimately to the Savannah River.

Upper Three Runs

Previous to 1986, there were only minor releases of tritium to Upper Three Runs. In 1986, the Effluent Treatment Facility (ETF) for F- and H-Areas began operation. This facility removes contaminant from water that had previously gone to the F and H Seepage Basins. However, the ETF is not capable of removing tritium. The effect of

Figure 3. Tritium Concentrations in Four Mile Creek as Influenced by Direct Releases and Migration from the H- and F-Area Seepage Basins.

the ETF can be seen in Figure 4. Tritium concentration have increased but not to the levels found in Four Mile Branch. One reason for the lower concentration is the great volume of water diluting the releases in Upper Three Runs. An additional reason is the decrease in effluents during this period.

Comparison of Georgia Department of Natural Resource Measurements and Atmospheric Deposition

In response to concerns about contamination of the Savannah River, the Georgia Department of Natural Resources (GDNR) initiated monitoring of surface water on the Georgia side of the river opposite the SRS boundary (Hardeman 1992). Most of the sampling points lie between the 20 and 40 pCi/m³ isopeth in figure 1. Using the average mixing ratio of the air at the SRS, 11 mL/m³, this corresponds to 1.8 to 3.6 pCi/mL of water.

The GDNR measurements range from 0.5 and 1.9 pCi/mL which is consistent with rainfall deposition of tritiated water released from the SRS. The results are consistent with the source of most of the tritium in the surface water coming from washout of tritium released from the SRS. The levels are all considerably below the EPA drinking water guide of 20 pCi/mL.

GROUNDWATER

Relationship of Rainwater and Groundwater Tritium Concentrations

In 1991, the Georgia Department of Natural Resources reported collecting samples of well water that had elevated tritium concentrations. The wells were on the Georgia side of the Savannah River near the southern boundary of the SRS. There was concern over the source of the tritium in the groundwater and the possibility of migration under the Savannah River from contaminated

Figure 4. The Mean, Maximum, and Minimum (Bars) Tritium Concentration in Upper Three Runs Creek as Influenced by the Opening of the H- and F-Area Effluent Treatment Facility.

under the Savannah River from contaminated groundwater within the boundary of the SRS.

Well water is ultimately derived from rainwater which has infiltrated into the soil and moved downward to the aquifer tapped by the well. The water in a well is from both the water infiltrating directly from above, from water that has infiltrated at some "source area" and moved laterally to the location of the well, or from both sources. In either case it is from past rainwater. Figure 5 shows the results of a calculation made to estimate the effect of past rainwater on the concentration of tritium in groundwater. The calculations assumes that a fraction of the rain infiltrates into the soil and moves downward without mixing with the water from past or previous rainfalls. The distance the water moves depends on displacement of the water by water from subsequent rain. As rainwater accumulates, the water from preceding rainfall moves deeper into the ground. The rate of movement depends on the rate of rainfall and the pore volume

in the soil. The calculation shown in figure 5 assumes that 30% of the rainfall infiltrates and 30% of the soil is pore space that contains water. An additional consideration is that tritium will radioactively decay, decreasing the concentration in the older water deeper in the ground.

The results suggest that concentration in the ground water from rainfall could range from 0 to 25 pCi/mL, with an average of approximately 6 pCi/mL near the SRS boundary. Rainwater concentration before 1974 was estimated from known atmospheric releases of tritium. Rainwater concentration after 1986 was estimated from measured air concentrations. The dotted lines indicate the range of tritium concentrations measured during the 1974 to 1986 period.

INADVERTENT TRITIUM RELEASES

Some releases of tritium to the environment are part of normal operation of the SRS facilities. Other releases are the result of mechani-

Figure 5. Tritium Concentration in Groundwater Calculated from Rain Concentration Corrected for Radioactive Decay

release was classified as an inadvertent release in WSRC-RP-91-424-1. The total annual inadvertent atmospheric and liquid releases are shown in Table 2. The large atmospheric release in 1987 was described in WSRC-RP-91-424-1. In the period from 1988 through 1990, these releases have been small compared with some previous years.

However, a relatively large inadvertent liquid release occurred in 1991. The history, environmental monitoring results, and dose assessment following this release has been thoroughly documented (Hamby et al. 1992). Only a short summary of the results will be given here.

Between December 22 and 25, 1991, approximately 150 gallons of tritiated moderator water (10 Ci/L) leaked from a heat exchanger into Pen Branch. The tritium from Pen Branch emptied into the Savannah River reaching the Highway 301 Bridge on December 26 and the Beaufort-Jasper water treatment plant intake on the morning of December 28. The maximum concentration of tritium was detected about 30 hours after the initial detection in both locations. The maximum concentration at the Highway 301 Bridge was 66.9 pCi/mL. Integration of the water concentration and Savannah River flow over the release period, led to an estimate of 5700 curies of tritium released.

A maximum dose of 0.035 mrem was calculated for a hypothetical individual who drank 2

Table 2.. Inadvertent Tritium Releases from the Savannah River Site During the period 1987 through 1990 (Curies).

<u>Year</u>	<u>Atmospheric</u>		<u>Liquid</u>
	<u>HT</u>	<u>HTO</u>	
1987	187344	15306.0	701
1988		197.3	--
1989		853.2	
1990		3.7	

liters of river water each day for the duration of the period of elevated tritium concentration. This dose is 100 times smaller than the EPA drinking water standard of 4 mrem/yr. Average individual dose to users of the Beaufort-Jasper and Port Wentworth domestic water supplies was 0.0048 and 0.015 mrem, respectively.

SRS TRITIUM RELEASES AND CALCULATED DOSE

Atmospheric releases decreased in 1989-90 (Table 3.). Calculated doses to the public decreased proportionately during this period.

The total liquid tritium releases from SRS have declined during 1989-90 (Table 4.). Because the calculated dose is dependent on the flow of the

Table 3. SRS Atmospheric Tritium Releases and Offsite Annual Dose Equivalents.

<u>Year</u>	<u>Atmospheric Tritium Releases</u>		<u>Offsite Annual Dose Equivalents</u>		
	<u>Total</u>	<u>HTO</u>	<u>Max</u>	<u>Avg</u>	<u>80-km</u>
	<u>Original</u>	<u>Component</u>	<u>Ind</u>	<u>Ind</u>	<u>Pop</u>
	<u>Release</u>	<u>Ci</u>	<u>EDE</u>	<u>EDE</u>	<u>EDC</u>
	<u>Ci</u>	<u>Ci</u>	<u>mrem</u>	<u>mrem</u>	<u>per-rem</u>
1989	309,000	218,000	0.239	0.0865	13.4
1990	175,000	96,800	0.141	0.0648	8.45

the calculated dose is dependent on the flow of the Savannah River, as well as the releases to the River, this has not resulted in a proportionate decrease in dose calculated for downstream user of the Savannah River. However, the general trend will decrease as indicated in the sections showing the decrease in the release from the capped seepage basins from Four Mile Run.

through the two year period from 1989-90 (Table 4.). Calculated doses to the public have decreased proportionately during this period.

Atmospheric releases have also decreased

Table 4. SRS Liquid Tritium Releases to Streams and the Offsite Dose Equivalents.

		<u>Tritium Releases to Streams</u>			<u>Offsite Annual Dose Equivalents</u>			
		River	Direct	Seepage	Original	SRS	100-Mile	100-Mile
		Flow	Releases to	to	Total	Maximum	Maximum	Average
		Rate	Streams	Streams	Release	Downstrm	Downstrm	Downstrm
						Individual	Individual	Individual
								Popula-
								tion
								Dose
								(person-
								rem)
<u>Year</u>	<u>(cfs)</u>	<u>(Ci)</u>	<u>(Ci)</u>	<u>(Ci)</u>		<u>(mrem)</u>	<u>(mrem)</u>	<u>(mrem)</u>
1989	7832	3700	13700	17400	0.073	0.106	0.054	3.49
1990	12064	2600	13600	16200	0.043	0.064	0.033	1.83

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