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HEALTH PHYSICS REGIONAL MONITORING

Semi-Annual Report

July through December 1955

WORKS TECHNICAL DEPARTMENT
E. I. du Pont de Nemours and Company
Explosives Department - Atomic Energy Division
Savannah River Plant

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Contents

Abstract

Radioactivity in the various types of samples from the environs of the Savannah River Plant from July 1955 through December 1955 is compared with the radioactivity in similar samples collected during the previous six months. Bomb fallout was negligible in comparison to the previous six months, but indications of contamination from Plant operations were more numerous.

Introduction

Under a program established by the Du Pont Company in June 1951, the Savannah River Plant Site and the surrounding region are systematically monitored for radioactive contaminants. This is necessary because of the release of small quantities of radioactivity to the environment by Plant operations. The quantity of radioactivity discharged must be kept below the maximum permissible concentrations recommended by the National Bureau of Standards for materials consumed by humans. The regional survey program accumulates information which is useful both as a measure of the effectiveness of Plant controls and as an authoritative record of environmental conditions. This report, on the period from July through December 1955, is one of a series of semi-annual reports covering the regional survey program at the Savannah River Plant.

Summary

- WASTE RELEASED BY PLANT OPERATIONS. Liquid waste discharged to streams by the 100 Areas contained 55 curies of nonvolatile beta emitters, and 100-Area stack releases included 6587 curies of tritium. In the 200 Areas, the Building 292 stacks released 2.8 curies of alpha emitters, 30 curies of nonvolatile beta emitters, 68 curies of radioiodine and 256×10^9 radioactive particles;

  Liquid waste from the 300 Area contained 28 millicuries of alpha emitters (uranium) and 54 millicuries of nonvolatile beta emitters (uranium daughters).

- VEGETATION. Alpha contamination of vegetation was detected near the 200 Areas and on the 25 mile radius. Average values near 200-H Area were as high as 0.6 d/m/g with a maximum of 11.7 d/m/g. A large decrease of both nonvolatile beta and radioiodine in vegetation was observed as a result of the decay of bomb fallout deposited during the spring of 1955. Maximum concentrations were found near the 200 Areas where average radioiodine activity was 3×10^{-12} c/g (H Area) with a maximum of 26×10^{-12} c/g and the average concentration of nonvolatile beta was 39×10^{-12} c/g (F Area) with a maximum of 310×10^{-12} c/g.

- STREAMS. Four Mile Creek was the only stream in which there was a general increase of the concentrations of radioactivity. Maximum concentrations of both alpha and nonvolatile beta emitters continued to be in the 300-Area effluent to Tims Branch (location 2). The average concentration of alpha activity at that location was

1189 × 10^{-3} d/m/ml of water with a maximum of 3350 × 10^{-3} d/m/ml and an average concentration of 793 d/m/g of mud with a maximum of 4000 d/m/g. Average concentrations of nonvolatile beta at Tims Branch location 2 were 678 × 10^{-15} c/ml of water with a maximum of 2860 × 10^{-15} c/ml and 419 × 10^{-12} c/g of mud with a maximum of 1760 × 10^{-12} c/g. Concentrations of radioactivity in the Savannah River remained negligible.

- SEEPAGE BASINS. The use of new seepage basins for both 200-F and H Areas began and use of the 700-Area basin continued. Average concentrations of U or Pu, nonvolatile beta, and radioiodine in the water were as high as 19 d/m/ml (200-F No. 3), 49 × 10^{-11} c/ml (200-H No. 1), and 10 × 10^{-11} c/ml (200-H No. 1), respectively.

- ATMOSPHERE. General atmospheric radiation as measured with detachable ionization chambers decreased. The most notable exception was near the 200-H seepage basin where the dosage rate averaged 1.4 mrad/24 hours. The maximum particulate fallout was noted inside 200-H Area where the deposition of radioactive particles averaged 39/ft^2/6 months and the maximum activity per particle was 13,600 d/m. The largest numbers of radioactive particles (10.7 to 13.8/1000 m^3) suspended in the atmosphere were found off-Plant at Allendale and Aiken, S. C. Maximum concentrations of alpha, beta, and radioiodine during the 6-month period averaged 0.7 × 10^{-14} µc/cc (200-F Area), 66 × 10^{-14} µc/cc (Talatha Gatehouse), and 28 × 10^{-14} µc/cc (200-H Area), respectively.

- RAIN WATER. Due to the absence of large quantities of bomb fallout there were large decreases of both nonvolatile beta and radioiodine in rain water. The highest average concentration of nonvolatile beta was 152 × 10^{-15} c/ml of water collected in the 700 Area and the maximum individual sample from that area was 820 × 10^{-15} c/ml. The largest amounts of radioiodine in rain water occurred in 200-F Area where the activity averaged 27 × 10^{-15} c/ml with a maximum of 320 × 10^{-15} c/ml.

- GROUND WATER. The largest quantity of radioactivity in the ground water was detected in an open well near 200-H Area. There the average concentration of alpha was 9 × 10^{-3} d/m/ml with a maximum of 18 × 10^{-3} d/m/ml and the average concentration of nonvolatile beta was 55 × 10^{-15} c/ml with a maximum of 92 × 10^{-15} c/ml. Neither the water from this nor any other wells had radioactivity that could be identified as resulting from Plant operations.

- PLANT DRINKING WATER. There was no evidence of contamination from Plant operations. Average concentrations of alpha emitters did not exceed 13 × 10^{-3} d/m/ml, and average concentrations of nonvolatile beta emitters did not exceed 12 × 10^{-15} c/ml.

- PUBLIC WATER SUPPLIES. Average alpha activity did not exceed 8×10^{-3} d/m/ml, and average nonvolatile beta activity in the various public water supplies near the Plant did not exceed 10×10^{-15} c/ml.

- BIOLOGICAL SPECIMENS. The maximum beta activity in an edible biological specimen was 130×10^{-12} c/g in the spleen of a rabbit collected November 25 near the 700 Area, and the maximum alpha activity was 3.6 d/m/g in the kidney of a raccoon trapped November 24 five miles west of the 200 Areas. Nine of the twenty-seven thyroids removed from small animals caught on the Plant site contained detected concentrations of radioiodine ranging from 10 to 96×10^{-12} c/thyroid. Diatoms collected in the Savannah River and Tims Branch continued to show slight uranium contamination.

Data Reporting

Survey data were averaged for each month and for the 6-month period. These averages and the previous 6-month averages (as presented in J. M. Alexander and J. H. Horton, Semi-Annual Progress Report, DPSP 56-25-13, April 5, 1956) are reported for comparison. Monthly averages generally are not reported except when necessary to distinguish between environmental contamination by Plant operations and environmental contamination by bomb fallout.

In reporting data, "average" or "total" refers to that of the 6-month report period, and "previous average" or "previous total" to the average or total for the preceding 6-month period.

Survey Results

Radioactive Waste Released by Plant Operations

Operations of the Savannah River Plant release solid, liquid and gaseous radioactive waste to the environment. Liquid waste is discharged to streams or seepage basins depending upon the source and the expected concentration of the radioactivity. Gaseous waste is discharged through the various process stacks, and solid waste consists of radioactively contaminated materials disposed of in the 643-G Burial Ground. The total activity released to the environment during the 6-month period included 2.8 curies of alpha emitting isotopes, 85.1 curies of nonvolatile beta emitters, 67.9 curies of radioiodine (I-131), 26.1 kilocuries of tritium, and 400 curies of radioargon (A-41). A summary of the more important releases of radioactive waste is reported on the following pages.

100 Areas

The major sources of radioactive liquid waste from the 100 Areas were the thermal shield water and the disassembly basin water. Alpha activity in these wastes was negligible and under routine operation the nonvolatile beta emitters consist chiefly of short half-life induced radioactive isotopes. The nonvolatile beta activity discharged from these two sources each month in each area is listed below.

Nonvolatile Beta in Thermal Shield Water, curies

Month	100-R	100-P	100-L	100-K	100-C	Total
July	2.2	0.8	1.3	0.3	0.1	4.7
August	2.8	1.1	2.0	0.4	0.1	6.4
September	1.6	0.6	1.2	0.6	0.1	4.1
October	1.8	0.8	1.8	0.2	0.2	4.8
November	1.7	0.8	1.9	0.5	0.1	5.0
December	0.5	0.1	1.6	0.6	0.5	3.3
Total	10.6	4.2	9.8	2.6	1.1	28.3
Previous Total	14.7	7.7	14.5	5.0	1.0	42.9

Nonvolatile Beta in Disassembly Basin Water, curies

Month	100-R	100-P	100-L	100-K	100-C	Total
July	0.13	7.21	0.35	0.08	0.31	8.08
August	0.06	0.20	0.10	0.11	0.32	0.79
September	0.31	1.71	0.62	0.18	8.50	11.32
October	0.24	0.12	0.17	0.34	0.62	1.49
November	0.22	0.91	0.50	0.25	0.49	2.37
December	1.47	0.06	0.80	0.25	0.52	3.10
Total	2.43	10.21	2.54	1.21	10.76	27.15
Previous Total	4.00	4.87	0.98	1.89	0.07	11.81

During December 100-R released 541 curies of tritium in the thermal shield water. This release followed a balancing operation in the top shield and subsequent purging of both top and bottom shields.

Process exhaust stacks in the 100 Areas vent the process vessels, purification facilities, and process water system. Tritium is the only significant radioactive material routinely released to the atmosphere through these stacks. The tritium released from the 100-Area stacks is tabulated on the following page.

Tritium Released from 100-Area Stacks, curies

Month	100-R	100-P	100-L	100-K	100-C	Total
July	83	297	242	226	76	924
August	83	345	269	480	74	1251
September	62	331	266	128	113	900
October	27	352	303	150	55	887
November	29	488	400	83	109	1109
December	279	405	404	115	313	1516
Total	563	2218	1884	1182	740	6587

A nonroutine stack release of radioactive gases occurred between September 3 and 11, 1955, when an estimated 400 curies of A-41 were released from 100-R. This resulted from neutron bombardment of A-40 used as an inert gas for extensive welding operations.

200 Areas

Liquid waste routinely discharged directly to streams by the 200 Areas consists only of sanitary water, storm sewer water and "segregated" cooling water, ie, cooling water which has been used in pressurized vessels and is not recycled. The activity of these waste streams is normally negligible. Although increases in activity have been observed in the effluents to Upper Three Runs and Four Mile Creek, these are believed to result largely from spills of radioactive material within the area being gradually washed into storm sewers by rain.

Approximately 70,000 gallons of low-level waste ($<10^{-9}$ c/ml) were discharged daily by each Separations Area to seepage basins. This waste consisted of evaporator condensates, nonradioactive chemical spills and, in F Area, trade waste from the laboratory and the laundry.

The Purex process stacks, 291-F and 291-H, release radioactive waste from the dissolvers, process vent systems, and heating and ventilating systems of the 221 Buildings and associated facilities. Releases from these stacks were many times greater than during the previous six months. The activity released per month by these 200-foot stacks is summarized on the following page.

The release of plutonium from the Purex stacks was sharply increased by frequent failures in the B-Line exhaust filters. The failures observed in some of these filters, covering individual cabinets in the B-Line mechanical lines, are tabulated on the following page along with the resulting release of plutonium to the atmosphere.

Backup filters covering these exhaust systems were installed in both areas during December. This reduced the alpha release to an average of 0.4 mc/24 hr in 200-F Area and 0.07 mc/24 hr in 200-H Area (last ten days of month).

Radioactive Waste Released from 291 Stacks

Month	Alpha,* c (curies)		Nonvolatile Beta,** c		Radioiodine, c		Particles, 1 × 10^9	
	F	H	F	H	F	H	F	H
July	0.03	Negl	0.8	0.5	0.42	Negl	12	0.06
August	0.08	0.09	1.2	2.5	0.09	0.04	12	4.0
September	0.42	0.01	2.1	9.0	0.50	2.40	96	10.0
October	0.51	0.16	0.4	11.9	0.46	4.00	53	15.0
November	1.07	0.35	0.2	0.4	1.50	7.70	36	9.0
December	0.09	0.02	0.5	0.1	26.80	24.00	8	0.8
Total	2.20	0.63	5.2	24.4	29.77	38.14	217	39.4
Previous Total	0.14		4.4		1.35		6	

* Predominantly Pu-239
** Predominantly ruthenium

Exhaust Filter Failures

Date	Area	Pu-239 Released, mc
8/7 to 8/8	H	80
8/26	F	35
9/12 to 9/16	F	221
9/21 to 9/24	F	118
9/29 to 9/30	F	61
10/4 to 10/12	F	326
10/15 to 10/19	H	77
10/31 to 11/4	F	256
11/4	H	59
11/6 to 11/8	H	102
11/6	F	63
11/8 to 11/11	F	350
11/23	H	32
11/25 to 11/29	F	273
12/1 to 12/2	F	42

The release of nonvolatile beta activity from 200-H Area during August, September and October far exceeded expectations based on 200-F Area experience. Investigation showed leakage through the 294-H sand filter bypass tunnel. The plug at the entrance to this bypass was sealed on November 1, 1955, and the nonvolatile beta release dropped by a factor of 90. The release of nonvolatile beta activity from 200-F Area dropped sharply during October; this was attributed to process modifications.

Radiostrontium (Sr-89,90) contributed 1.1% of the nonvolatile beta activity, with a total of approximately 340 mc during the 6-month period. The long-lived Sr-90 isotope comprised 50 mc of this release, as shown in the table below.

	Sr-90, mc	
Month	200-F	200-H
July	2.9	2.4
August	4.8	4.9
September	13.0	6.7
October	2.3	10.1
November	0.8	1.1
December	1.2	0.3
Total	25.0	25.5

The release of radioiodine generally reflected the age of the material in process, but increased more sharply during November and December, with a drop in over-all iodine DF. Average iodine DF's observed during the 6-month period were 160 in 200-F Area and 220 in 200-H Area. The primary source of iodine emission was the process vessel vent systems, with very little activity escaping through the dissolver off-gas system.

Data on particulate release are based on radioautographs of stack air samples collected on filter paper. Varying exposure times were used to prevent the beta radiation from "blacking out" the film and obscuring the discrete particles present; this caused some variation in particulate data.

During September, the radioautographing techniques were improved and revised to detect some of the low energy beta and high energy alpha emitting particles previously missed. This revision raised previous estimates of number of particles by a factor of six. This factor has been applied to all particulate data included in this report. The unusually high particulate release from 200-F in September, October and November was attributed to the large emission of finely divided plutonium.

Tritium is released to the atmosphere through a 200-foot stack handling Building 232-F off-gases. This facility was started up late in October and records of the stack release were maintained from November 5, 1955.

300 Area

Radioactive liquid waste from the 300 Area consists mainly of uranium. The effluent was proportionally sampled with a Trebler sampler. The amount of uranium discharged per month is listed below.

Month	Uranium, lb	Alpha, mc	Beta, mc
July	*	*	*
August	*	*	*
September	11	3	3
October	32	9	19
November	33	10	24
December	22	6	8
Total (4 months)	98	28	54
Previous Total (6 months)	138	41	-

* Incomplete data

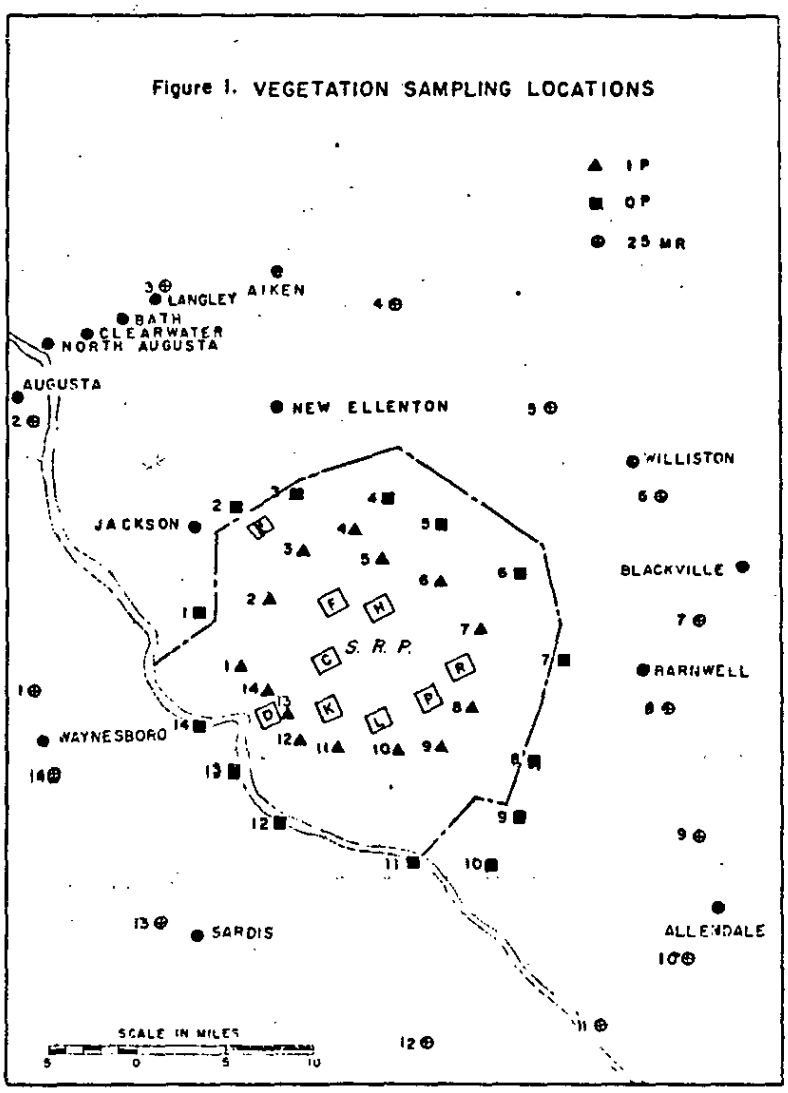
Radioactivity in Vegetation

There were 781 routinely-collected vegetation samples analyzed to determine alpha and nonvolatile beta activity, and 618 were analyzed for radioiodine. Samples were collected from locations arranged in three concentric circles: the inner perimeter (IP) within the project; the outer perimeter (OP) at the circumference of the project; and the twenty-five mile radius (25 MR) approximately twenty-five miles from the center of the project. Samples were also collected from two circles, each one-mile radius, surrounding 200-F and 200-H Areas, respectively. The sampling locations, except the 200-F and 200-H circles, are shown in figure 1.

The 6-month average concentrations of gross alpha, nonvolatile beta, and radioiodine in the various groups of vegetation samples are listed below.

	Gross Alpha, d/m/g			Nonvolatile Beta, 1×10^{-12} c/g			Radioiodine, 1×10^{-12} c/g		
Location	Max	Avg	Previous Avg	Max	Avg	Previous Avg	Max	Avg	Previous Avg
200-F	10.7	0.5	-	310	39	-	6	2	-
200-H	11.7	0.6	-	80	26	-	26	3	-
IP	1.4	0.3	0.3	130	30	685	5	1	18
OP	1.9	0.3	0.3	170	34	118	7	1	5
25 MR	2.7	0.4	0.2	210	34	171	6	1	6

Figure 1. VEGETATION SAMPLING LOCATIONS



Compared to background levels of radioactivity and changes from month to month, there appears to have been an increase of alpha activity in the vegetation near the 200 Areas. Most of the increased alpha activity in vegetation near the 200 Areas was detected during October and December, while in the 25 MR vegetation, it was detected during August and December.

There is no definite explanation for more alpha contamination on 25 MR vegetation than on the IP and OP vegetation, but additional proof of such contamination was observed twice when comparatively high concentrations of plutonium in 25 MR vegetation was determined by ether extraction and pulse height analysis. On August 3, five routine 25 MR vegetation samples describing an arc from location 5 to location 9 had an average U or Pu activity of 2.6 d/m/g. The maximum activity was 4.7 d/m/g, occurring in a sample taken at location 7. Pulse height analysis of these samples showed that most of the activity was due to plutonium. After several large stack releases of plutonium in November, routine

25 MR vegetation samples collected on November 30 showed a high concentration of U or Pu from location 8 to location 12. The average activity of these five samples was 3.1 d/m/g, with a maximum of 8.4 d/m/g in a sample collected at location 11. Pulse height analyses of these samples showed most of the activity to be due to plutonium. On December 9, forty-six special vegetation samples collected from the same general location showed no significant U or Pu activity. The absence of the plutonium on the follow-up samples may have resulted from wash-off by rain.

Another area of high plutonium contamination of vegetation was detected on November 9, as part of an investigation to determine the extent of deposition of particles (consisting of beta-gamma emitting isotopes) from the 292-H stack. Ether extraction of sixty-one vegetation samples collected in and near the 200-H Area revealed several unusually high concentrations of plutonium. The four highest concentrations were 8, 10, 11, and 12 d/m/g. There was no relation between the deposition of plutonium and nonvolatile beta. Furthermore, specific analyses of particles collected on flypaper showed negligible alpha activity. Hence, the plutonium probably did not result from the same incident which released the radioactive particles (see Radioactivity in the Atmosphere, Particulate Fallout, page 23).

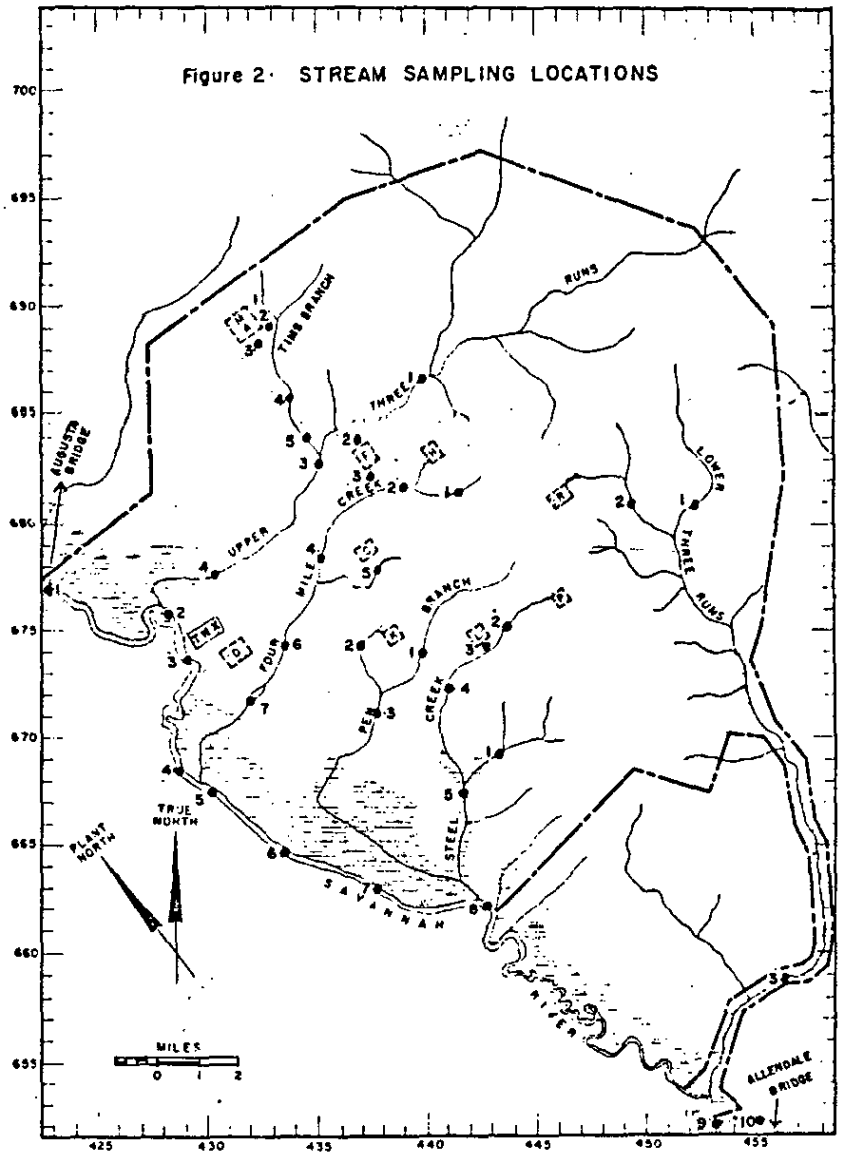
The decrease of both nonvolatile beta and radioiodine in vegetation was due to decay of bomb fallout from the 1955 Nevada tests. This decay continued to decrease the nonvolatile beta in vegetation until December 1955, when there was a slight increase as a result of small but detectable amounts of fallout from the 1955 Russian tests. Since the average concentrations of nonvolatile beta were similar to background levels, it must be concluded that little or no nonvolatile beta contamination of vegetation by Plant operations occurred. The slight radioiodine contamination of the vegetation near the 200 Areas, was largely a result of stack releases in these areas during November and December.

Radioactivity in Streams

Five streams on the Savannah River Plant site carry waste into the Savannah River; namely, Upper Three Runs, Four Mile Creek, Pen Branch, Steel Creek and Lower Three Runs. Tims Branch also carries Plant waste and flows into Upper Three Runs which in turn flows into the river. One other source of river contamination is the effluent from TNX which flows directly into the river. Water and mud samples were collected weekly from all locations shown in figure 2 except locations 2 through 9 on the Savannah River which were collected every two weeks. A total of 856 samples each of water and mud were analyzed for gross alpha and nonvolatile beta activity. Of these, 643 samples each of water and mud were analyzed for U or Pu.

Water samples collected from the control locations, those collected from the river, and those collected specifically for decay studies were obtained by dipping the water directly from the stream. Other stream water samples were obtained from continuous-drip water samplers in operation at the respective sample locations. These samplers collect a representative sample of the water flowing in the stream during the entire week.

Figure 2. STREAM SAMPLING LOCATIONS



Tims Branch

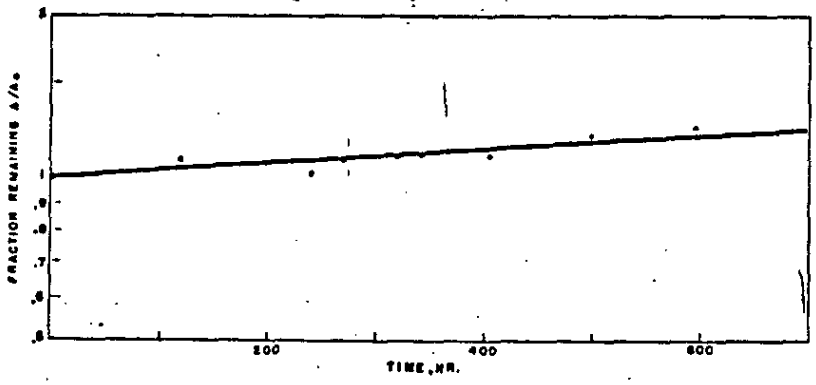
Tims Branch receives uranium waste from the 300 and 700 Areas. The 300-Area effluent flows directly into Steeds Pond which tends to normalize and decrease the concentration of radioactivity in the water which flows from it. The 700-Area effluent flows into a large swampy area which overflows into Tims Branch only during periods of heavy rainfall. No such overflow was observed during this 6-month period.

Water and mud samples were taken at four locations as shown in figure 2. The effluent from the 700 Area enters Tims Branch at location 1 and the effluent from the 300 Area enters at location 2. Repeated countings during a 700-hour period showed a buildup of radioactivity in a sample collected at location 2 on July 5, (figure 3), indicating that the uranium was not in equilibrium with its daughters.

Figure 3. BUILDUP OF NONVOLATILE BETA IN TIMS BRANCH WATER

Location No. 3 July 5, 1955

$A_0 = 670 \times 10^{-15}$ c/ml



A summary of the 6-month average concentrations of radioactivity at each location in Tims Branch is given below.

Radioactivity in Water

Location	Nonvolatile Beta, 1×10^{-15} c/ml			U or Pu, 1×10^{-3} d/m/ml		
	Max	Avg	Previous Avg	Max	Avg	Previous Avg
1	240	83	6660	420	128	14,856
2	2860	678	259	3350	1189	1,169
3	250	140	68	1000	421	167
4	165	40	26	390	74	42

Radioactivity in Mud

Location	Nonvolatile Beta, 1×10^{-12} c/g			U or Pu, d/m/g		
	Max	Avg	Previous Avg	Max	Avg	Previous Avg
1	920	258	168	970	312	31
2	1760	419	89	4000	793	176
3	34	15	13	61	23	33
4	52	11	12	56	16	19

Most of the decrease of radioactivity in the 700-Area effluent resulted from the absence of unusually high releases such as one observed during the previous six months.

At all locations influenced by the 300-Area effluent, the increased concentration of nonvolatile beta in the water resulted from increased releases of nonvolatile beta during October and November.

Upper Three Runs

Upper Three Runs receives radioactive waste from Tims Branch and ground contamination from the 200-F Area. Samples were collected at four locations as shown in figure 2. Location 2 is a storm sewer outlet which sometimes contains waste from spills in the 200-F Area.

The only changes in the radioactivity of the water and mud was a slight decrease of nonvolatile beta as a result of decreased bomb fallout. A summary of the radioactivity in both water and mud at each sampling location is listed below.

Radioactivity in Water

	Nonvolatile Beta, 1×10^{-15} c/ml			U or Pu, 1×10^{-3} d/m/ml		
Location	Max	Avg	Previous Avg	Max	Avg	Previous Avg
1	18	9	14	6	3	3
2	100	13	-	88	12	-
3	64	13	17	22	4	5
4	22	9	16	7	3	3

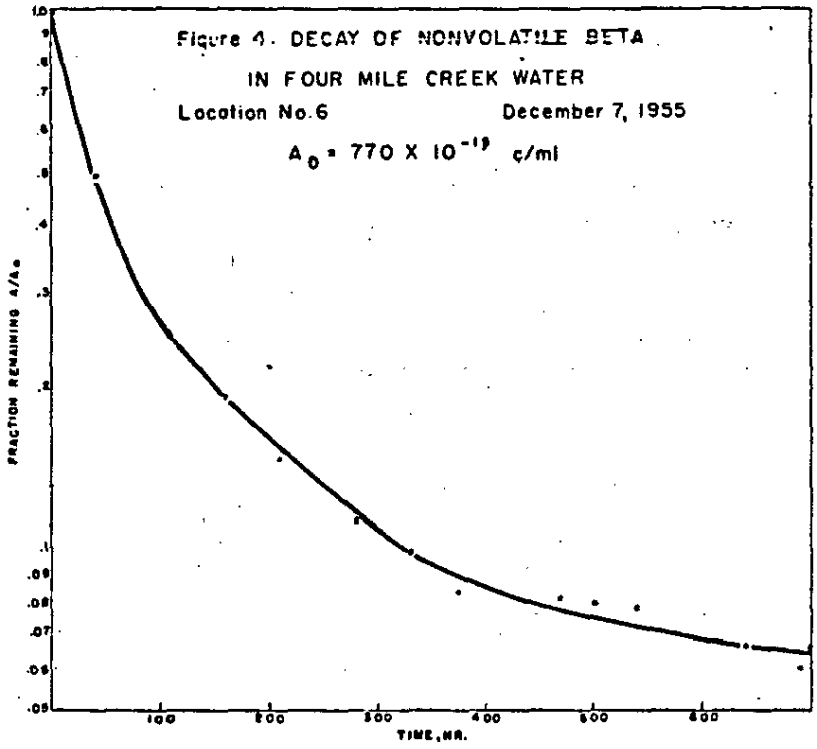
Radioactivity in Mud

	Nonvolatile Beta, 1×10^{-12} c/g			U or Pu, d/m/g		
Location	Max	Avg	Previous Avg	Max	Avg	Previous Avg
1	14	9	10	19	4	7
2	17	12	-	50	11	-
3	15	9	11	20	5	-
4	21	9	11	12	8	12

Four Mile Creek

Samples were collected at seven locations as shown in figure 2. The 200-H effluent enters Four Mile Creek at location 2, the 200-F effluent enters at location 3, and the 100-C effluent enters at location 5. The waste from Buildings 221-F and 221-H consists of uranium, plutonium and fission products, and the waste from Building 232-F consists of tritium and induced radioactive isotopes. (Tritium has not been detected in Four Mile Creek water.)

The 100-C Area continuously discharges thermal shield and disassembly basin water containing mainly short half-life beta emitters. The decay of nonvolatile beta in a water sample collected from location 6 is shown in figure 4. The activity had decayed 50% after 39 hours, and 94% had decayed after 700 hours.



A summary of the 6-month average concentrations of radioactivity in samples collected at each Four Mile location is given on the following page.

Increased radioactivity in the 200-H effluent occurred during July and August. An investigation at the time revealed a leak in the diversion box between the area and the seepage basin. Increased discharge of radioactivity in the 200-F effluent occurred in November and was continuing at the end of December at which time all efforts to locate the source had failed. Pulse height analyses of the radioactivity during December showed the major alpha emitter to be U-238. Increased discharge of nonvolatile beta from the 100-C Area began during August and continued through December.

Radioactivity in Water

Location	Nonvolatile Beta, 1×10^{-15} c/ml			U or Pu, 1×10^{-3} d/m/ml		
	Max	Avg	Previous Avg	Max	Avg	Previous Avg
1	23	9	16	4	1	2
2	460	73	12	490	25	3
3	450	59	33	1400	196	5
4	64	25	16	180	18	2
5	180	49	18	5	2	3*
6	92	23	14	49	5	2
7	61	22	13	6	1	3

Radioactivity in Mud

Location	Nonvolatile Beta, 1×10^{-12} c/g			U or Pu, d/m/g		
	Max	Avg	Previous Avg	Max	Avg	Previous Avg
1	14	8	9	34	4	5
2	59	13	7	28	7	3
3	39	12	8	110	16	3
4	11	8	7	53	6	3
5	58	23	12	27	6	1*
6	14	8	9	22	4	3
7	19	11	9	13	4	4

* gross alpha

Pen Branch

Pen Branch receives radioactive waste from the 100-K Area, which continuously discharges disassembly basin and thermal shield water. Mud and water samples were collected routinely at three locations as shown in figure 2. Effluent from 100-K enters Pen Branch at location 2. The radioactivity was largely confined to short half-life beta emitters, as shown by a decay study of a sample collected at location 2 on November 14, in which 50% of the nonvolatile beta had decayed after 24 hours, and 75% had decayed after 700 hours.

A summary of the 6-month average concentrations of radioactivity in samples collected at each of the Pen Branch locations is given below.

Radioactivity in Water

Location	Nonvolatile Beta, 1×10^{-15} c/ml			Gross Alpha, 1×10^{-3} d/m/ml		
	Max	Avg	Previous Avg	Max	Avg	Previous Avg
1	12	8	17	6	1	2
2	35	15	21	3	1	2
3	45	14	17	2	1	2

Radioactivity in Mud

Location	Nonvolatile Beta, 1 × 10^{-12} c/g			Gross Alpha, d/m/g		
	Max	Avg	Previous Avg	Max	Avg	Previous Avg
1	35	12	9	2.2	0.8	0.5
2	66	19	13	4.1	1.4	0.8
3	42	11	11	1.6	0.7	0.7

The slight decrease in nonvolatile beta activity in water at all locations was due to absence of fallout during this 6-month period. The slightly higher 6-month average of nonvolatile beta in mud at location 2 can be attributed to Plant operations.

Steel Creek

Samples of mud and water were collected routinely at five locations, shown in figure 2. The effluent from 100-P enters above location 2 and the effluent from 100-L enters at location 3. The 100-P and 100-L Areas continuously discharge disassembly basin and thermal shield water in which the radioactive components consist mainly of short half-life beta emitters. The decay of nonvolatile beta in a water sample collected from location 2 on December 7 showed that 50% of the activity had decayed after 25 hours, and 85% had decayed after 600 hours. The 6-month average concentration of radioactivity in samples collected at each of the Steel Creek locations is given below.

Radioactivity in Water

Location	Nonvolatile Beta, 1 × 10^{-15} c/ml			Gross Alpha, 1 × 10^{-3} d/m/ml		
	Max	Avg	Previous Avg	Max	Avg	Previous Avg
1	15	8	11	3	1	1
2	920	68	43	2	1	1
3	200	43	32	2	1	2
4	150	29	29	2	1	2
5	47	16	20	5	1	1

Radioactivity in Mud

Location	Nonvolatile Beta, 1 × 10^{-12} c/g			Gross Alpha, d/m/g		
	Max	Avg	Previous Avg	Max	Avg	Previous Avg
1	13	8	8	2.0	0.6	0.4
2	79	32	17	6.0	2.4	1.0
3	130	25	31	3.1	1.1	1.6
4	74	30	10	3.8	1.4	0.6
5	30	12	11	2.3	1.1	0.8

The increased 6-month averages for nonvolatile beta in water at location 2 and 3 reflected the increased discharges from 100-P in July and September and from 100-L during September and November.

Lower Three Runs

Samples of mud and water were collected at three locations as shown in figure 2. The effluent from 100-R Area, which continuously discharges disassembly basin and thermal shield water, enters at location 2. The radioactivity was largely confined to short half-life beta emitters. A decay study of nonvolatile beta in a water sample collected from location 2 on November 28 showed that 50% of the activity had decayed after 30 hours, and 70% had decayed after 700 hours.

A summary of the 6-month average concentrations of radioactivity in samples collected at each of the Lower Three Runs locations is given below.

Radioactivity in Water

	Nonvolatile Beta, 1×10^{-15} c/ml			Gross Alpha, 1×10^{-3} d/m/ml		
Location	Max	Avg	Previous Avg	Max	Avg	Previous Avg
1	37	10	15	11	2	2
2	290	37	30	5	1	2
3	245	26	12	10	2	2

Radioactivity in Mud

	Nonvolatile Beta, 1×10^{-12} c/g			Gross Alpha, d/m/g		
Location	Max	Avg	Previous Avg	Max	Avg	Previous Avg
1	85	12	9	3.0	0.7	0.6
2	68	17	14	2.1	1.1	1.4
3	18	8	9	1.8	0.6	0.6

The increased concentrations of nonvolatile beta in both water and mud at both locations influenced by the 100-R effluent resulted from an increased concentration of radioactivity in thermal shield water during August and an increase in concentration of radioactivity in disassembly basin water during December.

TNX Effluent

TNX discharges radioactive waste directly into the Savannah River, and samples were collected in the ditch between TNX and the river. The concentration of U or Pu in the mud was about one and one-half times as much as during the previous six months. Otherwise, the radioactivity in the TNX effluent decreased. These results are summarized below.

	Max	Avg	Previous Avg
Radioactivity in Water			
Nonvolatile Beta, 1×10^{-15} c/ml	29	11	14
U or Pu, 1×10^{-3} d/m/ml	65	10	15
Radioactivity in Mud			
Nonvolatile Beta, 1×10^{-12} c/g	28	11	15
U or Pu, d/m/g	76	18	12

Savannah River

The Savannah River receives Plant waste from each of the streams previously described. Samples were collected at the ten locations shown in figure 2. A summary of the concentrations of radioactivity in these samples is given below.

Radioactivity in Water

	Nonvolatile Beta, 1×10^{-15} c/ml			U or Pu, 1×10^{-3} d/m/ml		
Location	Max	Avg	Previous Avg	Max	Avg	Previous Avg
1	15	8	12	3	1	2
2	49	12	20	5	2	2
3	14	8	14	7	2	-
4	9	8	11	7	2	-
5	23	11	9	4*	1*	1
6	16	9	11	5	1	-
7	22	9	11	3	1	-
8	32	12	12	9	2	2
9	38	11	13	13	3	2
10	37	10	16	5	2	2

* gross alpha

Radioactivity in Mud

Location	Nonvolatile Beta, 1×10^{-12} c/g			U or Pu, d/m/g		
	Max	Avg	Previous Avg	Max	Avg	Previous Avg
1	52	27	27	9	4	4
2	29	18	15	6	3	3
3	28	17	17	5	3	-
4	30	22	20	6	3	-
5	36	25	25	6	3	5
6	26	9	16	7	2	-
7	34	18	16	5	2	-
8	31	22	24	14	3	3
9	250	39	19	4	2	3
10	28	12	22	8	2	5

Radioactivity in the Savannah River remained negligible. The slight decrease of nonvolatile beta in water was due to the absence of bomb fallout. At locations 2, 5, 8, 9, and 10, small concentrations of nonvolatile beta in the water probably resulting from Plant operations were detected.

Radioactivity in Seepage Basins

700-Area Seepage Basin

The 700-Area seepage basin receives waste containing as much as 1×10^{-10} c/ml from the low-level drain system of the 700-Area laboratories. During this report period, the average seepage and evaporation rate for this basin was 3000 gallons per day. Water samples, collected weekly from the basin, were analyzed for nonvolatile beta and U or Pu. The average concentrations for 26 samples collected are listed below. The increased nonvolatile beta activity occurred during November, while the increased U or Pu activity resulted from more numerous small increases.

Radioactivity in Water	Max	Avg	Previous Avg
Nonvolatile Beta, 1×10^{-12} c/ml	16	4	3
U or Pu, d/m/ml	13	3	1

200-Area Seepage Basins

Each of the 200 Areas discharges liquid waste into seepage basins at the rate of approximately 70,000 gallons per day. Each 200 Area has its own system of seepage basins with three basins in each system. The basins are arranged so that the liquid waste fills No. 1 basin first, overflows into No. 2 basin and finally into No. 3 basin.

200-F Area Seepage Basin. The 200-F Area waste overflowed into basin No.3 on July 26, and from this date through December 28, the average seepage and evaporation rate for the system was 54,000 gallons per day. From July 1 to July 26, the average seepage and evaporation rate from the first 2 basins was 28,000 gallons per day.

Samples were collected weekly from all three basins, and 84 samples were analyzed for nonvolatile beta and U or Pu. Thirteen samples from basin No. 1 were also analyzed for radioactive isotopes of Zr-Nb, Sr-Y, Ru, the Rare Earths; and, beginning in October, 13 samples were analyzed for radioiodine. The results of these analyses are summarized below.

200-F Seepage Basin No. 1, Radioactivity in Water

Month	Nonvolatile Beta, 1×10^{-11} c/ml		U or Pu, d/m/ml	
	Max	Avg	Max	Avg
July	134	65	54	22
August	124	56	29	16
September	9	5	7	6
October	4	3	43	15
November	6	5	33	17
December	4	3	5	3
Avg		26		14

200-F Seepage Basin No. 2, Radioactivity in Water

Month	Nonvolatile Beta, 1×10^{-11} c/ml		U or Pu, d/m/ml	
	Max	Avg	Max	Avg
July	96	59	19	9
August	40	37	18	11
September	15	15	15	10
October	6	6	9	6
November	8	5	24	17
December	4	4	14	9
Avg		24		10

200-F Seepage Basin No. 3, Radioactivity in Water

Month	Nonvolatile Beta, 1×10^{-11} c/ml		U or Pu, d/m/ml	
	Max	Avg	Max	Avg
July	44	44*	5	5*
August	39	35	263	45
September	19	14	15	11
October	6	6	10	7
November	6	5	26	19
December	4	3	22	12
Avg		16		19

* Only one sample collected.

A large reduction of the concentration of nonvolatile beta in the water occurred in all three basins during September, and smaller decreases continued to occur in basins No. 2 and No. 3 each month thereafter. Changes in the U or Pu concentrations were more variable with no general trends. Nonvolatile beta appears to decrease slightly as the water progresses through the series of basins, while U or Pu appears to be concentrating in the No. 3 basin.

The monthly average percentages of the various isotopes in the water in seepage basin No. 1 are listed below.

Month	No. of Samples	Nonvolatile Beta, %				Nonvolatile Beta Accounted For, %
		Rare Earths	Sr-Y	Zr-Nb	Ru	
August	1	8	2	71	22	103
September	4	15	3	55	28	101
October	4	23	4	46	17	90
November	3	32	5	32	14	83
December	1	33	10	44	9	96
Avg		22	4	47	19	93

The radioiodine content of the water in 200-F basin No. 1 fluctuated greatly during October, November and December, but generally exceeded the concentrations of nonvolatile beta during the same period. A summary of the monthly average concentrations of radioiodine is listed below.

Month	Radioiodine, 1×10^{-11} c/ml	
	Max	Avg
October	22	11
November	2	1
December	10	6
Avg		6

200-H Area Seepage Basin. The 200-H Area began use of the seepage basin on July 10, and as of December 28, the waste had not overflowed into the No. 2 basin. The average seepage and evaporation rate from July 10 through December 28 was 61,000 gallons per day.

Water samples were collected weekly from the 200-H seepage basin; a total of 21 samples were analyzed for nonvolatile beta and U or Pu. Starting October 18, these samples were also analyzed for radioiodine (total of 12 samples). The results of these analyses are summarized on the following page.

200-H Seepage Basin No. 1, Radioactivity in Water

Month	Nonvolatile Beta, 1 × 10^{-11} c/ml		U or Pu, d/m/ml	
	Max	Avg	Max	Avg
July	3	1	3	2
August	86	47	9	5
September	62	41	8	4
October	47	35	9	5
November	139	80	68	31
December	139	82	13	10
Avg		49		10

Large increases of the concentration of nonvolatile beta and U or Pu in the water in 200-H basin No. 1 occurred during August and November. The radioiodine concentration also increased during both November and December. A summary of the monthly concentrations of radioiodine is listed below.

Radioiodine, 1 × 10^{-11} c/ml

Month	Max	Avg
October	4	2
November	23	10
December	29	14
Avg		10

Particles Around the 200-Area Seepage Basins. To determine the amount of radioactivity being blown away from the seepage basins, 8" × 10" gummed papers (flypapers) were placed around the three seepage basins at the 200-F Area and the one seepage basin in use at the 200-H Area. These papers were changed weekly, and the number of particles collected each week was determined by radioautograph. Four hundred and sixteen flypapers were radioautographed during the 6-month period. The larger particles were then counted with an end window GM counter to determine the radioactivity of the individual particles. The results of these analyses are reported in the table below.

Location	Number of papers collected per week	Max particles per ft^2 per week	Avg number of particles deposited per ft^2 per 6-months	Avg beta activity per particle counted, d/m
F SB No. 1	3	300	184	147
F SB No. 2	1	2	4	33
F SB No. 3	8	2	2	28
H SB No. 1	4	202	98	65

Radioactivity in the Atmosphere

Radioactivity in the atmosphere was determined by ionization chambers, counting the radioactivity collected on air filters, and by determining (radioautograph) the number of particles collected on air filters and flypaper.

Radiation Dosage

Four detachable ionization chambers are located in each of the Plant areas. In addition to these, two circles, each one mile in radius and each having 12 ionization chambers on its perimeter, surround the 200-F and 200-H Areas. The chambers were read and recharged every week, so that 1612 readings were recorded during the 6-month period. The results of these readings are summarized below.

Radiation Dosage, mrad/24 hours

Location	Avg	Previous Avg
200-H No. 18*	1.40	-
100-P	1.02	0.98
100-L	1.01	-
100-K	0.96	-
300/700	0.92	0.95
200-H (inside)	0.89	0.92
200-F (outside)	0.88	0.94
400-D	0.88	0.93
TC	0.88	0.95
200-H (outside)	0.85	-
100-R	0.79	1.00
200-F (inside)	0.78	0.93
100-C	0.70	1.00

* Located on the H-Area circle about 100' from the seepage basin; it has been reported separately.

Atmospheric radiation decreased in some areas due to the decay of fallout from the 1955 Nevada tests, but the absence of such a decrease in other areas definitely indicates atmospheric radiation resulting from Plant operations. The monthly average radiation dose for all locations showed that general decreases occurred during October and November. These results are shown on the following page.

Month	Avg	Maximum Monthly Avg	Location
July	0.97	1.44	100-L
August	0.96	1.47	100-F
September	0.98	1.43	100-L
October	0.93	1.92	200-H No. 18
November	0.85	2.03	200-H No. 18
December	0.88	1.90	200-H No. 18

Particulate Fallout

Particulate fallout was collected on 8" x 10" flypapers at fourteen locations on the inner perimeter shown in figure 1, at eight locations forming two concentric circles around the 200-F Area, and at eight locations forming two concentric circles around the 200-H Area. In addition to these, five flypapers were placed in a vertical position around the 643-G Burial Ground to determine the number of radioactive particles blown away from the burial ground. The flypapers were changed weekly, and the number of radioactive particles collected was determined by radioautograph. During the 6-month period, 650 flypapers were collected. Results of the radioautographs are summarized in the table below.

Location	Max number of particles per ft^2 per week	Avg number of particles per ft^2 per 6 months	Avg number of particles per ft^2 per previous 6 months
IP	5	6	4863
Inside 200-F	5	12	1575
Outside 200-F	5	8	1937
Inside 200-H	73	39	-
Outside 200-H	7	8	-
Burial Ground	4	4	469

Because of the absence of heavy bomb fallout during this 6-month period, there was a very large decrease in the number of particles collected compared to the number collected during the previous six months. However, the larger number of particles collected near the 200 Areas indicate some contamination due to Plant operations. The monthly averages, given on the following page, show the times during which the contamination occurred.

The largest deposition of radioactive particles occurred during November and December and were partially due to Russian fallout. Prior to the fallout period, the larger number of particles collected in the 200-F and H inner circles can only be accounted for by Plant operations.

Month	Particles per ft² per month					
	IP	200-F		200-H		Burial Ground
		Inside	Outside	Inside	Outside	
July	0.2	0.5	0	0	0.5	0.4
August	0	0.5	0.5	3.2	0	0
September	0	1.4	0	1.8	0	0.7
October	0.3	0	0.5	2.7	0.5	0.7
November	1.5	2.3	1.4	22.1	2.3	0.7
December	5.1	8.1	6.3	8.6	4.5	1.4

To determine the magnitude of radioactivity of the particles collected, the larger particles were counted with an end-window GM tube. Previous to November, only one of 23 particles counted contained greater than 50 d/m/particle; the one exception contained 145 d/m/particle and was collected in the 200-H Area during August. During November and December the activity per particle greatly increased. The results for these two months are summarized below.

Location	Gross Beta Activity, d/m/particle					
	November			December		
	No. Counted	Max	Avg	No. Counted	Max	Avg
IP	4	570	155	17	112	59
200-F (inside)	5	1,570	345	15	135	42
200-F (outside)	3	285	121	10	745	160
200-H (inside)	49	13,600	1130	18	110	32
200-H (outside)	5	1,250	464	10	410	71

In general, the gross beta activity of the particles collected during November and December near the 200 Areas was greater than the activity of those collected at the IP locations.

Some of the particles collected in November and December were recounted after a period of about one week to determine the average half-lives of the radioactive constituents. Of the 14 particles recounted in November, the radioactive materials in six had half-lives of more than 90 days, while the materials in the remaining eight had half-lives of less than 60 days. In December, eight particles were recounted, and the radioactive materials in all eight samples had half-lives of less than 60 days. The source of the shorter half-lived radioactive materials was probably bomb fallout, whereas the materials with half-lives of more than 90 days probably originated from Plant operations. An account of the most notable occurrance of fallout due to Plant operations is given in the following paragraphs.

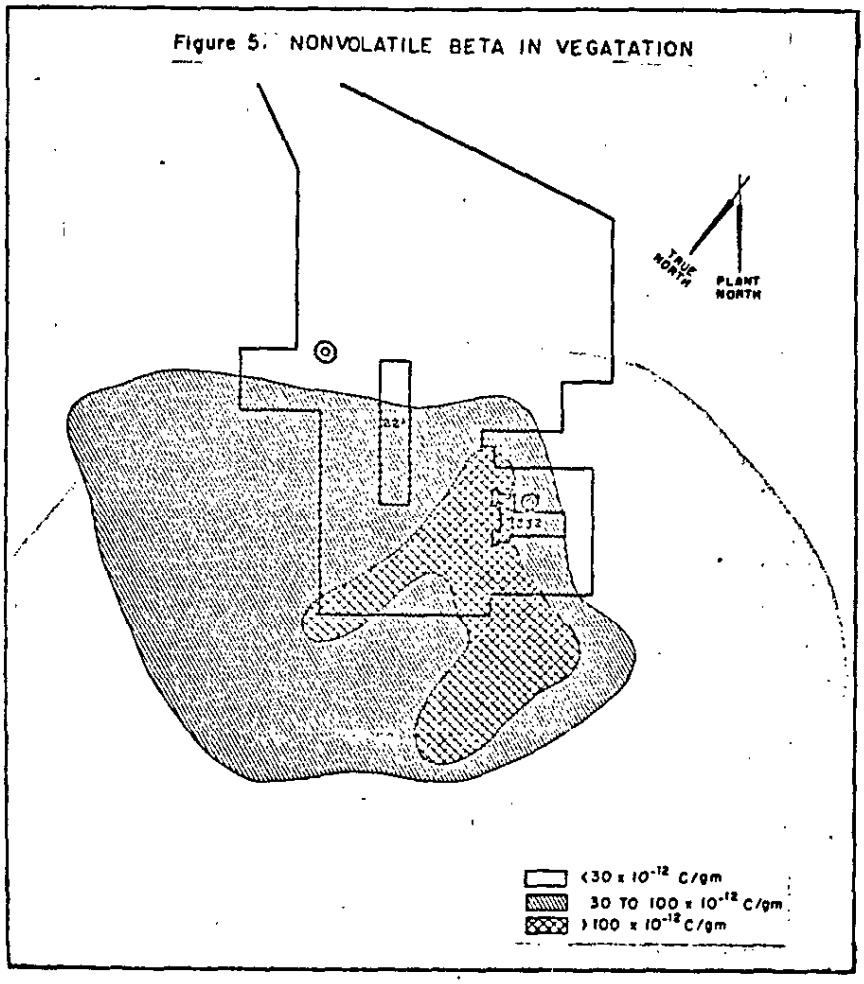
One flypaper collected on November 2 from the northwest corner of the 200-H Area had accumulated 73 particles/ft². The average activity of these particles was 1300 d/m and the maximum was 14,000 d/m.

The total particulate radioactivity deposited was 4.3×10^{-8} c/ft^2. Specific analysis of the particles showed the composition to be 68% Ru, 20% Zr and 6% Rare Earths; alpha activity was negligible.

On November 9, an intensive investigation was initiated to determine the extent of the deposition of these radioactive particles. A survey with Thyacs showed the highest concentration of the particles to be confined to an area of approximately 640,000 ft^2 located on the northwest boundary of the 200-H Area. The region coincides with the area of maximum nonvolatile beta on vegetation as shown in figure 5. Thyac readings of 16 particles located in this area averaged 5600 c/m with a maximum of 25,000 c/m. A subsequent survey of the Building 221-H roof located particles counting as high as 6000 c/m.

Analysis of 61 vegetation samples collected in the vicinity of the 200-H Area more clearly defined the extent of the radioactivity as shown by figure 5. Deposition of the radioactive particles appears to have been largely confined to an area approximately 0.4 square mile located in the northwest section of the 200-H Area. Eighteen vegetation samples collected in this area of maximum deposition contained an average nonvolatile beta concentration of 3.4×10^{-10} c/g, with a maximum of 2.7×10^{-9} c/g.

Figure 5. NONVOLATILE BETA IN VEGATATION



The origin of these radioactive particles could not be positively ascertained, but undoubtedly they were released by the Building 292-H stack. The most probable time of the release was during the repairs to the sand filter bypass on November 1.

Suspended Particles.

Radioactive particles suspended in the atmosphere were collected on 8" x 10" CWS 6 air filters at the ten constant air monitoring stations shown in figure 6.

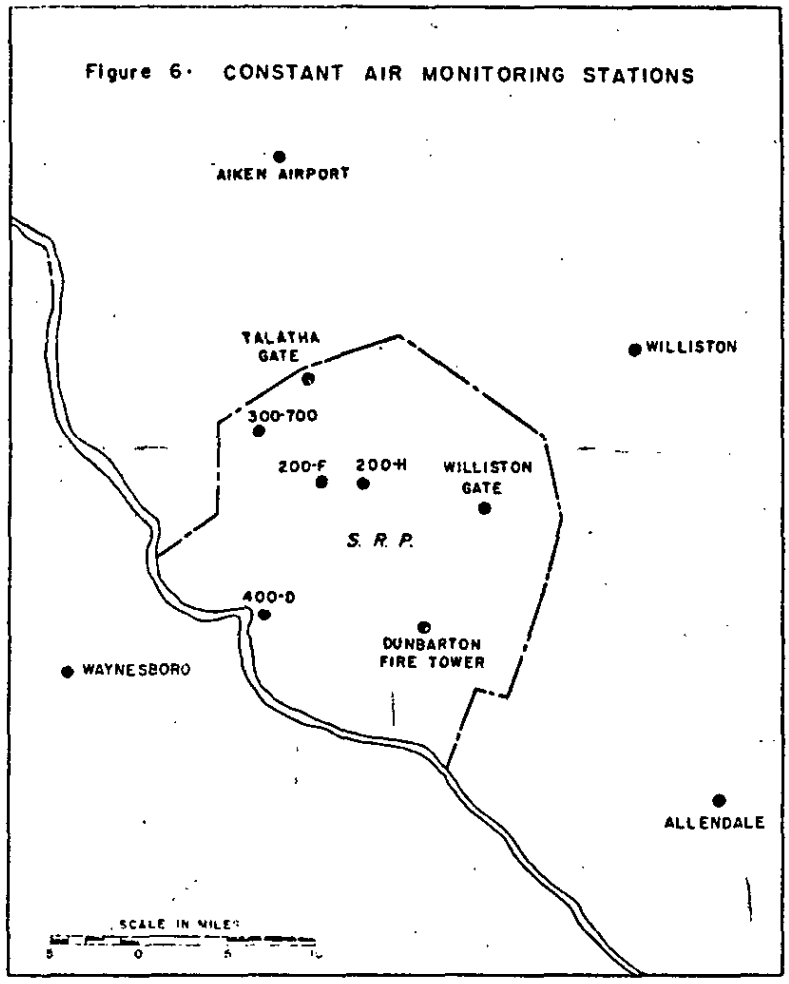


Figure 6. CONSTANT AIR MONITORING STATIONS

The rate of air flow through the filters was 2 cubic feet per minute. The filters were changed weekly and the number of radioactive particles collected was determined by radioautograph. Results from 260 air filters collected during the 6-month period are summarized on the following page.

Location	Particles per 1000cubic meters: Max per week	Avg	Previous Avg
Allendale	184	13.8	219
Aiken Airport	102	10.7	133
Waynesboro	137	8.5	132
200-H	153	8.0	240
400-D	170	7.5	150
Dunbarton Fire Tower	156	6.6	210
200-F	84	4.0	90
Williston	61	2.9	81
Talatha	9	0.7	98
300/700	7	0.4	49

The large decrease in the number of suspended radioactive particles in the atmosphere was due to the absence of large quantities of bomb fallout. For no apparent reason, the suspended particles were more numerous at Allendale and Aiken than at the other locations. The monthly average concentrations, as listed below, show that the largest number of particles were suspended in the atmosphere during December, the period during which small amounts of Russian fallout were detected.

Month	Particles per 1000cubic meters: Maximum per location	Average, all locations
July	2	0.3
August	2	0.1
September	4	0.3
October	12	0.5
November	53	3.5
December	184	35.7

The magnitude of radioactivity of individual particles, and the average half-lives of the radioactive materials in the particles were determined by counting the particles with an end-window GM tube. During July, August, September and October, none of the particles were radioactive to the extent of more than 40 d/m/particle. In November, 23 particles, out of a total of 99 collected, contained more than 40 d/m/particle. The average radioactivity of these 23 particles was 130 d/m/particle, and the maximum radioactivity was 650 d/m/particle. Thirteen of these particles were recounted after a period of one week to determine the half-life of the radioactive material. One particle, collected at the Aiken Airport during the week ending November 29, had a half-life of approximately 90 days, indicating that the source of contamination could be Plant activity. The particle contained 235 d/m of radioactive material. The remaining 12 particles had half-lives of less than 42 days, indicating the

source of contamination to be bomb fallout. The average radioactivity of these particles was 190 d/m/particle, and the maximum radioactivity in one particle was 650 d/m.

In December, 63 particles out of a total of 815 collected contained more than 40 d/m/particle. The average radioactivity of these was 117 d/m/particle and the maximum was 790 d/m/particle. Twenty of these particles were recounted after a period of one week to determine the half-life of the radioactive materials. Two particles, one collected at Allendale during the week ending December 28 and the other collected at Waynesboro during the week ending December 20, had half-lives of approximately 90 days, indicating that the source of the particles could be Plant activity. The radioactivity of these was 122 d/m/particle and 80 d/m/particle, respectively. The remaining 18 particles had half-lives of less than 42 days, indicating the source of contamination to be bomb fallout. The average radioactivity of these was 191 d/m/particle with a maximum of 647 d/m/particle.

Atmospheric Radioactivity as Determined by Counting Air Filters

Airborne radioactivity was collected on 2-inch-diameter CWS 6 filters at each of the constant air monitoring stations shown in figure 6. The flow of air through the filters was 2 cubic feet per minute, and the filters were changed weekly. After collection, three days were allowed for decay of radon and thoron daughters, and then the filters were counted with an end-window GM tube. Starting in August, the filters were also counted with an alpha scintillation counter. During the 6-month period, 260 samples were counted for gross beta, and 210 were counted for alpha.

Silver nitrate impregnated HV70 filters were used to collect radioiodine. The flow of air through these filters was 2 cubic feet per minute, and these filters also were changed weekly. One hundred and fifty-two silver nitrate filters were analyzed specifically for radioiodine.

Results from filters collected at ten locations are summarized on the following page.

Atmospheric Radioactivity, 1×10^{-14} µc/cc

Location	Gross Alpha		Gross Beta			Radioiodine	
	Max	Avg	Max	Avg	Previous Avg	Max	Avg
200-F	3.6	0.7	320	63	152	57	7
200-H	2.4	0.6	220	58	110	180	28
Dunbarton Fire Tower	0.4	0.2	260	50	119	15	7*
Talatha Gatehouse	2.7	0.4	340	66	154	19	3
400-D	2.5	0.4	260	64	167	34	6
Williston Gatehouse	2.9	0.5	300	59	151	31	10*
700-A	1.8	0.3	410	54	112	24	3
Waynesboro	0.4	0.2	230	44	98	11	4*
Aiken Airport	0.5	0.2	240	48	120	3	2*
Allendale	0.2	0.1	200	41	109	7	3*

* Results cover only the last 6-8 weeks of the period.

Because of the absence of heavy bomb fallout during this 6-month period, gross beta activity at all locations decreased. However, the concentrations of both alpha and beta activity were higher at the "on-Plant" locations than at the "off-Plant" locations, indicating some contamination from Plant operations. Radioiodine activity was highest at 200-H Area, reflecting the release of radioiodine from the 200-H stack. The times at which the contamination occurred are indicated in the table below.

Atmospheric Radioactivity, 1×10^{-14} µc/cc
Average For All Locations

Month	Gross Alpha		Gross Beta		Radioiodine*	
	Max	Avg	Max	Avg	Max	Avg
July	-	-	76	26	4	2
August	2.2	0.3	37	22	11	2
September	2.4	0.3	41	22	50	5
October	2.7	0.4	410	31	7	3
November	2.9	0.4	340	66	44	8
December	3.6	0.3	280	167	180	32

* Results include only those locations where silver nitrate filters were in use during the entire 6-month period.

The highest levels of alpha contamination occurred during October and November, and the largest amounts of gross beta and radioiodine were present in the atmosphere during November and December. Most of the increased alpha contamination was probably released by the 200-Areas stacks, while the gross beta and radioiodine were due to both fallout from the Russian tests and 200-Area stack releases.

Radioactivity in Rain Water

Rain water samples were collected weekly at each of the constant air monitoring stations shown in figure 6. A total of 167 samples were collected and analyzed for gross alpha, nonvolatile beta and radioiodine. The concentrations of gross alpha were negligible, the maximum 6-month average being 2.6×10^{-3} d/m/ml, and therefore have not been reported. During November and December, 45 samples were analyzed for tritium, but all of them contained less than 0.01 μc/ml. A summary of the nonvolatile beta and radioiodine is listed below.

Location	No. of Samples	Nonvolatile Beta, 1×10^{-15} c/ml			Radioiodine, 1×10^{-15} c/ml		
		Max	Avg	Previous Avg	Max	Avg	Previous Avg
300/700	17	820	152	7,043	38	12	93
200-H	15	310	88	-	42	14	-
Talatha Gatehouse	19	220	72	748	46	14	58
Aiken Airport	19	405	68	410	34	11	619
Allendale	17	350	66	128	30	11	48
Dunbarton Fire Tower	13	160	62	11,586	21	10	1860
Waynesboro	18	120	59	402	41	11	48
Williston Gatehouse	15	110	52	4,376	50	12	1870
200-F	17	120	51	1,207	320	27	2229
400-D	17	92	50	2,780	120	16	906

Because of the absence of large quantities of bomb fallout, there were very large decreases of both nonvolatile beta and radioiodine in rain water. There does not appear to be any relation between the proximity to the 200 Areas where most of the stack-released radioactivity occurred and the concentrations of nonvolatile beta and radioiodine in the rain water. However, this does not indicate that the radioactivity in the rain water was not the result of Plant operations since many factors are involved, such as the amount of rainfall in relation to the magnitude of stack releases. Hence, during periods of large stack release, a light shower of rain (low dilution factor) at a great distance from the 200 Areas could produce rain water more concentrated with radioactivity than would a heavy rain (high dilution factor) in the 200 Areas during periods when the stack release was small. The monthly average concentrations of radioactivity in the rain water provide indications as to the source of the radioactivity. These results are summarized on the following page.

Month	Nonvolatile Beta, 1×10^{-15} c/ml		Radioiodine, 1×10^{-15} c/ml	
	Max	Avg	Max	Avg
July	824	106	10	8
August	405	73	15	9
September	135	37	42	12
October	49	28	13	11
November	307	54	21	11
December	305	135	318	64

The general decrease of nonvolatile beta from July through October coincides with the decay of bomb fallout from the 1955 Nevada tests, and the increases during November and December coincide with the atmospheric contamination detected as a result of the 1955 Russian tests. Contrary to this, the general trends in stack-released nonvolatile beta were in opposite directions. Thus, it appears that a large percentage of the nonvolatile beta in rain water was contributed by nuclear tests.

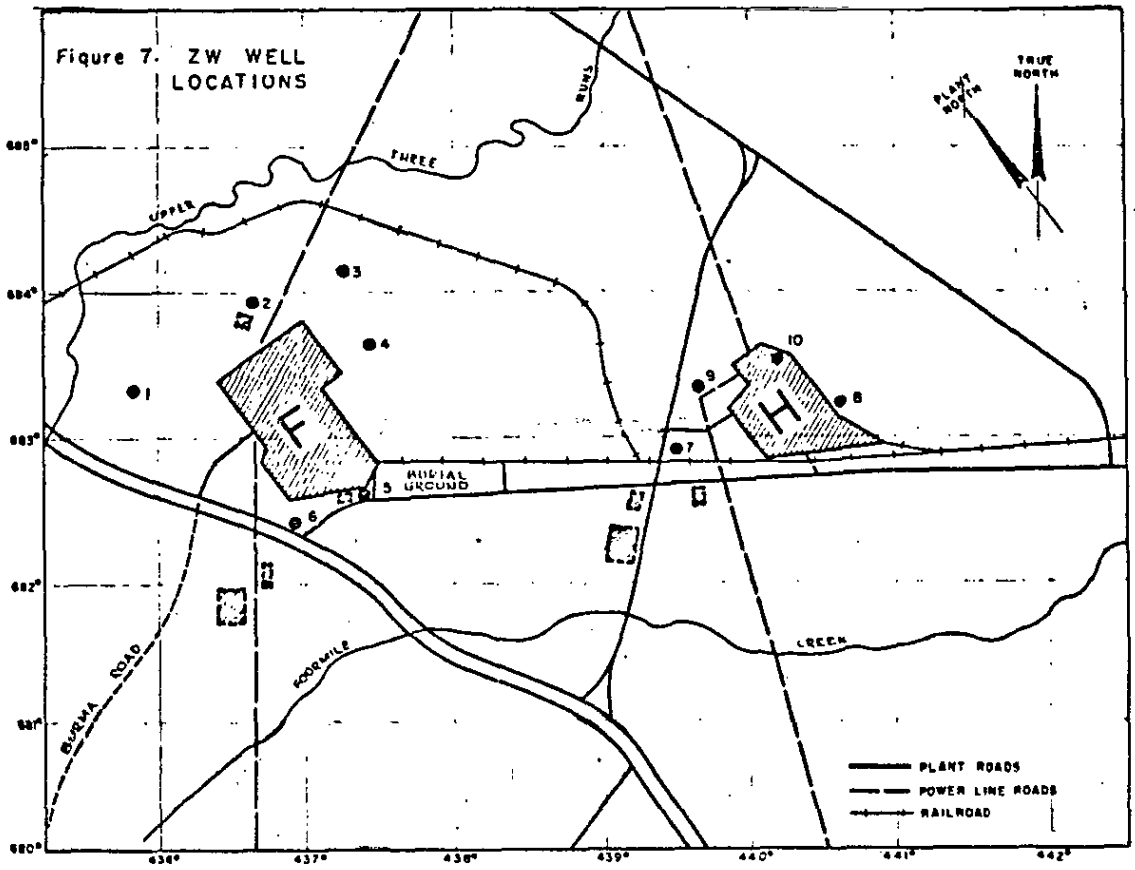
With regard to the radioiodine in rain water, the indications of contamination from Plant operations are more positive. During July the low concentrations of radioiodine in the rain water indicate that decay has eliminated it as a source of radioactive fallout. Therefore, the small but detectable amounts of radioiodine in the rain water during August, September and October were unquestionably due to 200-Area stack releases. The larger concentration observed during December coincides with increased 200-Area stack releases.

Radioactivity in Ground Water

Ground water was monitored for radioactivity by the analysis of well water samples. Two types of wells were sampled; namely, ZW (3"-diameter drilled) wells and open wells. The ZW wells are all located near the 200-F and 200-H Areas, while the open wells were selected near each of the Plant areas.

ZW Wells

Water samples were collected monthly from the ZW wells shown in figure 7. The results of analyses of 41 samples collected during the 6-month period are summarized on the following page.

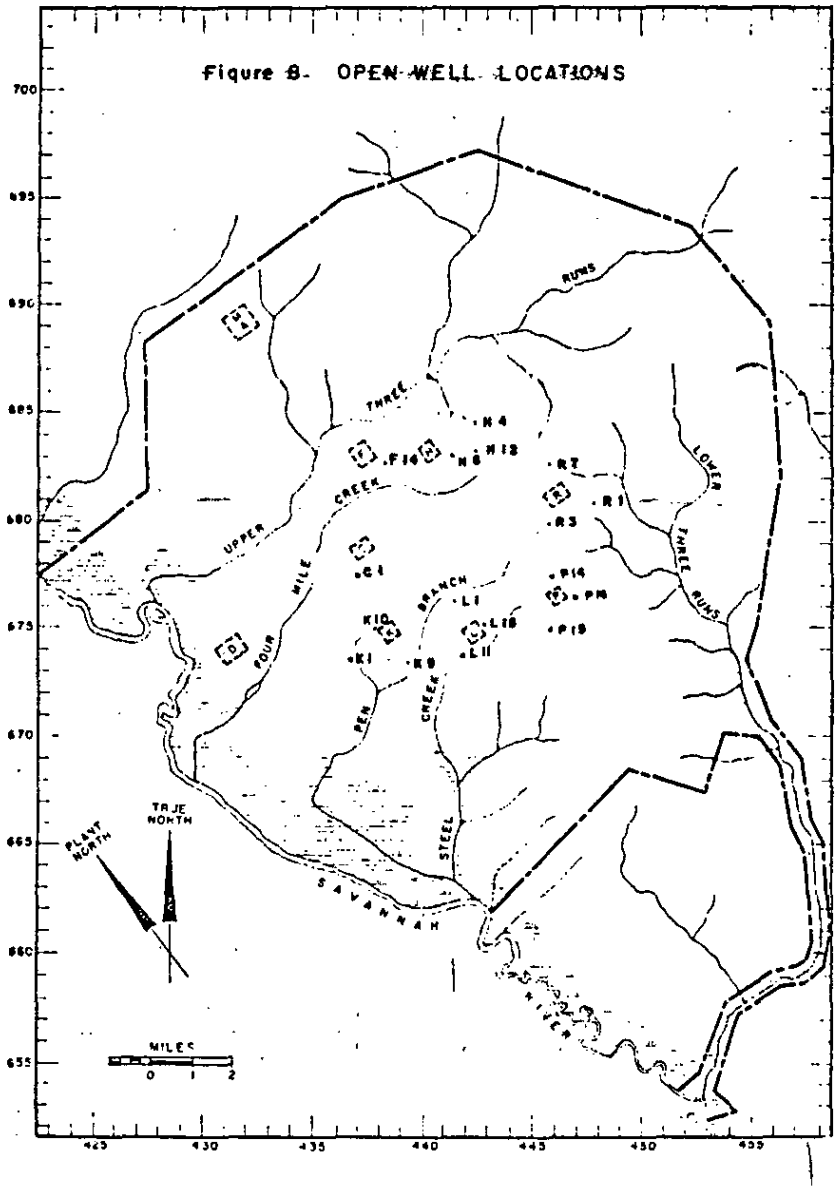


Location	No. of samples	Nonvolatile Beta, 1×10^{-15} c/ml Max	Avg	Previous Avg	Gross Alpha, 1×10^{-3} d/m/ml Max	Avg	Previous Avg
1	dry						
2	6	13	8	21	3	2	4
3	4	28	13	12	3	1	-
4	6	17	8	26	4	2	5
5	7	19	10	34	13	3	22
6	6	46	13	47	14	4	15
7	6	59	26	38	4	2	9
8	6	23	13	17	5	2	10
9	dry						
10	dry						

The monthly averages from July through December 1955 were fairly constant; hence, the decreases of both gross alpha and nonvolatile beta occurred during the previous 6 months. Observation of the radioactivity variations in the ground water at the Savannah River Plant since 1951 indicates that variations of the natural radioactivity in ground water may be related to large changes in the water table.

Open Wells

Before the construction of the Savannah River Plant, a number of the residents of the area now covered by the Plant site obtained water from open wells. Sixty-seven of these wells were preserved for sampline purposes, and samples were collected from 17 of these during the 6-month period. The locations of these wells are shown in figure 8.



Forty water samples were collected and analyzed for gross alpha and nonvolatile beta. The results of these analyses are summarized on the following page.

Location	No. of Samples	Nonvolatile Beta, 1 × 10⁻¹⁵ c/ml			Gross Alpha, 1 × 10⁻³ d/m/ml		
		Max	Avg	Background*	Max	Avg	Background*
C-1	3	16	12	-	18	8	-
F-14	3	14	11	-	3	1	-
H-4	2	24	20	18	8	6	2
H-8	3	92	55	30	18	9	2
H-12	2	41	40	-	4	4	-
K-1	3	20	14	6	4	3	0.7
K-9	2	23	21	-	4	4	-
K-10	2	54	50	-	2	2	-
L-1	2	12	10	9	9	5	1
L-11	2	41	29	15	5	3	1
L-15	3	10	9	8	2	2	0.8
P-14	2	21	16	20	5	3	2
P-16	2	27	23	15	3	3	0.5
P-19	2	13	10	7	3	2	1
R-1	2	9	8	7	2	1	1
R-3	2	23	20	12	3	2	1
R-7	3	19	15	10	3	3	1.7

* Results of background survey, May 1953.

Compared with other wells, the concentrations of radioactivity in the wells at locations H-8 and K-10 were high. During the 6-month period, the water level in these wells dropped; and as noticed in previous cases, this drop in water level seems to be related to an increase in the concentration of radioactivity. No other explanations for the increases were apparent. When compared with the results of the background survey, the concentrations of both alpha and nonvolatile beta has increased in the water from many of the wells. These increases also appear to be related to changes in the water table.

Radioactivity in Plant Drinking Water

Samples of drinking water were collected monthly from 19 locations on the Plant site. The results of the analyses of 114 samples collected during the 6-month period are summarized on the following page.

Location	Gross Alpha, 1 × 10⁻³ d/m/ml			Nonvolatile Beta, 1 × 10⁻¹⁵ c/ml		
	Max	Avg	Previous Avg	Max	Avg	Previous Avg
Barricade No. 2	15	13	21	17	10	18
TC-1	15	10	13	16	12	12
200-F	17	10	10	18	12	11
200-H	13	7	13	19	11	9
Barricade No. 4	8	6	7	13	9	9
Barricade No. 1	5	4	5	11	8	9
400-D	5	3	6	15	10	10
Pump House No. 1	6	2	3	11	9	9
Pump House No. 2	4	2	3	16	9	10
Central Shops	3	1	3	16	9	9
100-K	2	1	5	12	9	12
100-R	1	1	15	9	8	15
CMX	1	1	1	8	8	8
Barricade No. 3	2	1	2	8	8	8
Barricade No. 5	3	1	2	8	7	9
100-P	1	1	1	8	7	8
100-L	1	1	2	8	7	8
100-C	1	1	19	8	7	22
300/700	2	1	2	8	7	8

All changes of radioactivity levels in the drinking water appear to be natural fluctuations.

Radioactivity in Public Water Supplies

Samples of public drinking water were collected from 14 of the surrounding towns shown in figure 1. Samples were collected weekly from Waynesboro, Georgia; Clearwater, South Carolina; and Aiken, South Carolina; since they have open water systems. Samples from other locations were collected monthly. The results of analyses of 154 samples collected during the 6-month period are summarized on the following page.

Location	Gross Alpha, 1 × 10^{-3} d/m/ml			Nonvolatile Beta, 1 × 10^{-15} c/ml		
	Max	Avg	Previous Avg	Max	Avg	Previous Avg
Aiken	16	8	9	19	9	8
Allendale	2	1	2	8	8	10
Augusta	1	1	1	8	7	8
Barnwell	2	1	1	12	8	8
Bath	6	2	2	8	8	8
Blackville	3	1	2	8	8	8
Clearwater	3	1	1	14	8	10
Jackson	15	8	5	15	10	9
Langley	5	3	2	9	8	11
New Ellenton	2	1	1	11	8	8
North Augusta	3	1	1	10	8	8
Sardis	1	1	1	8	8	9
Waynesboro	2	1	1	11	8	9
Williston	4	2	2	9	8	8

The relatively high alpha activity at Jackson and at Aiken, South Carolina, can be attributed to natural sources.

The slight decreases in nonvolatile beta at Allendale, Clearwater, and Langley, South Carolina, were probably because of the large decrease of bomb fallout during this period, as compared to the previous 6-month period.

Radioactivity in Biological Specimens

Zoological Specimens

During the 6-month period, various organs of 27 zoological specimens were analyzed for radioactivity. The locations from which these specimens were collected are shown in figure 9.

The spleen, intestinal tract contents, muscle, liver, lung, kidney, bone, and gonads of three rabbits and one raccoon were analyzed for alpha and nonvolatile beta. The results of most of the analyses were less than the sensitivity of the counters (0.4 to 5 d/m/g alpha and 10 to 150 × 10^{-12} c/g nonvolatile beta; depending on the weight of the organ analyzed, conversion factors of the instruments, etc). The positive results are summarized on the following page.

Date	Location	Species	Organ	Gross Beta, 1 X 10-12 c/g	Gross Alpha, d/m/g
11/24	1	Rabbit	Intestinal tract	51	
			Bone	19	
11/24	6	Raccoon	Kidney		3.6
			Liver		1.2
11/25	3	Rabbit	Spleen	130	
			Intestinal tract	24	

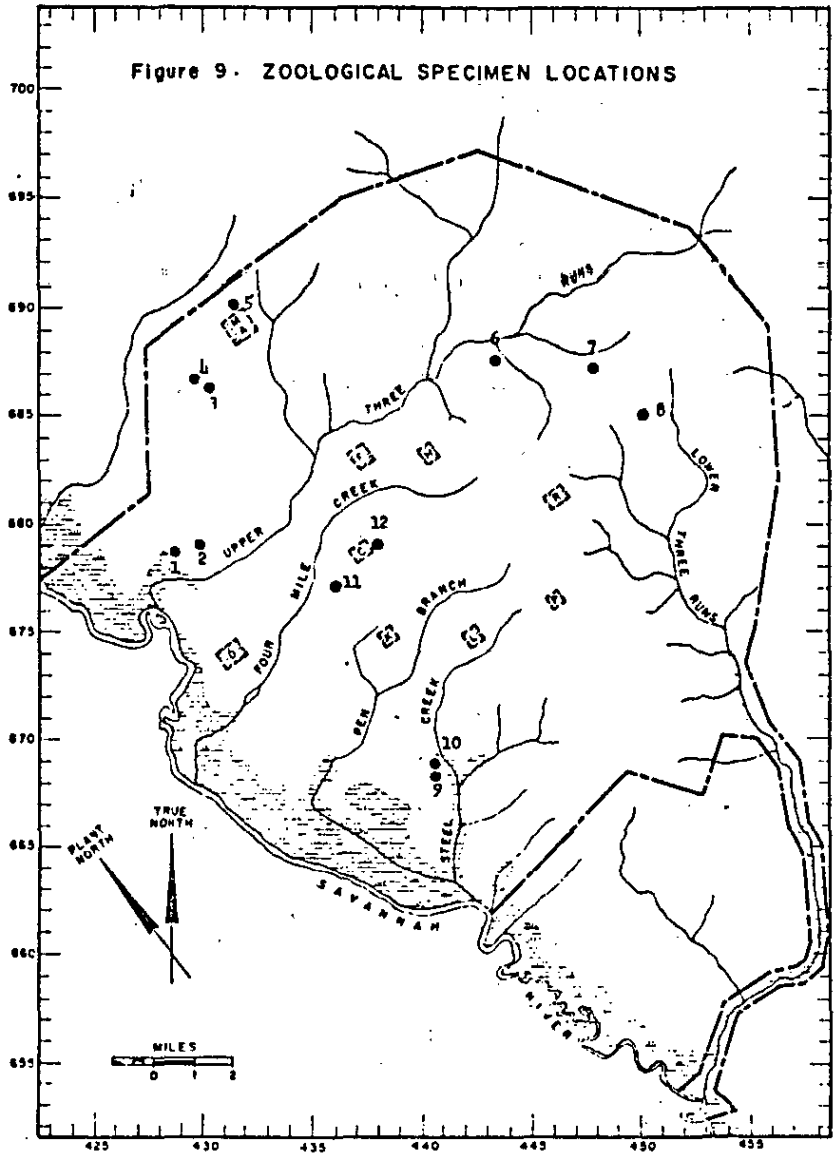


Figure 9. ZOOLOGICAL SPECIMEN LOCATIONS

The thyroids of two quail, two opposums, seven raccoons, two bobcats, one squirrel, five foxes, and eight rabbits were removed and analyzed for radioiodine. The results of eighteen of these analyses were less than the sensitivity of the counters (8 to 12 $\times 10^{-12}$ c/thyroid). The positive results are summarized below.

Date	Location	Species	Radioiodine, 1×10^{-12} c/thyroid
11/22	7	Rabbit	63
11/24	8	Raccoon	10
11/25	4	Rabbit	13
11/25	11	Fox	14
11/25	2	Fox	11
12/13	12	Rabbit	96
12/18	9	Rabbit	40
12/18	10	Rabbit	22
12/22	5	Rabbit	27

Gross beta concentration by the various zoological specimens has been negligible; but the increase of radioiodine in the thyroid of specimens, with one exception, shows a definite correlation with the stack releases of radioiodine.

Diatoms

Diatom samples were collected every two weeks at the four locations shown in figure 10. During the 6-month period, 85 samples were collected and analyzed for uranium. The results of these analyses are summarized below.

Location	Uranium Content, µg of U/g		
	Max	Avg	Previous Avg
1. Savannah River Above Plant	45	25	12
2. Savannah River Below Plant	490	38	13
3. Four Mile Creek	65	17	28
4. Tims Branch	4170	1191	911

Figure 10. DIATOM COLLECTION LOCATIONS