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HEALTH PHYSICS REGIONAL MONITORING

Semiannual Report,
July through December 1960

October 1961

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Report Declassified with Deletions on Pages 6, 36.

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E. I. du PONT de NEMOURS & COMPANY
EXPLOSIVES DEPARTMENT - ATOMIC ENERGY DIVISION
SAVANNAH RIVER PLANT

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EXPLOSIVES DEPARTMENT - ATOMIC ENERGY DIVISION
SAVANNAH RIVER PLANT

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HEALTH PHYSICS REGIONAL MONITORING

Semiannual Report,
July through December 1960

Prepared by
Environmental Monitoring Staff

October 1961

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

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Abstract

Radioactivity in the Plant environs was measured during the six-month period ending December 31, 1960. No significant amounts of radioactivity were detected in the environment as a result of Plant discharges. Nonvolatile beta releases from Reactor Areas to effluent streams decreased approximately 70%. Nonvolatile beta and alpha releases from F-Area stacks increased while decreased releases were observed from H-Area stacks. The six-month average concentration of nonvolatile beta activity in air was the lowest observed to date.

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Introduction

Under a program established by the Du Pont Company in June 1951, the Savannah River Plant site and surrounding region are systematically monitored for radioactivity. The regional monitoring program accumulates information that is useful both as a measure of the effectiveness of Plant controls and as an authoritative record of environmental conditions. This report, covering the period from July through December 1960, is one of a series of reports relating to the regional monitoring program.

Data Reporting

Survey data were averaged for the six-month period and compared with the previous six-month averages ("Health Physics Regional Monitoring Semiannual Report," DPSP 60-25-26, October 1960). In reporting data, "Avg" or "Total" refers to the average or total for this six-month report period, while "Prev Avg" or "Prev Total" refers to the average or total for the preceding six-month period. Unless otherwise specified, "Max" refers to the greatest concentration observed in a single sample collected during the report period. Improved beta counting sensitivities, accomplished by installations of gas flow counters in August 1960, resulted in an apparent but not actual decrease in nonvolatile beta activity when this activity in environmental samples approached sensitivity levels.

Sensitivity and Standard Deviation of Laboratory Analyses

The sensitivity of laboratory analyses refers to the minimum amount of radioactivity that can be detected by the radiochemical analytical techniques in use. It is based on statistical counting error (90% confidence level) and is influenced by sample size, counter efficiency, and counter background. No self-absorption corrections have been applied.

The standard deviations, calculated from spike recovery values, are applicable to the six-month averages of data in this report.

Analysis	Sample	Sensitivity	Standard Deviation, %	Spike Value
Alpha	Water	0.19 ± 0.14 × 10^{-15} c/ml	8	45 × 10^{-15} c/ml
	Mud	0.19 ± 0.14 × 10^{-12} c/g	-	-
	Vegetation	0.10 ± 0.07 × 10^{-12} c/g	-	-
	Air	0.033 ± 0.025 × 10^{-14} μc/cc	-	-
Beta	Water	4.4 ± 3.6 × 10^{-15} c/ml	-	-
	Mud	4.4 ± 3.6 × 10^{-12} c/g	-	-
	Vegetation	2.2 ± 1.8 × 10^{-12} c/g	-	-
	Biological Specimens	2.2 ± 2.0 × 10^{-12} c/g*	-	-
	Air	0.78 ± 0.64 × 10^{-14} μc/cc	-	-
TBP Extraction	Water	0.22 ± 0.17 × 10^{-15} c/ml	18	45 × 10^{-15} c/ml
	Mud	0.25 ± 0.20 × 10^{-12} c/g	19	45 × 10^{-12} c/g
	Vegetation	0.031 ± 0.025 × 10^{-12} c/g	22	4.5 × 10^{-12} c/g
Radioiodine	Water	6.7 ± 5.5 × 10^{-15} c/ml	11	300 × 10^{-15} c/ml
	Vegetation	0.55 ± 0.46 × 10^{-12} c/g	15	20 × 10^{-12} c/g
	Air	1.78 ± 1.46 × 10^{-14} μc/cc		
	Milk	10.0 ± 1.5 × 10^{-15} c/ml	8.6	3000 × 10^{-15} c/ml
Tritium	Water	4.0 ± 0.4 × 10^{-12} c/ml	2	2500 × 10^{-12} c/ml
Radiocesium	Water	5.3 ± 4.3 × 10^{-15} c/ml	5 & 17**	600 × 10^{-15} c/ml
Radiostrontium	Water	5.9 ± 4.9 × 10^{-15} c/ml	14	225 × 10^{-15} c/ml
Strontium-90	Water	4.8 ± 3.9 × 10^{-15} c/ml	12	225 × 10^{-15} c/ml

* Approximate average; sample size varied.
** % Standard deviation for two methods of analyses.

Where samples were analyzed by gamma spectrometery, the lower level of detection of a given isotope varies with: (1) background of each individual channel grouping and (2) geometry and volume of sample analyzed. For this reason no average sensitivities are given. Furthermore, using gamma spectrometry, it is not practical to differentiation between nuclides emitting gamma rays of nearly the same energy. Thus, data are reported as $Ru^{103,106}$, $Ce^{141,144}$, Co^{60}/Fe^{59}, etc; such notations do not mean that both isotopes were necessarily present. The differentiation between members of most of such groupings can be made, if required, by: (1) approximate age estimates of the fission products at the time of release, (2) chemical separations and decay, and (3) beta absorption studies.

Summary

Radioactivity released to the environment by stacks and effluent streams included approximately 0.4 curie alpha, 197 curies of nonvolatile beta, 26 curies of radioiodine and 482,500 curies of tritium.

Nonvolatile beta radioactivity discharged from the reactor disassembly basin decreased from 650 curies to 186 curies. Approximately 40% of the radioactivity was long lived (primarily $Ce^{141,144}$) resulting from releases associated with discharges of enriched uranium loadings

Nonvolatile beta and tritium releases from Reactor-Area discharges were detectable in the Savannah River at points below the Plant. It was estimated that the Plant contributed 67 curies of nonvolatile beta and 26,700 curies of tritium to the flow of radioactivity in the river at the Highway 301 crossing during the 6-month period.

The radioactivity stabilization program for the R-Area seepage basin area continued by backfilling and clay capping the basin system. Excavation of a trench for the clay containment dike around basin 1 was initiated.

Radioactivity observed in Savannah River fish was generally confined to low'level concentrations of radiostrontium in the bones; fish collected from all four reactor effluent streams contained significant concentrations of radiostrontium in the bones and radiozinc in both the bones and fleshy tissues. Lower Three Runs and Steel Creek fish also contained radiocesium in the flesh. The uptake of radioactivity by terrestrial animals on the Plant site was highest in the immediate vicinity of R-Area seepage basins. Sr-89 and Sr-90 were the main isotopes found in the bones while Cs-134 and Cs-137 were the primary isotopes present in the fleshy tissues.

Nonvolatile beta and alpha stack releases from F Area increased, whereas, radioiodine releases continued at a low level. Decreased stack releases from H Area were observed throughout the period. Environmental effects due to stack released radioactivity were negligible.

Airborne radioactivity decreased from 18×10^{-14} to 8×10^{-14} μc/cc, the lowest six-month average concentration observed to date. Four continuous air monitoring stations were installed at locations approximately 100 miles from the Plant. These more distant stations, operated at Savannah and Macon in Georgia, and at Columbia and Greenville in South Carolina serve as "reference points" for determining background levels of radioactivity in air.

Analysis of rainwater samples indicated a Plant deposition of approximately 40 millicuries of nonvolatile beta and 30 curies of tritium per square mile.

F-Area nonvolatile beta releases for this 6-month period exceeded the previous total releases to Four Mile Creek from F Area since startup in 1955. These releases were attributed to: (1) the overflow of the 281-3F retention basin in July following a high activity waste evaporator coil leak, and (2) the contamination of the F-Area process (recirculating) cooling water system. Nonvolatile beta releases to Four Mile Creek from F and H Areas totaled 4.9 and 0.3 curies, respectively.

Radioactivity Releases

Plant Discharge

100 AREAS

The major source of radioactive waste discharged from the Reactor Areas to Plant effluent streams was disassembly basin water which was pumped at a rate of 1000 to 2000 gpm. Purging of the thermal shield system was discontinued with the exception of R Area; nonvolatile beta releases from this source were negligible (3 millicuries).

Radioactivity discharged from the disassembly basins during this report period decreased despite an increase in the number of reactor discharge outages (11 during the period January through June 1960; 14 during the period July through December 1960). This decrease may have resulted from decreased corrosion in the process system due to more effective control of reactor moderator pH. Approximately 40% of the total activity released to reactor effluent streams had half lives greater than 15 days (primarily $Ce^{141,144}$). A summary of nonvolatile beta releases from the Reactor Areas to Plant streams, as determined by radioanalyses of disassembly basin weir samples is shown in the following table.

Beta Releases, curies

Area	Long-lived Isotopes*	Short-lived Isotopes*	Previous Total
R	11.4	26.1	84
P	9.8	27.6	35
L	15.2	13.9	297
K	30.0	30.8	147
C	8.7	12.6	87
Total →	75.1	111	650**

* The specific distribution of both long and short-lived isotopes (half lives greater and less than 15 days, respectively) will be presented in a future waste audit report. The value shown for the total short-lived isotopes includes approximately 24 curies of radioiodine.

** Includes 190 curies of long-lived isotopes.

The alpha radioactivity discharged in the Reactor-Area effluent streams was estimated to be approximately 0.3 curie and is attributed almost entirely to the naturally occurring radioactivity in cooling water.

Moderator losses associated with reactor discharges resulted in a tritium release to reactor effluent streams of approximately 22,000 curies (including 3400 curies from R Area to Par Pond) compared to 25,000 curies during the previous six-month period.

Monitoring of the Building 105 stack exhaust was initiated in all Reactor Areas on September 29. Alpha releases from this source were negligible. Gamma pulse height analysis revealed the presence of $Ru^{103,106}$, $Ce^{141,144}$, $Zr\text{-}Nb^{95}$, I-131, as well as some induced activities (Cr-51, Fe^{59}/Co^{60} and Mn^{54}/Co^{58}) on isolated samples; however, the quantities were too low to permit accurate specific analyses. A single short-lived isotope (Cs-138, a 33-minute daughter product of Xe-138) was common to all area releases. The following table summarizes Reactor-Area stack releases during the fourth quarter of 1960.

Area	Stack-Released Nonvolatile Beta, mc
R	0.30
P	0.21
L	0.37
K	1.84
C	1.00
Total →	3.72

Reactor-Area stack-released tritium totaled 121,000 curies compared to 140,000 curies during the previous report period.

200 AREAS

Nonvolatile beta and alpha releases from the F-Area canyon stack increased despite the cessation of operations in this area during the last half of the report period. The maximum nonvolatile beta monthly release (2.3 curies) occurred in September.

Alpha releases totaled 72 millicuries, including 27 millicuries in October, the highest monthly release since July 1956. Alpha releases decreased significantly following shutdown of B-Line Recovery facilities in November. The radioiodine release (1.3 curies all in F Area) was the lowest six-month total since separations operations began.

Stack releases for F Area and H Area are summarized in the following tables.

	Stack-Released Radioactivity			
	F Area		H Area	
	Total	Prev Total	Total	Prev Total
Nonvolatile Beta, mc				
$Ru^{103,106}$	5334	3361	16.6	142
$Sr^{89,90}$	1.4	5	5.0	1
$Ce^{141,144}$	48	110	59.3	25
Cs^{137}	1.5	15	6.6	1
$Zr\text{-}Nb^{95}$	38	122	14.8	37
Ag^{110}	18			
Total →	5441	3613	102	206
Alpha, mc	72*	21	1	1
I-131, curies	1.3	6	-	-

* 80% plutonium.

Nonvolatile beta releases from F Area to Four Mile Creek exceeded the previous total releases from F Area to Four Mile Creek since startup in 1955. These acute releases occurred in July and September and resulted from: (1) overflow of the 281-3F retention basin following a coil leak in the high activity waste evaporator, and (2) contamination of the F-Area process (recirculating) cooling water system. Nonvolatile beta releases to Four Mile Creek from F and H Areas totaled 4.9 and 0.3 curies, respectively. Predominant isotopes in the process cooling water were Ce-141 and Ce-144.

300 AREA

The estimated release of natural uranium to Tims Branch from 300 Area was 70 pounds or 30 millicuries.

700 AREA

Releases of radioactivity from Building 773-A (Savannah River Laboratory) stacks included approximately 98 µc alpha, 47 mc nonvolatile beta, 13 mc radioiodine and 2000 curies of tritium. An additional 400 curies of tritium were released from TNX stacks.

Bomb Fallout

Radioactivity in air and rainwater samples reached its lowest level in Plant history. Deposition of nonvolatile beta on the Plant site was 40 millicuries per square mile. The concentration of filterable beta in air averaged 8×10^{-14} μc/cc during the six-month period.

Survey Results

Gamma Radiation Levels

A summary of 408 readings made with Landsverk L-65 pocket chambers and a modified L-60 electrometer is given in the following table.

Location	Dose Rate, mr/24 hours Avg	Prev Avg
F Area	1.22	2.18
H Area	0.66	0.97
R Area	.52	.56
P Area	.51	.50
L Area	.60	.58
K Area	.43	.56
C Area	.52	.49
Aiken Airport	.36	.40
Allendale	.38	.42
400 Area	.46	.48
300/700 Area	.67	.73
TC Area	.54	.51
Waynesboro	.39	.38
Dunbarton Fire Tower	.36	.41
Williston	.36	.27
Williston Gatehouse	.33	.36
Talatha Gatehouse	.36	.36
Bush Field	.31	.30
Barnwell	.40	.29
Sardis	.36	.32
Langley	.30	.33
Green Pond Church	.34	.36
Military Recreation Site	.29	.36
Jackson	0.43	0.38

Atmosphere

Air samples were collected weekly from the 18 air monitoring stations shown in figure 1.

Radioactivity in the atmosphere was determined by:

- Counting 612 two-inch-diameter air filters for alpha and beta activity.
- Chemically analyzing 509 two-inch-diameter silver nitrate impregnated air filters for radioiodine.

Results of the samples are shown in the following table.

Radioactivity in the Atmosphere

Location	Alpha, 1 x 10^{-14} μc/cc*			Filterable Beta, 1 x 10^{-14} μc/cc*			Radioiodine, 1 x 10^{-14} μc/cc			Tritium, 1 x 10^{-9} μc/cc**		
	Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg
F Area	2.5	0.27	0.4	139	20	32	36	6	8	1.4	0.47	0.46
H Area	0.7	0.13	0.1	28	11	20	14	2	6	20.9	2.37	1.36
3/700 Area	0.3	0.12	0.1	27	8	18	4	†	4	0.76	0.30	0.15
Talatha Gatehouse	0.2	0.10	0.1	27	9	19	3	2	4	1.7	0.33	0.17
Williston Gatehouse	0.1	0.07	0.1	19	7	20	3	†	4	0.74	0.24	0.27
Dunbarton Fire Tower	0.2	0.10	0.1	21	8	20	2	†	4	1.2	0.29	0.27
400 Area	0.2	0.11	0.4	35	8	23	3	†	4	1.3	0.35	0.20
Aiken Airport	0.3	0.11	0.1	15	7	15	2	†	4	0.61	0.14	0.08
Allendale	0.1	0.07	0.1	14	7	19	2	†	4	0.27	0.10	0.07
Waynesboro	0.2	0.09	0.1	21	8	19	2	2	4	0.62	0.15	0.09
Langley	0.1	0.09	0.1	16	6	11	2	†	4	1.30	0.19	0.07
Williston	0.1	0.05	0.1	18	6	13	3	†	4	0.66	0.11	0.14
Barnwell	0.2	0.09	0.1	18	6	16	5	2	4	0.70	0.17	0.14
Sardis	0.1	0.03	0.1	11	4	12	7	2	4	0.19	0.08	0.03
Bush Field	0.1	0.09	0.1	9	6	15	3	†	4	0.90	0.13	0.10
Green Pond Church	0.1	0.06	0.1	17	6	15	2	†	4	0.89	0.31	0.14
Military Recreation Site	0.4	0.07	0.1	14	8	18	2	†	4	1.20	0.32	0.19
Jackson	0.2	0.09	0.1	28	10	20	2	†	4	1.10	0.30	0.12
Columbia, S. C.	0.6	0.12	-	8	6	-	-	-	-	-	-	-
Greenville, S. C.	0.5	0.13	-	13	6	-	-	-	-	-	-	-
Macon, Ga.	0.5	0.12	-	12	7	-	-	-	-	-	-	-
Savannah, Ga.	0.3	0.08	-	10	7	-	-	-	-	-	-	-

* Minimum of three days decay allowed for radon and thoron daughters.

** Concentration in air moisture converted to concentration in air by use of appropriate humidity values.

† Less than sensitivity of analysis (1.78 x 10^{-14} μc/cc).

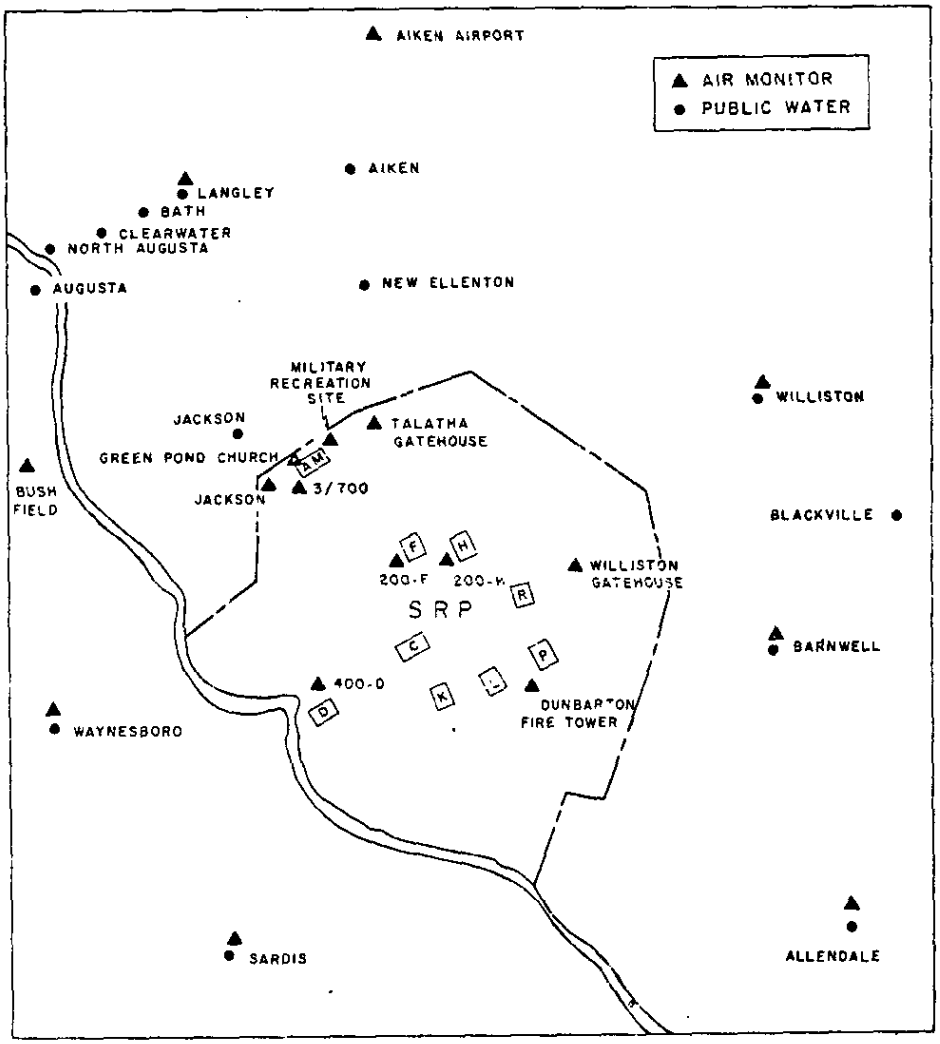

FIGURE 1. CONSTANT AIR MONITORING STATIONS AND PUBLIC WATER SAMPLING LOCATIONS

The maximum alpha and filterable beta concentrations were observed during the weeks ending August 1 and September 2 (four-day sampling period), respectively. Stack-released alpha (primarily B-Line Recovery) during the week ending August 1 totaled 5.7 mc and could have accounted for the high alpha air concentration. No unusual stack releases were observed during the September 2 sample period.

Single-filter Gelman pumps were installed at U. S. Weather Bureau stations in June and July at Columbia and Greenville, South Carolina and Savannah and Macon, Georgia. The air filters from these locations are replaced weekly by Weather Bureau personnel and mailed to the Health Physics Control Laboratories for analysis. While occasional concentrations of filterable beta in air at the Plant perimeter and at the 25-mile radius locations were slightly higher than that observed at the more distant locations, no consistent relationship with Plant stack releases was observed.

Particulate Fallout

Adhesive papers were collected weekly and radioautographed. Sample results and their locations are summarized in the following table.

Location	Particles/Ft^2/Week Max	Avg	Prev Avg
F Area	18	0.38	4.2
F Area (at 1-mile radius)	7	0.30	2.1
H Area	41	0.50	2.4
H Area (at 1-mile radius)	4	0.12	1.6
Burial Ground	4	0.28	2.2
R Area	2	0.11	2.3
P Area	0	0.00	2.4
L Area	2	0.02	1.6
K Area	5	0.13	1.4
C Area	4	0.16	2.0
On-Plant Air Monitor Locations*	2	0.09	2.7
Off-Plant Air Monitor Locations	2	0.04	2.8

* Excluding monitoring locations in F and H Areas.

The decrease in the number of radioactive particles detected in air by radioautograph resulted from decreased fallout levels observed throughout the report period.

Rainwater

Rainwater is collected continuously at each monitoring location. The results of samples collected and analyzed weekly are shown in the following table.

Radioactivity in Rainwater

Location	Alpha, 1 x 10^{-15} c/ml Max	Avg	Prev Avg	Nonvolatile Beta, 1 x 10^{-15} c/ml Max	Avg	Prev Avg	Radioiodine, 1 x 10^{-15} c/ml Max	Avg	Prev Avg	Tritium, 1 x 10^{-12} c/ml Max	Avg	Prev Avg
F Area	4.3	0.8	4.3	406	135	170	14	*	27	153	29	63
H Area	4.9	1.0	0.9	151	35	81	13	*	25	815	167	176
300/700 Area	1.2	0.6	0.9	81	35	110	14	*	23	43	21	11
Talatha Gatehouse	2.2	0.5	0.9	61	24	110	15	*	21	59	13	6
Williston Gatehouse	1.1	0.6	0.6	59	24	43	17	*	21	32	12	11
Dunbarton Fire Tower	0.6	0.4	0.5	30	20	36	14	*	20	174	25	16
400 Area	2.4	0.4	0.6	34	18	45	13	*	25	40	12	17
Aiken Airport	1.0	0.4	0.8	46	26	90	14	*	19	8	4	5
Allendale	1.9	0.7	0.5	56	25	59	13	*	23	16	5	4
Waynesboro	0.8	0.3	0.6	45	21	67	14	*	22	8	4	8
Langley	3.7	0.7	0.6	57	21	92	27	8	21	23	8	5
Williston	2.1	0.3	0.4	28	13	53	26	7	22	18	6	5
Barnwell	0.9	0.2	0.5	44	16	79	27	7	26	20	6	4
Sardis	0.8	0.3	0.5	42	24	72	13	*	23	14	5	6
Bush Field	0.8	0.3	0.6	43	27	110	23	*	21	26	8	5
Green Pond Church	1.4	0.5	0.9	41	18	70	22	8	19	257	24	5
Military Recreation Site	0.7	0.3	0.6	32	14	73	18	8	19	61	14	5
Jackson	1.3	0.3	0.5	25	13	61	13	*	18	70	16	6

* Less than sensitivity of analysis (3.7×10^{-15} c/ml).

The radioactivity deposited on the Plant site, estimated from rainwater analyses and rainfall measurements, is shown in the following table. During periods when no rain occurred, daily measurements were made of radioactivity collected in an open pan of water located near building 735-A. These measurements were used to estimate nonvolatile beta deposition.

	Nonvolatile Beta, mc/mile^2	Tritium, c/mile^2
July	9.1	2.2
August	13.4	3.0
September	3.7	6.1
October	6.6	4.6
November	3.6	4.7
December	3.8	2.3
Total →	40.4	22.9
Previous Total →	90	24.9

The environmental radioiodine was so low during the 6-month period (average concentations in rainwater at sensitivity levels) that radioiodine deposition data are not reported.

Vegetation

There were 312 vegetation samples analyzed for alpha and nonvolatile beta activity and 940 samples analyzed for radioiodine. Sample locations are shown in figures 2 and 3. Results are shown in the following table.

Location	Alpha, 1×10^{-12} c/g Max	Avg	Prev Avg	Nonvolatile Beta, 1×10^{-12} c/g Max	Avg	Prev Avg	Radioiodine, 1×10^{-12} c/g Max	Avg	Prev Avg
F Area (at 1-mile radius)	0.3	0.1	0.2	81	17	48	2.3	1.0*	2.9
H Area (at 1-mile radius)	0.3	0.1	0.2	35	14	48	0.9	0.6*	2.1
Plant Perimeter	1.0	0.1	0.2	39	15	33	1.5	**	1.1
25-Mile Radius	0.5	0.1	0.2	29	15	34	3.4	**	1.0

* Two months avg - Analysis discontinued in September following decreased stack releases in F. Area.

** Less than sensitivity of analysis.

Milk

Samples were collected weekly from Talatha, Snelling, Aiken, North Augusta, and Langley. Of 130 samples analyzed for radioiodine and tritium the average radioiodine concentration was less than 9×10^{-15} c/ml, and the average tritium concentation was 5×10^{-12} c/ml.

Regional milk produced by dairy herds and by family owned cows was analyzed for Sr-90 content quarterly. The averages are shown in the following table.

Type Sample	Sr-90 in Milk, μμc/ℓ* March	June	October	December
"Family" Cow	26.3	19.1	36.6	19.5
Local Dairy	13.2	11.5	14.5	11.6
Major Distributor	12.0	10.0	13.1	11.1

* These are 1960 results.

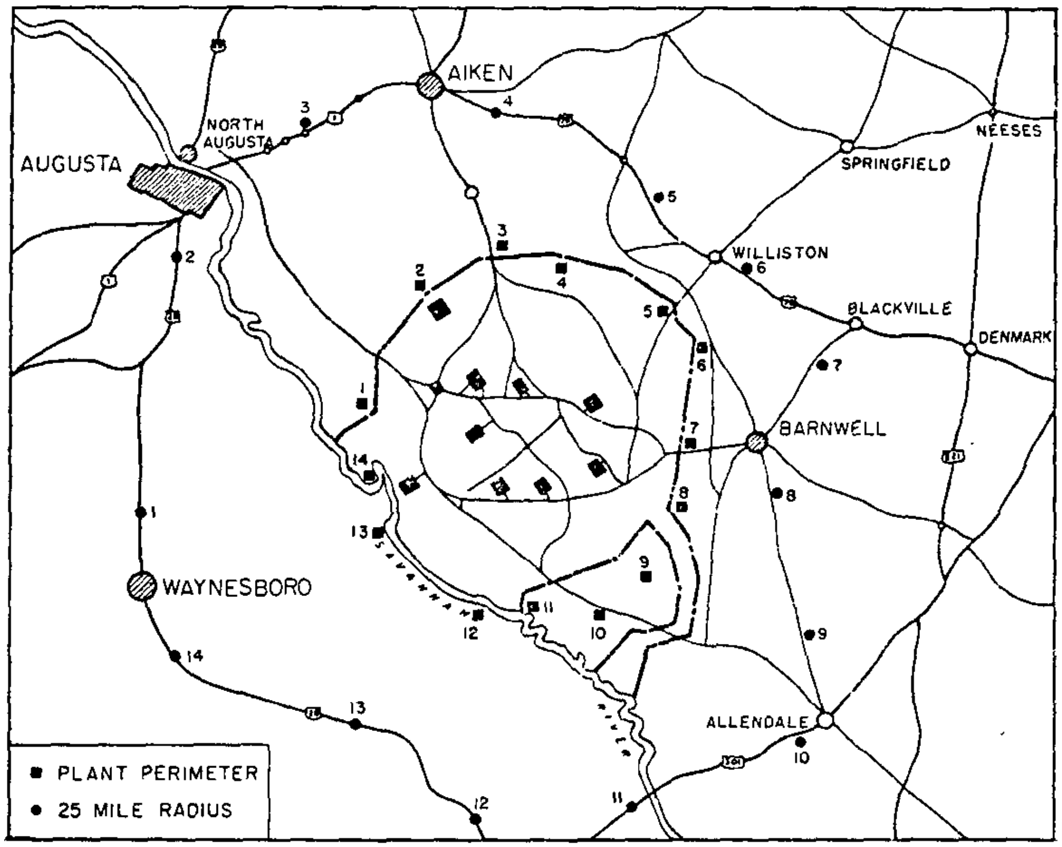

FIGURE 2. VEGETATION SAMPLE LOCATIONS

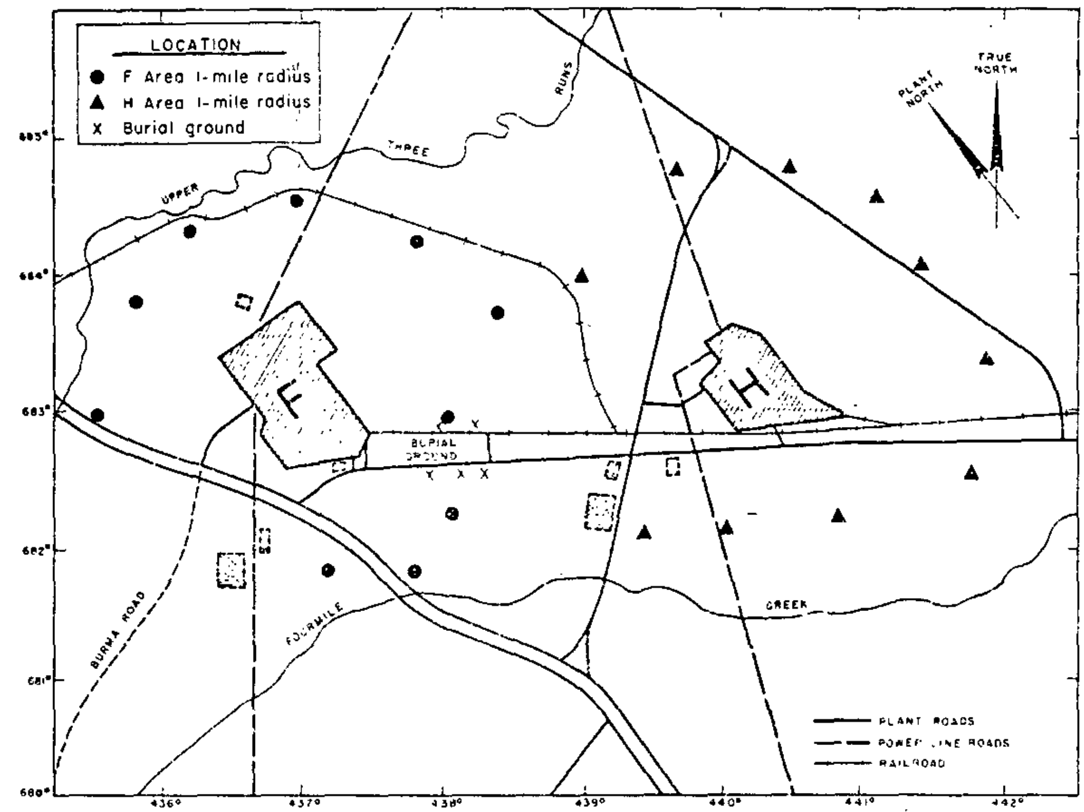

FIGURE 3. VEGETATION SAMPLE LOCATIONS IN F AND H AREAS

Streams and the Savannah River

Weekly water and mud samples were collected at the stream locations shown in figure 4. Analyses of 598 water samples and 593 mud samples are summarized in the following tables.

TIMS BRANCH

	Radioactivity in Water, 1×10^{-15} c/ml					
	Alpha			Nonvolatile Beta		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg
2*	470	64	50	1700	290	150
3**	500	160	520	2200	560	640
4	44	9	23	150	34	80

* Tritium concentration at location 2 averaged 4×10^{-12} c/ml with a maximum of 10×10^{-12} c/ml.

** Maximum alpha and nonvolatile beta concentrations at location 3 (300-Area effluent) occurred in a sample collected on September 1.

	Radioactivity in Mud, 1×10^{-12} c/g					
	TBP Extractable Alpha			Nonvolatile Beta		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg
2	42	20	16	100	40	40
3	280	110	170	300	71	300
4	54	18	15	53	16	14

UPPER THREE RUNS

Analyses of water and mud samples are shown in the following table.

	Alpha			Nonvolatile Beta		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg
	Radioactivity in Water, 1×10^{-15} c/ml					
1A (Control)	9.2	3.5	3.2	25	10	9
1 (Control)	2.8	1.5	2.0	27	10	14
2	4000	350	28	150,000	18,500	130
3	2.8	1.6	3.5	24	8	13
4*	1.3	0.7	1.7	31	7	6
	Radioactivity in Mud, 1×10^{-12} c/g					
1A (Control)	1.0	[illegible]	0.4	14.1	[illegible]	8
1 (Control)	1.2	0.5	0.6	22.8	10	11
2	4.4	1.8	1.1	3,400	1,175	350
3	3.3	1.3	1.0	34	16	18
4	2.3	0.6	0.5	15.4	9	10

* Tritium concentration at location 4 averaged 6×10^{-12} c/ml with a maximum of 10×10^{-12} c/ml.

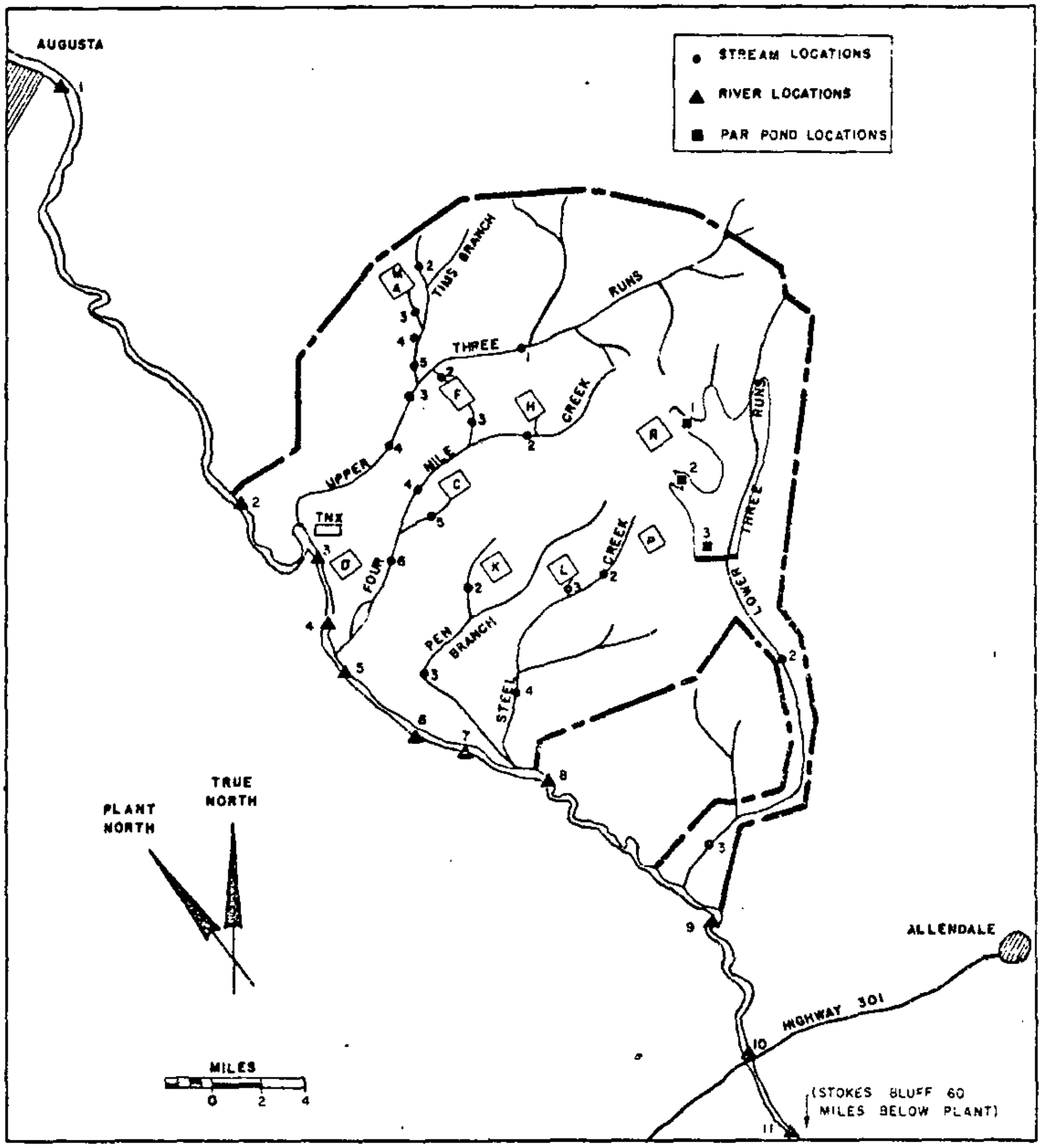

FIGURE 4. STREAM AND RIVER SAMPLE LOCATIONS

The combined effects of the contamination of the F-Area recirculating cooling water system (which was detected August 25) and the flushing of the spare hydrate evaporator cell (August 30, September 7, and September 13) resulted in the highest sustained nonvolatile beta concentrations to date in the F-Area storm sewer (Upper Three Runs location 2). The maximum nonvolatile beta and alpha concentrations observed in the storm sewer effluent occurred on August 25 and September 1, respectively. A temporary dam was constructed, at this time, across the storm sewer effluent and wastes accumulated during flushing operations were pumped to the abandoned seepage basin north of the area. While Ru-103 and Ru-106 were the predominate gamma emitting isotopes present in the storm sewer effluent during flushing operations, Ce-141 and Ce-144 were also detected. The alpha emitter was identified as natural uranium. The radiocesium resulted from discharges of the recirculating cooling water into storm sewer drains. Previous abnormal nonvolatile beta activity observed in storm sewer samples ($59,000 \times 10^{-15}$ c/ml on August 11) consisted of 90% $Ru^{103,106}$. The two incidents (contamination of the spare hydrate evaporator cell, and contamination of the recirculating cooling water system) brought to light several anomalies in the disposition of the cooling water and activity releases through floor drains. Perhaps the most significant of these was the fact that the spare hydrate evaporator cell drained directly into the storm sewer and hence to Upper Three Runs Creek. This condition was corrected.

FOUR MILE CREEK

Analyses of water and mud samples are summarized in the following table.

Location	Alpha Max	Alpha Avg	Alpha Prev Avg	Nonvolatile Beta Max	Nonvolatile Beta Avg	Nonvolatile Beta Prev Avg
	Radioactivity in Water, 1×10^{-15} c/ml					
2	1.4	0.6	1.3	400	82	300
3	69	7.0	12.0	150,000	10,000	3600
4	3.6	1.0	1.8	9,900	1,500	320
5	1.0	0.4	0.7	31,000	3,400	1100
6	1.0	0.2	0.5	4,000	260	400
	Radioactivity in Mud, 1×10^{-12} c/g					
2	0.7	0.2	0.3	64.2	14	22
3	2.8	0.6	0.4	4,200	860	260
4	0.4	0.2	0.3	490	200	29
5	29.0	1.5	0.5	390	39	15
6	1.3	0.5	0.6	237	47	71

While the increase of radioactivity in water shown at location 3 reflects the chronic contamination of the F-Area segregated cooling water system (beginning November 1959), acute releases of radioactivity to the F-Area effluent occurred in July and September 1960.

Discharges from the 281-3F retention basin (beginning during the week ending June 30) resulted in a peak nonvolatile beta activity level in Four Mile Creek location 3 during July of 150,000 × 10^{-15} c/ml. Specific analysis of a Building 281-3F water sample collected on July 15 indicated that the basin contained 65 curies of nonvolatile beta activity, including 1.7 curies of radiostrontium. This increase of basin activity resulted from the diversion of segregated cooling water to the retention basin on July 13 following a coil leak in the high activity waste evaporator. Pulse height analysis of both the retention basin and effluent samples revealed the following percentages of gamma emitting isotopes: $Ru^{103,106}$, 93.3%; $Ce^{141,144}$, 6.5%; and $Zr\text{-}Nb^{95}$, 0.2%. Increased alpha concentrations, associated with these releases (July average 28 × 10^{-15} c/ml) were due primarily to Pu-239.

A second rise of radioactivity in Four Mile Creek location 3 occurred during September and was ascribed to the contamination of the F-Area process (recirculating) cooling water system (August 25). The predominant gamma emitting isotopes present in the recirculating cooling water system were Ce-141 and Ce-144. The radioactivity released to the F-Area effluent as a result of the contamination of the segregated cooling water system (September 13) was greatly minimized by the diversion of the cooling water to the seepage basins (September 17-28). However, some of the effects of this incident were evident in continued high concentrations in Four Mile Creek at location 3 (5000 × 10^{-15} c/ml, average) during October. Following cessation of operations in F Area in October, radioactivity concentrations in the segregated cooling water effluent decreased during November and December to an average of 1700 × 10^{-15} c/ml.

The releases of radioactivity to the cooling water effluents in F and H Areas (a total of 5.3 curies of which 4.9 curies were attributed to F-Area releases) resulted in the increased concentration observed at location 4.

Three high weekly nonvolatile beta concentrations were observed in September, November, and December following reactor discharges in C Area and accounted for 84% of the six-month average at location 5 (C-Area effluent). Approximately one-third of the nonvolatile beta activity released (21 curies) to Four Mile Creek from the C-Area disassembly basin was attributed to isotopes having half lives greater than 15 days (primarily $Ce^{141,144}$).

Analyses for selected specific isotopes are shown as follows.

Radioactivity in Water

	Tritium, 1 × 10^{-12} c/ml			Radioiodine, 1 × 10^{-15} c/ml			Radiostrontium, 1 × 10^{-15} c/ml			Radiocesium, 1 × 10^{-15} c/ml		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg
2	380	248	120	-	-	-	-	-	-	-	-	-
3	46	13*	-	-	-	-	5500	840	600*	1200	280	170
6	910	67	91	120	26	49*	37	11	16	20	7	7

* Five-month average.

PEN BRANCH

Analyses of water and mud samples are shown in the following table.

Location	Alpha Max	Alpha Avg	Alpha Prev Avg	Nonvolatile Beta Max	Nonvolatile Beta Avg	Nonvolatile Beta Prev Avg
	Radioactivity in Water, 1×10^{-15} c/ml					
2	0.8	0.5	0.5	100,000	5300	1200
3	7.5	0.3	0.4	2,700	260	360
	Radioactivity in Mud, 1×10^{-12} c/g					
2	0.8	0.5	0.5	2,800	370	53
3	0.6	0.2	0.3	500	47	17

Approximately 78% of the average concentration of nonvolatile beta in water at location 2 was due to two weekly samples which reflected K-Area reactor discharge releases in August and December. K-Area nonvolatile beta releases to Pen Branch totaled 61 curies, approximately 50% of which was attributed to radionuclides having half lives greater than 15-days (primarily $Ce^{141,144}$).

Analyses for selected specific isotopes follow.

Radioactivity in Water

Location	Tritium, 1×10^{-12} c/ml Max	Avg	Prev Avg	Radioiodine, 1×10^{-15} c/ml Max	Avg	Prev Avg	Radiostrontium, 1×10^{-15} c/ml Max	Avg	Prev Avg	Radiocesium, 1×10^{-15} c/ml Max	Avg	Prev Avg
2	9600	470	-	-	-	-	18	10	62	-	-	14
3	820	80	28	1700	83	150*	66	14	22	44	7	8

* Five-month average.

STEEL CREEK

Analyses of water and mud samples are shown in the following table.

Location	Alpha Max	Alpha Avg	Alpha Prev Avg	Nonvolatile Beta Max	Nonvolatile Beta Avg	Nonvolatile Beta Prev Avg
	Radioactivity in Water, 1×10^{-15} c/ml					
2	1.0	0.7	0.9	11,000	920	350
3	1.2	0.3	0.5	6,600	571	2700
4	1.1	0.2	0.5	1,000	200	530
	Radioactivity in Mud, 1×10^{-12} c/g					
2	2.2	1.0	0.8	54	22	26
3	0.9	0.5	0.4	500	120	110
4	1.2	0.6	0.5	510	73	91

The major portion of the nonvolatile beta activity measured in Steel Creek water at Location 3 (L-Area effluent) resulted from high concentrations (5500×10^{-15} c/ml average) observed during a two-week period in September following reactor discharge. During the entire report period, the estimated total nonvolatile beta release from the L-Area disassembly basin was 29 curies, including 15 curies of long-lived (>15-day half life) fission products (primarily $Ce^{141,144}$) and induced activities.

Of the total contribution from P Area (37 curies) to the nonvolatile beta activity observed at Steel Creek location 2, approximately 10 curies were long-lived isotopes.

Analyses for selected specific isotopes follow.

Location	Tritium, 1×10^{-12} c/ml			Radioiodine, 1×10^{-15} c/ml			Radiostrontium, 1×10^{-15} c/ml			Radiocesium, 1×10^{-15} c/ml		
	Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg
4	200	62	89	120	14	86*	30	8	47	23	9	8

* Five-month average.

PAR POND

Analyses of water and mud samples are shown in the following table.

Location	Alpha Max	Alpha Avg	Alpha Prev Avg	Nonvolatile Beta Max	Nonvolatile Beta Avg	Nonvolatile Beta Prev Avg
	Radioactivity in Water, 1×10^{-15} c/ml					
1	1.0	0.4	0.7	640	180	220
2	0.8	0.2	0.6	220	120	56
3	0.8	0.3	0.8	360	140	67
	Radioactivity in Mud, 1×10^{-12} c/g					
1	0.5	0.2	0.3	343	26	9
2	0.4	*	0.2	17	6	7

* Less than sensitivity of analysis (0.19×10^{-15} c/ml)

R-Area effluent releases are reflected in radioactivity concentrations in Par Pond and Lower Three Runs. Isotopes having half lives greater than 15 days accounted for 11 of the 38 total nonvolatile beta curies discharged from R-Area to Par Pond.

Analyses for selected specific isotopes follow.

	Radioactivity in Water											
	Tritium, 1×10^{-12} c/ml			Radioiodine, 1×10^{-15} c/ml			Radiostrontium, 1×10^{-15} c/ml			Radiocesium, 1×10^{-15} c/ml		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1	250	120	260	31	6	49*	40	12**	21	59	53**	24
2	150	120	110	-	-	-	21	9	7	42	22	12
3	150	120	110	-	-	-	19	10	8	150	32	14

* Five-month average.

** Three-month average.

LOWER THREE RUNS

Analyses of water and mud samples are shown in the following table.

Location	Alpha Max	Alpha Avg	Alpha Prev Avg	Nonvolatile Beta Max	Nonvolatile Beta Avg	Nonvolatile Beta Prev Avg
	Radioactivity in Water, 1×10^{-15} c/ml					
2	0.5	0.2	0.4	140	78	32
3	0.5	*	0.4	85	40	20
	Radioactivity in Mud, 1×10^{-12} c/g					
2	0.5	0.2	0.3	350	20	11
3	0.6	0.2	0.4	22	6	12

* Less than sensitivity of analysis (0.19×10^{-15} c/ml).

Results of analyses for selected specific isotopes follow.

	Radioactivity in Water								
	Tritium, 1×10^{-12} c/ml			Radiostrontium, 1×10^{-15} c/ml			Radiocesium, 1×10^{-15} c/ml		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg
2	110	65	27	14	9	9	32	23	13
3	100	39	14	16	9	6	31	12	8

The radioactivity measured in Lower Three Runs reflects only the discharge from Par Pond.

SAVANNAH RIVER

Samples of river water were collected weekly at the locations shown in figure 4. Continuously collected samples were obtained from locations 2 and 10 throughout the report period. In November, continuous paddle wheel samplers were also installed at locations 3, 5, 8, 9 and 11, making a total of seven locations on the river where continuous sampling is maintained. Monthly mud samples from locations 1 through 9 and weekly samples from locations 10 and 11 were analyzed for TBP extractable alpha.

Analyses of 264 water samples for alpha and nonvolatile beta, 174 mud samples for TBP extractable alpha, and 285 mud samples for nonvolatile beta are summarized in the following tables.

Radioactivity in Water, 1×10^{-15} c/ml

Location	Alpha			Nonvolatile Beta		
	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1	1.2	0.2	0.4	16	6	7
2 (formerly 1A)	0.5	*	0.3	7	*	7
3	0.5	0.2	0.5	8	5	8
4	0.6	0.2	0.5	31	5	9
5	0.6	0.2	0.5	34	10	10
6	0.4	0.2	0.6	27	7	11
7	0.7	0.2	0.5	39	8	9
8	0.6	0.2	0.4	380	74	44
9	0.5	0.2	0.5	53	22	32
10	0.4	*	0.4	98	28	22
11	1.0	0.3	0.4	68	26	15

* Less than sensitivity of analysis (0.19×10^{-15} c/ml, alpha and 4.4×10^{-15} c/ml, nonvolatile beta).

Radioactivity in Mud, 1×10^{-12} c/g

Location	TBP Extractable Alpha			Nonvolatile Beta		
	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1	2.4	2	1.7	26	12	17
2 (formerly 1A)	5.6	10	2.2	21	10	17
3	2.8	2	2.7	26	15	18
4	4.3	2	2.1	35	18	20
5	5.2	3	1.7	27	17	19
6	3.8	1	1.7	26	7	12
7	3.0	2	2.2	37	13	18
8	2.5	2	1.9	32	17	23
9	2.0	0.7	0.9	28	8	12
10	16.0	3	2.5	26	15	18
11	7.0	1	0.8	11	6	5

The maximum nonvolatile beta concentrations observed in water samples from river locations 8 and 10 followed an enriched fuel discharge in L Area in September.

Analyses of water samples for selected specific isotopes are summarized in the following table.

Radioactivity in Water

Location	Tritium, 1×10^{-12} c/ml Max	Avg	Prev Avg	Radioiodine, 1×10^{-15} c/ml Max	Avg	Prev Avg	Radiostrontium, 1×10^{-15} c/ml Max	Avg	Prev Avg	Radiocesium, 1×10^{-15} c/ml Max	Avg	Prev Avg
2 (formerly 1A)	29	5	4	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	13	*	6	13	7	4
9	-	-	-	-	-	-	13	*	4	10	*	4
10	56	11	7	15	6	14	12	*	3	14	6	3
11	46	10	7	-	-	-	12	*	4	12	*	3

* Less than sensitivity of analysis (5.9×10^{-15} c/ml, radiostrontium and 5.3×10^{-15} c/ml, radiocesium).

The average strontium-90 concentrations and the estimated number of curies in river water collected at locations 2 and 10 are shown in the following table.

Radioactivity in River Water

Location	Strontium-90, 1×10^{-15} c/ml Avg	Prev Avg	Strontium-90, curies Total	Prev Total	Apparent Plant Contribution, curies Total	Prev Total
2	0.35	0.45	0.97	3.61	-	-
10	0.68	0.78	1.93	5.95	0.96	2.34

FLOW OF RADIOACTIVITY IN EFFLUENT STREAMS AND RIVER

Results of water samples collected at the Road A intersection of each reactor effluent stream showed the following curies of radioactivity passed these locations. The flow of radioactivity past river locations 2 (Control) and 10 (10 miles downstream from Plant) is presented for comparison.

Radioactivity in Water, curies/6 months

Location	Nonvolatile Beta	Tritium	Radioiodine	Radiostrontium	Radiocesium
Four Mile Creek (Location 6)	34.1	3,700	3.5	1.1	[illegible]
Pen Branch (Location 5)	30.7	[illegible]	[illegible]	1.9	[illegible]
Steel Creek (Location 4)	[illegible]	17,000	5.6	[illegible]	1.5
Lower Three Runs (Location 3)	3.5	2,400	-	0.5	[illegible]
Total at Road A Locations	→ [illegible]	32,000	[illegible]	[illegible]*	[illegible]
River 2	19.9	3,000	-	-	-
River 10	86.3	29,700	-	-	-
Apparent Plant Contribution					
At Road A Stream Locations**	97.0	32,000	-	-	-
At River 10	67.4	26,700	-	-	-

* Includes 1.3 curies of Sr-90 distributed as follows: Four Mile 6, 0.2 curie; Pen Branch 5, 0.2 curie; Steel Creek 4, 0.7 curie; and Lower Three Runs 0.2 curie.

** Compensation was made for the estimated volume of river water used by the Plant facilities in calculating the Plant contribution at the Road A stream locations.

CHEMICAL WATER QUALITY OF LOWER THREE RUNS CREEK AND SAVANNAH RIVER WATER

The following table shows the water quality analyses of the Savannah River both upstream (location 2) and downstream (location 10) from the Plant site during the past six months. Water quality analyses at location 3 on Lower Three Runs Creek are also presented. All data except those for dissolved oxygen and BOD (biochemical oxygen demand) represent the average analyses of composite water samples which are collected weekly. The dissolved oxygen and BOD values reflect the average of weekly determinations at the time of collection.

Chemical Quality of Water

	Lower Three Runs			River Upstream			River Downstream		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
Color (APHA)	35	15	24	25	10	18	30	10	[illegible]
pH	9.7	7.1	8.1	10	7.1	8.3	8.3	7.0	8.4
Methyl Orange, ppm $CaCO_3$	50	2.7	24	48	13	18	26	7.8	17
Dissolved Oxygen, ppm	12	6.2	8.8	12	6.1	9.0	15	6.5	9.7
Sulfide, ppm S	0.2	0	0.2	0.2	0	<0.2	0.2	[illegible]	0.2
Hardness, ppm $CaCO_3$	37	14	25	13	7.8	10	16	[illegible]	12
Conductivity, µmhos	82	7.9	66	78	36	46	64	35	43
Total Iron, ppm Fe	0.68	0.06	0.25	0.40	0.05	0.19	0.90	0.06	0.24
Total Dissolved Solids, ppm	70	36	52	71	23	35	51	[illegible]	33
Chloride, ppm Cl	11	0.23	3.6	8.2	0.92	2.4	10	0.8	2.5
Nitrate, ppm N	0.04	0.01	0.04	0.08	0.04	0.04	0.16	0.03	0.04
Sulfate, ppm SO_4	5.7	2.0	2.5	4.8	2.0	2.8	6.4	2.0	3.3
Nitrite, ppm N	0.005	0.001	0.001	0.007	0.001	0.001	0.002	0.001	0.001
Lignin, ppm	8.0	1.2	3.4	[illegible]	1.1	1.8	12	0.80	2.4
Surfactant, ppm	0.09	0.02	0.05	0.04	0.02	0.03	0.07	0.02	0.05
BOD, ppm	4.0	0	1.1	4.9	0	0.37	5.4	0	1.0

DISSOLVED OXYGEN PROFILES

SAVANNAH RIVER. Quarterly dissolved oxygen surveys of the Savannah River were made in September and December to obtain dissolved oxygen profiles during periods of low river flow. The sample locations extended from the Butler Creek entry to the Highway 301 bridge. The dissolved oxygen content in river water decreased slightly during a period of median temperature and low flow (September 30, 1960). No significant decreases were observed in the oxygen concentrations of river water as it passed the Plant site during a period of low temperature and low flow (December 16, 1960). The data in the following table show that the oxygen content in river water is normal for a stream not adversely affected by pollution and that the oxygen content is not changed significantly due to Plant use of river water.

Location	River Mile	September 30 Dissolved Oxygen, ppm	September 30 Water Temp, °C	December 16 Dissolved Oxygen, ppm	December 16 Water Temp, °C
Butler Creek	203	8.1	22	10.9	11
Spirit Creek	198	8.2	22	10.6	11
Silver Bluff	189	8.2	22	10.8	11
Grays Landing	184	8.2	22	10.9	11
River (Location 2)	175	8.4	23	11.0	10
Hancock Landing	165	7.4	23	10.9	10
Griffin Landing	160	7.4	23	10.9	10
Brighams Landing	157	7.2	23	10.9	10
Steel Creek	155	7.0	26	9.8	12
Little Hell Landing	144	6.9	24	11.1	10
Lower Three Runs	140	6.7	24	11.8	8
Johnsons Landing	135	6.8	24	11.2	10
Highway 301	129	7.1	24	11.0	10

REACTOR EFFLUENTS. The dissolved oxygen content of each reactor effluent is measured weekly at the Road A sample locations to determine the minimum dissolved oxygen content in water returned to the river. Compensation is made for water temperature variations in calculating the percent saturation. Dissolved oxygen data obtained during the report period are presented in the following table.

Dissolved Oxygen Content of Reactor Effluents

Effluent	Dissolved Oxygen, ppm Minimum	Dissolved Oxygen, ppm Average	Percent Saturation Average
Upper Three Runs (Control)	6.5	9.1	94
Four Mile Creek	4.8	6.1	97
Pen Branch	4.3	5.8	98
Steel Creek	4.9	6.1	99
Lower Three Runs	6.2	8.6	90

Plant Drinking Water

Samples of drinking water were collected monthly from operating areas and quarterly from other domestic water systems. Analyses of 138 samples are summarized in the following table.

	Radioactivity in Water					
	Alpha, 1×10^{-15} c/ml			Nonvolatile Beta, 1×10^{-15} c/ml		
Location	Max	Avg	Prev Avg	Max	Avg	Prev Avg
F Area	8.0	4.3	6.7	45	26	22
H Area	6.7	4.8	4.6	38	24	25
300/700 Area	2.0	1.4	0.8	13	8	7
400 Area	1.8	1.1	1.2	11	8	7
TNX	1.0	0.7	0.9	10	7	9
Pump House 1*	0.7	0.6	0.8	7	5	12
Pump House 2*	0.5	0.5	0.7	7	5	7
R Area	0.6	0.3	0.2	7	3	9
P Area	1.3	0.5	0.6	19	8	8
L Area	0.2	**	0.5	8	6	7
K Area	0.5	**	0.3	11	5	7
C Area	0.3	**	0.2	14	4	7
Par Pond - Pump House	0.6	0.2	0.2	13	5	8
TC-1	3.8	3.1	2.8	12	10	9
Classification Yards	0.8	0.6	0.5	7	**	7
Central Shops	0.7	0.5	0.5	9	6	7
Barricade 1	0.9	0.8	1.8	**	**	7
Barricade 2	37	33	6.2	57	52	28
Barricade 3	0.2	0.2	0.1	5	4	7
Barricade 4	3.0	2.9	3.8	7	6	7
Barricade 5	0.2	**	0.2	**	**	7
Donora Station Well	0.2	**	0.2	11	5	7
Burial Ground Domestic Well	0.4	0.2	0.3	8	**	7

* Analyses of drinking water samples showed no detectable tritium concentration.

** Less than sensitivity of analysis (0.19×10^{-15} c/ml, alpha and 4.4×10^{-15} c/ml, nonvolatile beta).

As in the past, the comparatively high alpha and beta activity found in F Area, H Area and Barricade 2 drinking water was attributed primarily to natural occurring radioactivity.

Public Water Supplies

Samples of public drinking water were collected monthly from the 14 surrounding towns shown in figure 1. Analyses of 98 samples collected during the report period are summarized in the following table.

Location	Alpha, 1×10^{-15} c/ml Max	Avg	Prev Avg	Nonvolatile Beta, 1×10^{-15} c/ml Max	Avg	Prev Avg
Allendale	*	*	0.2	7.7	*	7
Sardis	*	*	0.1	9.6	4.8	8
Waynesboro	0.20	*	0.2	7.2	*	7
Augusta	*	*	0.2	7.0	*	7
North Augusta	0.41	*	0.4	6.5	*	7
Clearwater	0.61	0.21	0.4	7.7	4.5	8
Bath	3.2	1.6	2.4	9.6	7.0	9
Langley	1.9	1.6	1.8	10.0	7.5	7
Jackson	4.0	3.2	3.1	9.0	6.9	8
New Ellenton	0.86	0.5	0.8	7.4	4.8	7
Aiken	1.4	1.1	1.1	6.2	*	8
Williston	1.2	0.9	0.8	6.3	4.6	7
Blackville	0.4	0.2	0.2	7.2	*	7
Barnwell	0.33	0.2	0.2	10.8	*	7

Radioactivity in Water

* Less than sensitivity of analysis (0.19×10^{-15} c/ml, alpha and 4.4×10^{-15} c/ml, nonvolatile beta).

Public drinking water samples contained no detectable tritium concentrations.

Ground Water

Ground water was monitored by analysis of water samples collected from drilled, cased wells near F and H Areas (Z and ZW wells) and at the burial ground. Locations of the wells are shown in figures 5, 6 and 7.

Z WELLS

Results of 21 samples of ground water collected from twelve Z wells, 20 samples from ten ZW wells, and 44 samples from nine burial ground wells are shown in the following table.

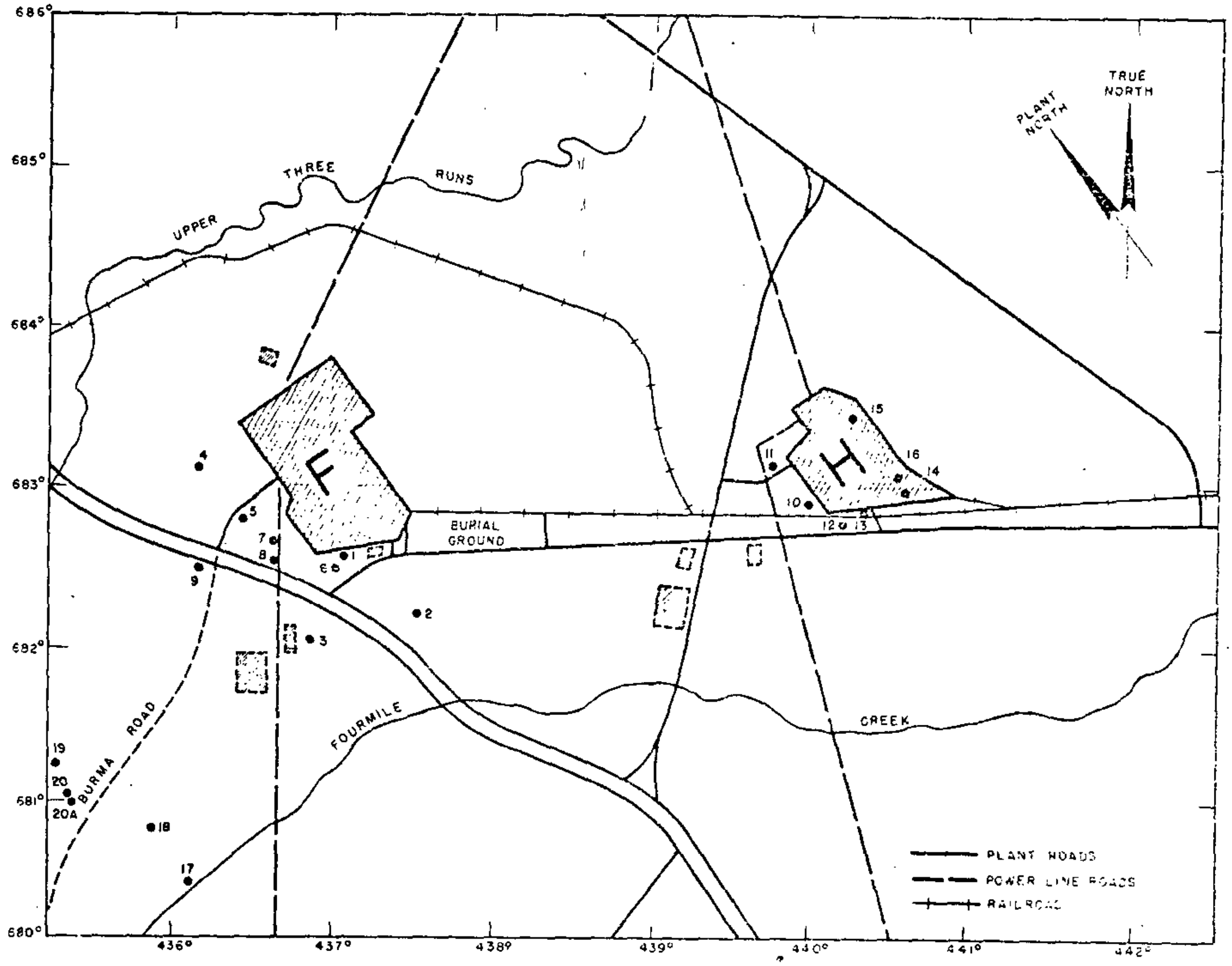

FIGURE 5. Z WELL LOCATIONS

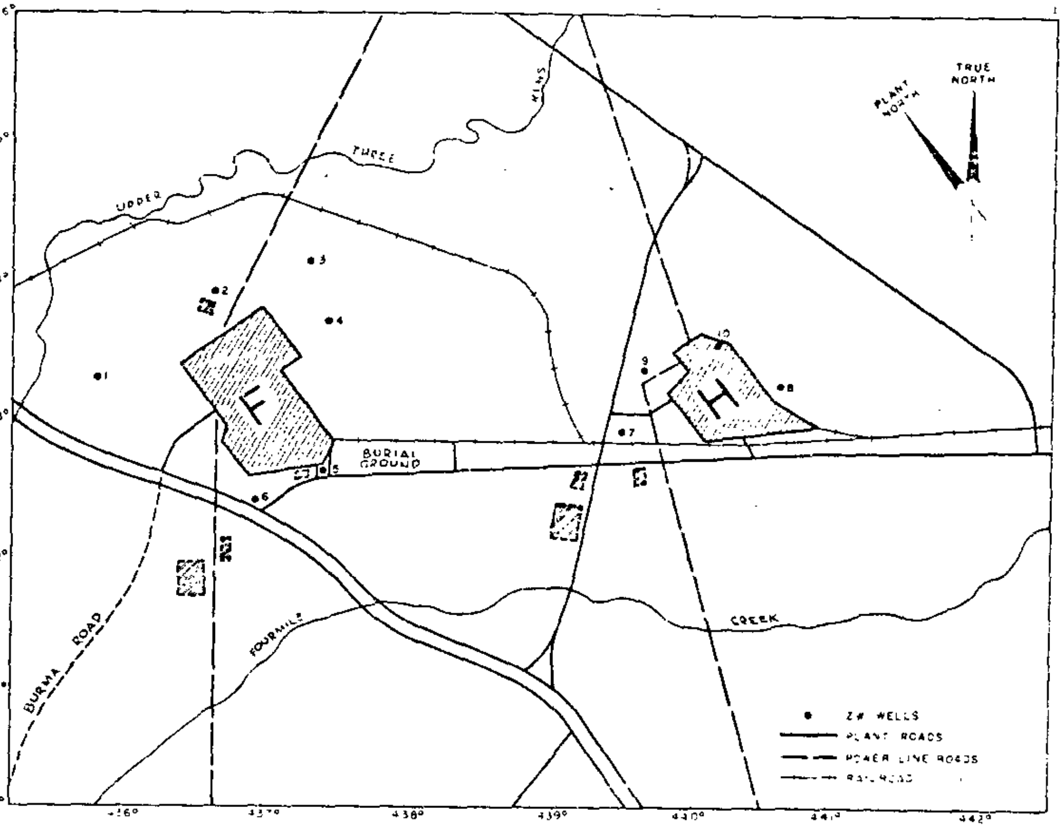

FIGURE 6. ZW WELLS, F AND H AREAS

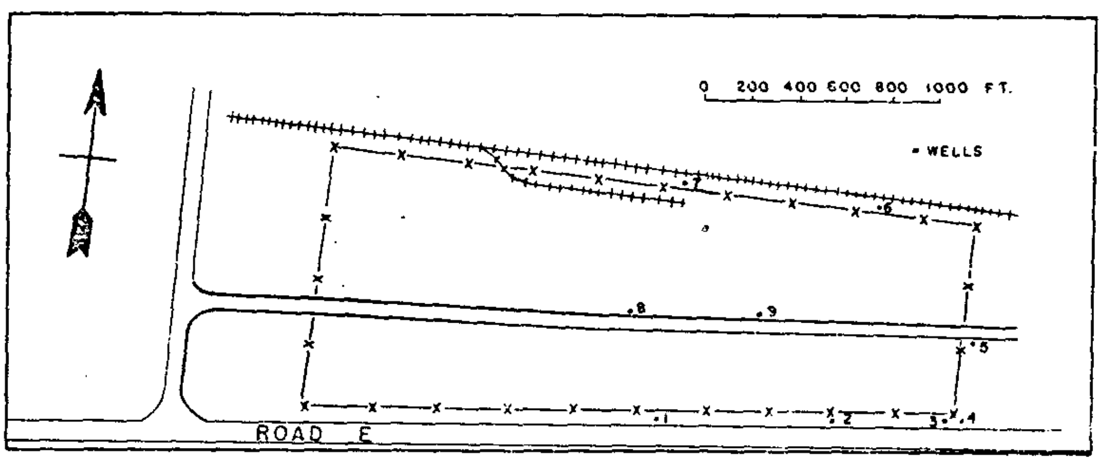

FIGURE 7. BURIAL GROUND WELLS

Tritium in Ground Water, 1×10^{-12} c/ml

Well No.	Z Wells Max	Z Wells Avg	Z Wells Prev Avg	ZW Wells Max	ZW Wells Avg	ZW Wells Prev Avg	Burial Ground Wells Max	Burial Ground Wells Avg	Burial Ground Wells Prev Avg
1	18	14	24	4	4	4	27	10	5
2	4	4	10	7	5	4	44	12	5
3	4	4	4	32	27	34	5	4	4
4	*	*	*	41	35	42	180	130	190
5	*	*	*	32	31	51	45	37	37
6	*	*	*	47	40	57	24	11	5
7	*	*	*	32	28	120	5	4	4
8	16	12	11	31	17	4	100	76	4
9	20	20	*	98	58	46	27	8	6
10	*	*	*	26	15	4	-	-	-
11	47	47	64	-	-	-	-	-	-
12	8	8	16	-	-	-	-	-	-
13	4	4	6	-	-	-	-	-	-
14	*	*	*	-	-	-	-	-	-
15	100	94	99	-	-	-	-	-	-
16	*	*	*	-	-	-	-	-	-
17	3	3	4	-	-	-	-	-	-
18	30	23	26	-	-	-	-	-	-
19	*	*	4	-	-	-	-	-	-
20	4	4	4	-	-	-	-	-	-
20A	*	*	*	-	-	-	-	-	-

* Water sample unobtainable.

ZW WELLS, F AND H AREAS

Analyses of 20 samples are summarized in the following table.

Radioactivity in Ground Water

Location	Alpha, 1×10^{-15} c/ml Max	Alpha Avg	Alpha Prev Avg	Nonvolatile Beta, 1×10^{-15} c/ml Max	Nonvolatile Beta Avg	Nonvolatile Beta Prev Avg
1	0.7	0.6	0.6	5	5	7
2	0.4	0.2	0.8	31	18	7
3	0.9	0.5	0.8	7	6	7
4	0.4	0.4	0.7	10	6	7
5	0.4	0.3	0.8	6	*	8
6	0.6	0.4	0.5	6	*	7
7	*	*	0.4	*	*	8
8	0.3	0.3	0.5	6	5	8
9	0.4	0.2	0.8	7	6	8
10	1.4	1.1	0.8	10	9	8

* Less than sensitivity of analysis (0.19×10^{-15} c/ml, alpha and 4.4×10^{-15} c/ml, nonvolatile beta).

BURIAL GROUND WELLS

Analyses of 55 samples are summarized in the following table.

Radioactivity in Ground Water

Location	Alpha, 1 × 10^{-15} c/ml			Nonvolatile Beta, 1 × 10^{-15} c/ml		
	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1	0.4	0.3	0.4	28	10	7
2	0.6	0.3	0.5	7	5	8
3	0.7	0.3	0.5	8	5	7
4	1.4	0.8	0.7	21	8	7
5	0.4	0.3	0.4	18	8	7
6	0.6	0.3	0.4	8	6	7
7	0.6	0.3	0.4	14	7	8
8	1.4	0.6	1.2	35	12	9
9	0.4	0.3	0.4	12	6	8

Seepage Basins

100 AREAS

Alpha activity discharged to the 100-Area seepage basins was negligible. Nonvolatile beta activity discharged to the basins is shown in the following table.

Nonvolatile Beta Discharged to 100-Area Seepage Basins, curies

Area →	R	P	L	K	C
Total	0	3	0.7	0	2.5
Previous Total	0	58	1.5	3.1	61

R AREA. The containment program to minimize future migration of radioactivity from the R-Area seepage basin system began in October. This program may be briefly described as follows:

- Denudation of the seepage basin area and treatment with herbicide to prevent growth of all vegetation.
- Backfilling and capping of the open basins to eliminate the hydraulic head feeding of underground water movement.
- Construction of a clay dike around basin 1 and the north end of basin 5 in an effort to retain the radioactive waste by ion exchange.

During this report period the radioactivity stabilization program progressed through the backfilling and capping of basins 2, 3, and

4. Clayey sands from the abandoned construction parking lot were placed in the bottoms of the basins followed by a layer of more sandy soils to absorb the displaced water. A sandy clay soil for capping the basin system was obtained from a borrow pit near L Area. Construction of a clay dike was initiated. Basin 5 was left open for disposal of radioactive soil that may be encountered during the evacation of the trench for the dike.

The R-Area seepage basins and monitoring wells are shown in figure 8. Nonvolatile beta concentrations in basin water are shown in the following table. Reported averages for basins 2, 3, and 4 represent samples collected prior to October when these basins were backfilled.

	Nonvolatile Beta in Water, 1×10^{-10} c/ml				
	Basin 2	Basin 3	Basin 4	Basin 5	Basin 6
Avg	1.1*	1.3**	0.8**	1.4**	0.3
Previous Avg	4	2	1	2	0.2

* Four-week average.
** Fourteen-week average.

The Sr-90 concentrations measured in seepage basin water are shown in the following table.

	Sr-90 in Water, 1×10^{-10} c/ml			
	Basin 2	Basin 3	Basin 4	Basin 5
Avg	0.8*	0.9**	0.6†	0.5†
Previous Avg	2	0.9	0.5	0.7

* One sample.
** Three-month average.
† Four-month average.

The maximum nonvolatile beta concentration observed in 225 water samples collected from permanent monitoring wells located near the seepage basins was $35,000 \times 10^{-15}$ c/ml in well A-5. This well is located 50 feet from basin 3. The maximum concentration observed in wells more distant than 50 feet from the basins was 110×10^{-15} c/ml in well C-1, 500 feet west of basins 2 and 3. These concentrations represent decreases from levels observed during the previous 6-month period, when maximum concentrations were $45,000 \times 10^{-15}$ c/ml in the 50-foot distant wells and 200×10^{-15} c/ml in the more distant wells.

P AREA. Releases of radioactivity to the P-Area seepage basins resulted from handling of Chalk River reactor components.

L AREA. Radioactivity released to the L-Area seepage basin resulted from flushing of a purification filter change tank.

K AREA. No radioactivity was released to the K-Area seepage basin.

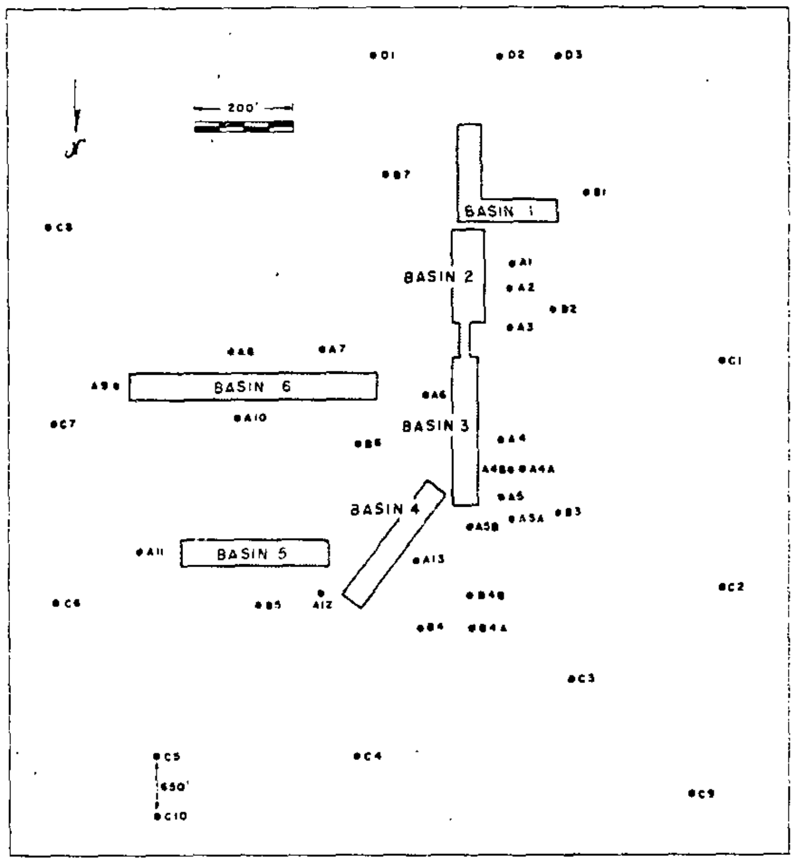

FIGURE 8. R-AREA SEEPAGE BASINS AND MONITORING WELLS

C AREA. Releases of radioactivity to the C-Area seepage basin resulted from vacuum cleaning of the monitor basin in which failed fuel element disassembly was completed.

700 AREA. Waste discharged to the 700-Area seepage basins included approximately 16 mc alpha and 48 mc nonvolatile beta in 2.81×10^6 liters of water. Analyses of 5 water samples collected during the report period are summarized in the following table.

Radioactivity in Water

Alpha, 1×10^{-12} c/ml			Nonvolatile Beta, 1×10^{-12} c/ml		
Max	Avg	Prev Avg	Max	Avg	Prev Avg
0.72	0.32	0.28	4.4	2.1	2.3

TNX

TNX and CMX discharge waste to a seepage basin which overflows to the Savannah River. Analyses of 25 water samples collected from the basin are summarized in the following table.

Radioactivity in Water

Alpha, 1×10^{-12} c/ml			Nonvolatile Beta, 1×10^{-12} c/ml		
Max	Avg	Prev Avg	Max	Avg	Prev Avg
9.6	3.2	6.0	40	13	16

200 AREAS

The F and H seepage basin and monitoring well systems are shown in figure 9.

F AREA. The average liquid input to the basin system was 4.9×10^5 liters/day of waste and 0.64×10^5 liters/day of rain. The average seepage and evaporation rate was 6.1×10^5 liters/day.

Waste released to the system is shown in the following table.

Radioactivity Released in 8.90×10^7 Liters of Water

	Alpha Emitters, mc			Beta Emitters, c	
	Total	Prev Total		Total	Prev Total
Uranium	320	298	$Ru^{103,106}$	86.1	54.3
Plutonium		396	$Sr^{89,90}$	31.1	0.7
	-	-	$Zr\text{-}Nb^{95}$	50.0	98.7
	-	-	$Ce^{141,144}$	70.5	7.3
	-	-	Cs^{137}	6.3	0.6
	-	-	I^{131}	1.6	3.3
Total →	320	694		245.6	164.9

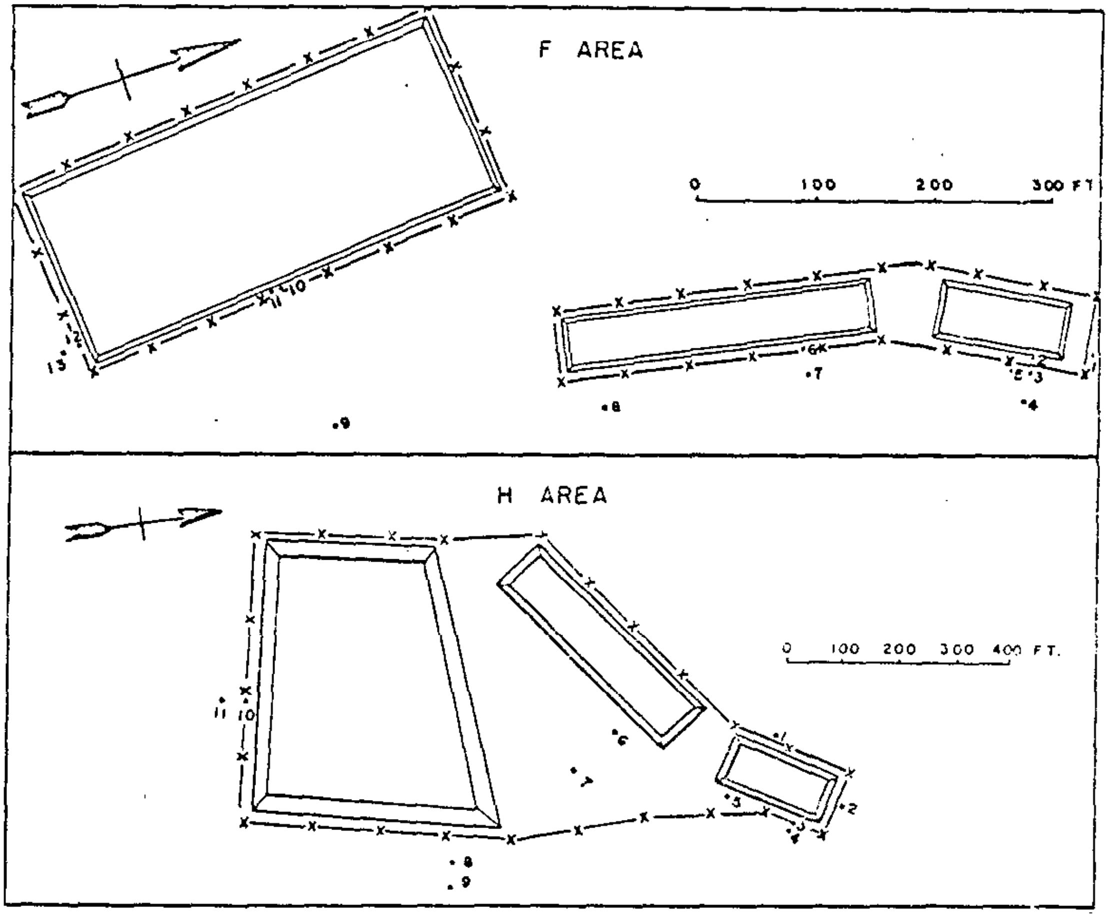

FIGURE 9. SEEPAGE-BASIN MONITORING WELLS IN F AND H AREAS

Analyses of 78 samples collected from the basins are summarized in the following table.

Radioactivity in Water

Basin No.	Alpha, 1×10^{-12} c/ml Max	Avg	Prev Avg	Nonvolatile Beta, 1×10^{-12} c/ml Max	Avg	Prev Avg	Radioiodine, 1×10^{-12} c/ml Max	Avg	Prev Avg
1	41	7.9	14	3300	860	2900	210	25	79
2	11	5.2	11	740	480	1500	10	4.6	21
3	5.7	4.2	8	390	280	680	6.7	4.0	-

H AREA. The average liquid input to the basin system was 1.3×10^5 liters/day of waste and 0.43×10^5 liters/day of rain. The average seepage and evaporation rate was 1.8×10^5 liters/day.

Waste released to the system is shown in the following table.

Radioactivity Released in 2.37×10^7 Liters of Water

	Alpha Emitters, mc Total	Prev Total		Beta Emitters, c Total	Prev Total
Uranium	63	9	$Ru^{103,106}$	4.7	12.7
Plutonium		9	$Sr^{89,90}$	0.17	0.3
	-	-	$Zr\text{-}Nb^{95}$	4.4	31.3
	-	-	$Ce^{141,144}$	0.81	4.4
	-	-	Cs^{137}	0.81	0.4
	-	-	I^{131}	0.02	0.3
Total	63	18		10.9	49.4

Analyses of 78 water samples collected from the basin are summarized in the following table.

Radioactivity in Water

Basin No.	Alpha, 1×10^{-12} c/ml Max	Avg	Prev Avg	Nonvolatile Beta, 1×10^{-12} c/ml Max	Avg	Prev Avg	Radioiodine, 1×10^{-12} c/ml Max	Avg	Prev Avg
1	27	4	0.12	1300	860	510	7.4	3.6	4.2
2	0.6	.23	0.34	200	71	340	5.2	1.8	-
3	0.31	0.20	0.47	30	27	57	0.8	.39	-

MONITORING WELLS, F AREA. Analyses of 72 samples are summarized in the following table.

		Radioactivity in Water								
		Alpha, 1×10^{-15} c/ml			Nonvolatile Beta, 1×10^{-15} c/ml			Radiostrontium, 1×10^{-15} c/ml		
Well No.	Distance from Basin, ft	Max	Avg	Prev Avg	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1*	34	6800	1800	528	380,000	300,000	82,000	5,000	1000	9,000
2	5	0.9	0.7	1.4	130	93	88	-	-	-
3	29	0.4	0.2	0.3	1,400	700	34	-	-	-
4	73	0.51	0.2	0.5	1,500	350	35	-	-	-
5*	24	**	**	0.4	16,000	9,500	1,300	-	-	-
6*	6	5500	1100	100	430,000	100,000	30,000	54,000	4200	8,000
7*	46	810	500	100	27,000	19,000	3,300	7,300	4400	800
8	63	1.0	0.6	0.7	15.6	10	8	-	-	-
9	150	1.7	0.6	0.4	101	29	6	-	-	-
10*	9	730	410	3000	190,000	110,000	200,000	8,900	3200	14,000
11	9	1.6	1.1	0.3	44	33	14	-	-	-
12*	29	720	320	2400	88,000	66,000	120,000	12,000	3500	14,000
13*	58	1000	440	2200	67,000	58,000	73,000	6,100	2900	11,000

* Wells into perched water table.

** Less than sensitivity of analysis (0.19×10^{-15} c/ml, alpha).

Continued high concentrations of nonvolatile beta were observed in the perched water table underneath the F-Area seepage basins. Specific chemical analyses indicated that approximately 5% of the nonvolatile beta activity was attributable to radiostrontium.

MONITORING WELLS, H AREA. Analyses of 77 samples are summarized in the following table.

		Radioactivity in Water					
		Alpha, 1×10^{-15} c/ml			Nonvolatile Beta, 1×10^{-15} c/ml		
Well No.	Distance from Basin, ft	Max	Avg	Prev Avg	Max	Avg	Prev Avg
1	24	40	20	20	26,000	8,000	1,100
2	25	0.76	0.49	0.5	29	18	7
3	15	0.65	0.40	0.4	382	130	200
4	45	0.65	0.43	0.4	12	8	3
5*	13	40	20	25	42,000	15,000	14,000
6	6	0.85	0.36	0.3	220	130	110
7	63	0.85	0.40	0.3	12	7	7
8	18	1.2	0.36	0.3	73	43	60
9	75	0.39	0.22	0.4	15	17	11
10	19	0.72	0.36	0.3	18	15	10
11	79	**	**	0.2	240	170	110
A-37	-	5.3	2.5	2.8	640	440	1,000
A-38	-	4.4	3.5†	4.6	890	820†	1,000
A-39	-	2.6	2.0†	2.2	670	340†	850
A-40	-	1.3	0.75†	0.5	1,100	310†	200
A-41	-	1.6	0.95†	0.5	730	620†	260

* The average concentration of Sr-90 in well 5 was 3×10^{-12} c/ml. The maximum concentration was 12×10^{-12} c/ml.

** Less than sensitivity (0.19×10^{-15} c/ml, alpha).

† Average of 3 months samples.

Wells A-37 through A-41 are located about $12\frac{1}{2}$ feet apart, a few feet uphill from a swamp bordering the H-Area effluent. They were installed in the zone of the most rapid movement of seepage basin water into the swamp. Tritium was detected in all of these wells. The average concentration from analyses of 38 samples was 5×10^{-8} c/ml with a maximum of 8×10^{-8} c/ml. Specific chemical analyses of water from well A-37 indicated a $Sr^{89,90}$ average concentration of 0.1×10^{-12} c/ml as compared with a 0.3×10^{-12} c/ml average during the previous 6-month period.

Upper Tank Farm, Building 241-H

On September 8, the level of radioactive liquid in the annulus of tank 16, approached the top of the containment saucer. Rate-of-rise calculations indicated an apparent loss of 500 to 1000 gallons or a maximum of 5000 curies from the annulus.

Static ground water levels of existing monitoring wells near tank 16 indicated a 0.06% water table gradient in a west-northwest direction. Since the pre-existing monitoring wells were 40 feet from the tank 16 encasement, a considerable period of time would be expected to elapse before the radioactivity could be detected in the ground water at these locations (assuming a loss of radioactivity from the tank encasement). To deliniate the direction of any outward movement of radioactivity from tank 16 at 241-H, fifty-six monitoring wells were installed in the vicinity of the tank.

Four 4" diameter test wells (HP wells 1, 3, 5 and 8; see figure 10) were drilled 5 feet from the tank 16 encasement down to the concrete working pad which is under and common to tanks 13, 14, 15, and 16. Each well was cased and continuous pumping was initiated in the downgradient well (HP3) on September 23. Substantial concentrations of radioactivity were detected in well HP3 after 12 days of continuous pumping. The nonvolatile beta activity in this well reached a maximum level of 860×10^{-12} c/ml during the latter part of November and decreased to 150×10^{-12} c/ml by the end of December.

Following the detection of radioactivity in well HP3, twenty-one additional wells (see figure 10), spaced at 13-foot intervals, were drilled on a circumference one foot from the tank 16 encasement. Ten wells were drilled at 4-foot intervals on either side of wells 7 and 12 because mastic removed from the surface of the concrete working slab during drilling operations on these wells was contaminated. No significant activity was detected in water samples collected from these wells.

To eliminate tank 14 as a possible source of the activity found in well HP3, three test holes (HP3A, B, and C, figure 11) were drilled between tank 14 and HP3. Water collected from these wells revealed no activity. Six additional wells (3-1 through 3-6 as shown in figure 11) installed at approximately 2-foot intervals on a circumference 2 feet from well HP3 contained no unusual amounts of radioactivity.

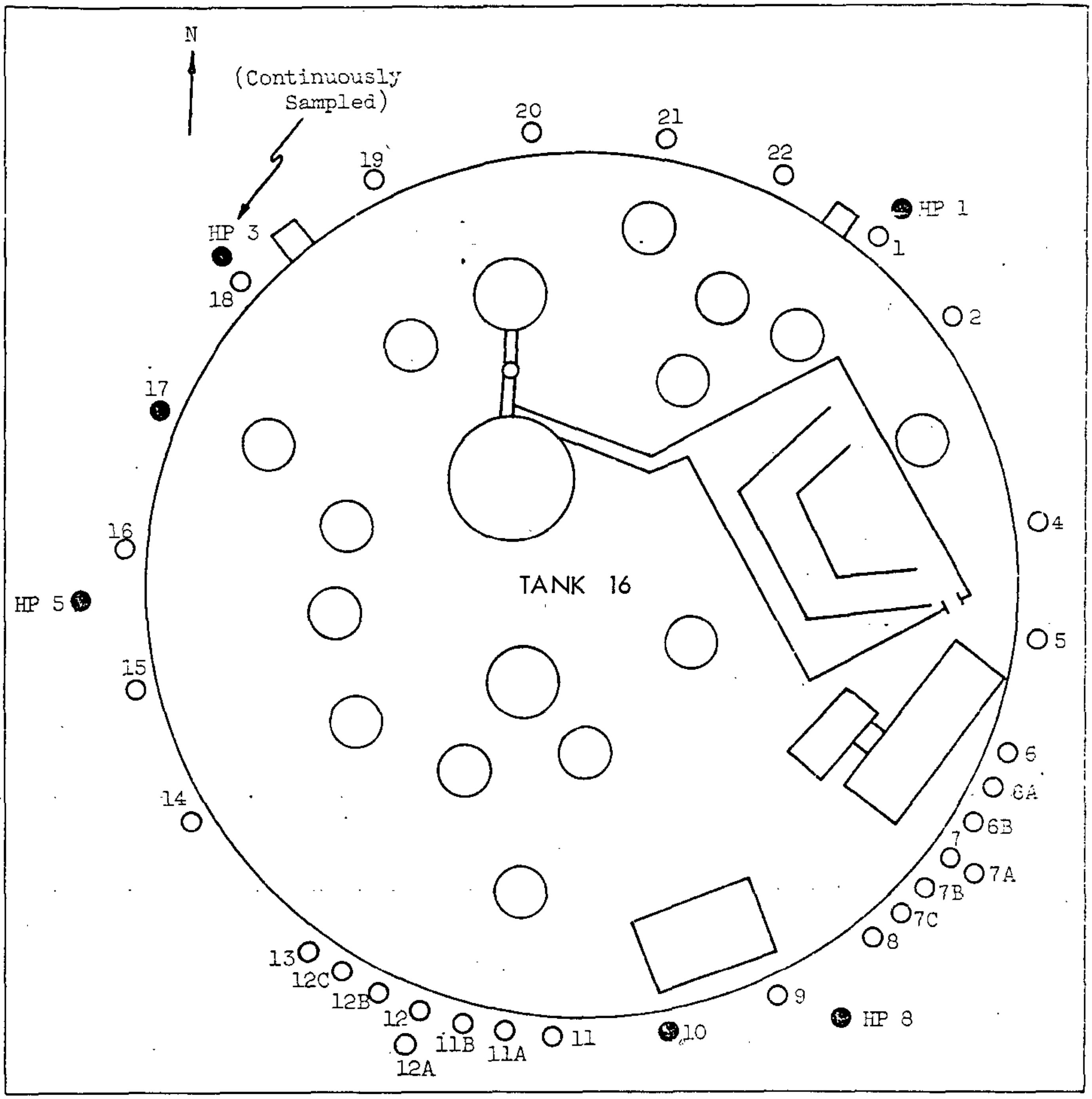

FIGURE 10. MONITORING WELLS AT TANK 16, BUILDING 241-H

● Cased Wells

○ Uncased Wells

HP Wells 5' From Tank

24-Series Wells 1' From Tank

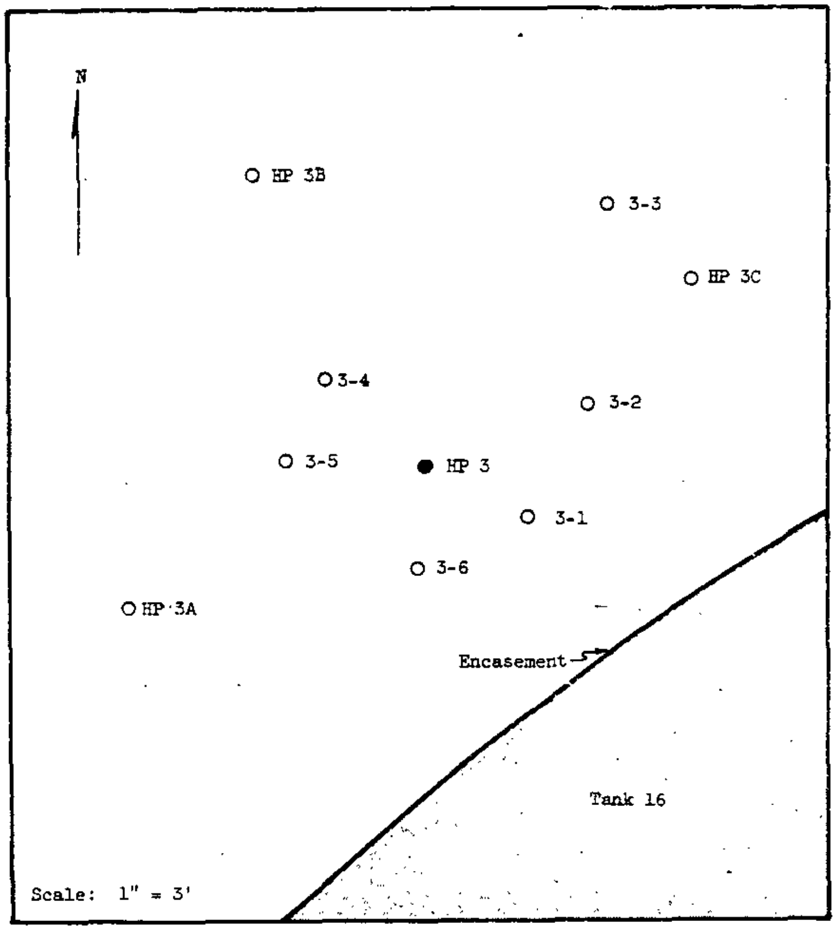

FIGURE 11. LOCATION OF BUILDING 241-H WELLS

●	Cased - continuously sampled
○	Cased with 10' well points - sampled daily

The soil shrinkage system underlying tanks 13, 14, 15 and 16 was sampled to determine if downward movement of radioactivity had occurred. Analyses of water collected from riser 2 (see figure 12) indicated that ground water in the soil shrinkage system was contaminated to levels approaching 1×10^{-6} c/ml.

Twelve monitoring wells (HPM wells, figure 12) were installed at the perimeter of the concrete working pad (Upper Tank Farm). The weekly average nonvolatile beta concentration in these wells has not exceeded 70×10^{-15} c/ml.

While the nonvolatile beta activity in two pre-existing wells (TW3 and 4, figure 12), reached maximum weekly averages of 600×10^{-15} and 1300×10^{-15} c/ml, respectively, neglible concentrations of radioactivity were observed in water collected weekly from a pre-existing test well situated in the center of the Lower Tank Farm. The radioactivity measured in semiweekly H-Area drinking water samples remained at essentially the same level (19×10^{-15} c/ml, average) as was observed in past years.

Pulse height analyses of ground water samples collected from well HP3 and the soil shrinkage system revealed a Cs-137 to Cs-134 ratio of approximately 8 to 1. Calculation of the Cs-137 and Cs-134 production rates in reactor (Cs-134 is produced from Cs-133, a fission product, by neutron capture) indicates a ratio of Cs-137 to Cs-134 in waste tanks 13 and 14 of greater than 20 to 1. The wastes which were in tank 16 should have a Cs-137 to Cs-134 ratio approaching 9 to 1 (assuming a decay time of 1 year).

In order to minimize the outward movement of radioactivity, a Test Authorization was prepared to continuously pump the soil shrinkage system from the center of the system (riser 5) thus creating a cone of depression in the water table in the vicinity of the tank. Drawdown of the water table will be limited to the level of the soil shrinkage system. Since discharge of the water from the soil shrinkage system directly to the seepage basin system could result in waste releases up to 20 curies/month (the limit for seepage basin discharges under DPSTS RH-W-221.03), the pump discharge will be passed through closed drums of nonexpanded vermiculite (a natural ion exchange media). The treated water will then be discharged to the seepage basins.

Biological Specimens

TERRESTRIAL

Following the detection of high radioactivity levels in domestic cats at R Area in early 1960, the terrestrial animal monitoring program was expanded to determine the extent of radioactivity uptake

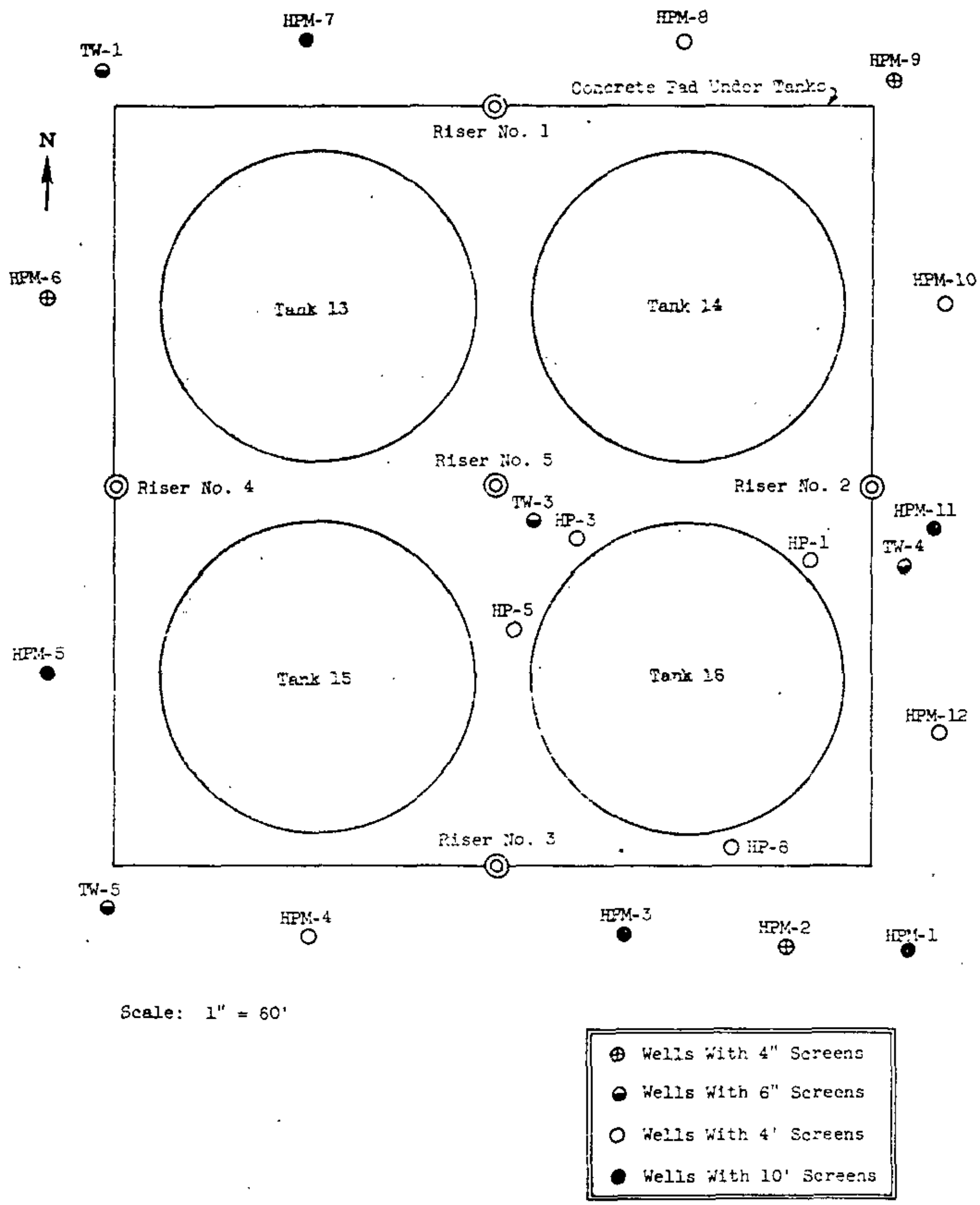

FIGURE 12. BUILDING 241-H UPPER TANK FARM

by wildlife within a half-mile radius of the R-Area seepage basins. The data collected throughout 1960 are shown in the following table. Radiocesium ($Cs^{134,137}$) and radiostrontium ($Sr^{89,90}$, and Y-90) were the predominant isotopes found in the flesh and bones, respectively.

Radioactivity in Animals Collected Near R-Area Seepage Basins

Species	No. of Samples	Nonvolatile Beta, 1×10^{-12} c/g Bone Max	Bone Avg	Flesh Max	Flesh Avg
Domestic Cat	5	30,000	14,000	20,000	4800
Mice	3	11,000	5,800	6,400	3100
Racoon	9	1,300	210	10	8
Fox	12	1,200	130	65	10
Opossum	1	-	130	-	3
Rat	2	110	75	40	35
Rabbit	11	100	40	20	7
Bobcat	2	25	20	15	10
Dog	3	30	15	5	5

Nonvolatile beta concentrations found in terrestrial animals collected at random from the Plant site are shown in the following table.

Radioactivity in Animals Collected at Random from the Plant Site

Species	No. of Samples	Nonvolatile Beta, 1×10^{-12} c/g Bone Max	Bone Avg	Flesh Max	Flesh Avg
Domestic Cat	3	45	30	4	3
Beaver	1	-	30	-	2
Rabbit	10	40	20	15	5
Racoon	3	25	20	15	10
Fox	1	-	20	-	3
Bobcat	2	15	10	4	3
Deer	2	15	10	4	3

AQUATIC

A total of 889 aquatic samples, including 601 fish, 280 algae samples and 8 clams were collected from the reactor effluents and the Savannah River. The algae and fish collected from the reactor effluents were radioanalyzed to determine the maximum uptake of Plant contributed radioactivity by aquatic specimens. Savannah River algae and fish were routinely collected to determine concentrations of radioactivity contained in aquatic specimens accessible to the public.

REACTOR EFFLUENT. Radiostrontium (Sr-89, Sr-Y^{90}) was the primary beta emitter in the bones of fish collected from all four reactor effluents. Radiozinc (Zn-65) and radiocesium (Cs-134, Cs-137) were the main gamma emitters present in the bones and fleshy tissues. In Par Pond and Lower Three Runs (R-Area effluent), radiocesium was the primary isotope in the bones and flesh. In Steel Creek (L, P, and K-Area effluents), radiozinc was the predominant isotope. In fish collected from Four Mile Creek (C-Area effluent), trace concentrations of radiozinc were present in the bones and fleshy tissues. No significant concentrations of radiocesium were found in Four Mile Creek fish.

The nonvolatile beta concentrations in both the bones and flesh of Steel Creek and Lower Three Runs fish decreased. The concentrations in Par Pond fish remained essentially the same as reported last period, as shown in the following table.

		Nonvolatile Beta in Effluent Fish, 1×10^{-12} c/g					
		Bones			Flesh		
Location	No. of Samples	Max	Avg	Prev Avg	Max	Avg	Prev Avg
Upper Three Runs (Control)	7	25	10	15	5	4	4
Steel Creek and Pen Branch	40	665	115	415	40	15	70
Par Pond	222	490	155	150	130	30	35
Lower Three Runs							
1 Mile Below Dam	63	395	115	175	90	25	70
6 Miles Below Dam	49	240	95	225	95	25	40
14 Miles Below Dam	46	155	60	85	90	20	35
Four Mile Creek	3	15	15	15	5	4	4

The nonvolatile beta concentrations in reactor effluent algae, collected at Road A, also decreased with the exception of algae in Lower Three Runs. The nonvolatile beta concentrations in effluent algae were higher by a factor of 10^3 than those found in effluent water. The average concentrations found in weekly samples are shown in the following table.

	Nonvolatile Beta in Effluent Algae, 1×10^{-12} c/g		
Effluent	Max	Avg	Prev Avg
Upper Three Runs (Control)	75	35	50
Four Mile Creek	3100	920	1500
Pen Branch	4800	1335	1950
Steel Creek	2000	1500	6500
Lower Three Runs	315	110	65

Data obtained from a quantitative gamma pulse height analysis of an algae sample collected from Pen Branch in October 1960, are shown in the following table. The radiostrontium content of this sample was 0.9 ± 0.7 × 10^{-12} c/g.

Isotope	Gamma Activity in Pen Branch Algae, 1 × 10^{-12} c/g
$Ce^{141,144}$	245.0
Ru^{106}	39.0
Cs^{137}	0.7
$Zr\text{-}Nb^{95}$	29.6
Zn^{65}	25.3
K^{40}	35.1

SAVANNAH RIVER. The uptake of radioactivity by Savannah River fish, collected near the mouth of each reactor effluent, at the Highway 301 bridge and at Stokes Bluff, was generally confined to low level concentrations of nonvolatile beta in the bones with no significant concentrations in the fleshy tissues (see the following table).

Nonvolatile Beta in Savannah River Fish, 1 × 10^{-12} c/g

River Location	No. of Samples	Bone			Flesh		
		Max	Avg	Prev Avg	Max	Avg	Prev Avg
Above Upper Three Runs (Control)	35	30	10	14	10	4	4
Upper Three Runs	12	30	13	12	5	3	3
Four Mile Creek	13	50	20	25	10	4	4
Steel Creek and Pen Branch	7	55	21	55	10	6	5
Lower Three Runs	18	35	16	20	10	5	4
Highway 301	47	40	17	15	10	4	4
Stokes Bluff	26	20	12	15	7	4	4

Several fish collected near the mouth of Steel Creek in November contained low level concentrations of radiozinc and radiocesium in the bones and fleshy tissues (see the following table).

Gamma Activity in Savannah River Fish Collected Near Steel Creek, 1 × 10^{-12} c/g

Species	Bone		Flesh	
	Cs-137	Zn-65	Cs-137	Zn-65
Catfish	2.3	10.7	2.8	4.3
Eel	*	7.1	2.3	1.2
Bass	*	*	0.6	0.2
Bream	*	*	1.0	*

* Concentrations below the sensitivity of the procedure.

The nonvolatile beta concentrations found in Savannah River algae collected near the mouth of each reactor effluent were generally higher than those measured during the previous period. Radioactivity released by Plant operations was detectable in river algae as far downstream as Stokes Bluff, 80 miles below the Plant site. The nonvolatile beta concentrations measured in river algae are shown in the following table.

River Location	Nonvolatile Beta in River Algae, 1×10^{-12} c/g		
	Max	Avg	Prev Avg
Above Upper Three Runs (Control)	30	25	35
Upper Three Runs	35	25	30
Four Mile Creek	340	95	45
Steel Creek and Pen Branch	2400	550	85
Lower Three Runs	320	140	70
Highway 301	265	105	80
Stokes Bluff	70	35	65

Clams were collected in September from the Savannah River above the Plant site and below the mouth of each reactor effluent. Gamma pulse height analysis data indicate that the muscle tissue of clams collected below the mouths of Steel Creek and Lower Three Runs contained trace amounts of $Ru^{103,106}$, Cs-137 and Zn-65 (see the following table).

Isotopes	Gamma Activity in Clam Muscle Tissue, 1×10^{-12} c/g	
	Steel Creek	Lower Three Runs
$Ru^{103,106}$	0.69 ± 0.57	1.64 ± 0.57
Cs^{137}	0.23 ± 0.13	0.30 ± 0.13
Zn^{65}	0.58 ± 0.14	1.01 ± 0.14

No gamma emitters were detected in the tissue or shell of clams collected above the Plant site or below the mouth of Four Mile Creek. The nonvolatile beta concentrations found in these specimens are presented in the following table. Radiostrontium was the primary beta emitter in the clam shells.

Location	Nonvolatile Beta in Savannah River Clams, 1×10^{-12} c/g	
	Shell	Flesh
Above Upper Three Runs	5.4	1.0
Below Four Mile Creek	7.3	1.0
Below Steel Creek and Pen Branch	15.0	1.0
Below Lower Three Runs	25.0	2.1

Automated Counting Room

Automation of the alpha and beta counters used for the evaluation of environmental samples was completed in August. In the new system, which consists of two alpha scintillation counters and two beta counters, gas flow counters replaced the end-window GM tube counters. These four counters adequately handle the counting room load which formerly required twenty beta counters (GM tube) and ten alpha scintillation counters. The automated system provides improved accuracy and sensitivity and also facilitates calculations and summaries of regional survey data. Results are machine-punched into tape which is later processed by the Data Processing Section and returned to the Regional Survey group in tabular and correlated form.

The gas-flow proportional counters are calibrated with Ra D&E standards and are specifically calibrated for iodine-131, radiostrontium, and cesium-137. The counting efficiencies of these new counters as compared with the previous beta counters (GM tube) are shown in the following table.

Beta Counting Efficiencies, Percent

	GM Tube Counters	Gas-Flow Proportional Counters No. 3	Gas-Flow Proportional Counters No. 4
Ra D&E	13	29	33
I^{131}	10	27.8	29.4
Radiostrontium	12.6	29	32.3
Cs^{137}	10.6	27.4	29.3
Avg Background, count/10 minutes	250 ± 25	152 ± 22	168 ± 25

The alpha scintillation counters have essentially the same counting efficiency (40%) as those previously used.

Geology

L Area

At the request of the Reactor Department, the geology of an area south of L Area was investigated to determine its suitability as a site for disposal of chemical and oily waste. In addition, the proposed basin will receive waste from the 100 Areas' decontamination facility, Building 714-G. Thirty-nine test holes were bored throughout the proposed site. Both stratigraphic and hydrologic data showed this area as suitable for disposal of these wastes. A detailed report of the investigations, including a recommended site, was prepared.

Building 643-G

An investigation of the geologic feasibility of solid high level waste disposal in the area east of Building 643-G was undertaken prior to extending the burial ground in this direction (a previous survey revealed the west section unsuitable for disposal of this waste). Forty-five exploratory holes were bored in the area extending from the railroad track to Plant Highway E. Forty of these were on a grid 1000 feet long by 400 feet wide located between an old county road and the railroad track. The five remaining holes were drilled in the area south of the county road (between the county road and Plant Highway E). Based on the findings of this investigation, the area situated adjacent to the railroad track and extending 1000 feet east of the burial ground was recommended for high level solid waste disposal. The area paralleling the high level area and adjacent to Plant Highway E was recommended for low level use pending more extensive investigation.

Special Biological Studies

Uptake and Retention of Cs-137 by Algae

The cesium uptake and retention patterns of the blue-green algae, Microcoleus vaginatus, were studied in the laboratory during this period. Studies were carried out under conditions of both no-flow (batch tests) and continuous flow (15 ml/hr) of cesium spiked culture media. In the cesium uptake tests, algal inoculums were cultured in media that contained 100 d/m, 200 d/m and 400 d/m of Cs-137 per ml, respectively, for 21 days. In the retention tests, algal inoculums were subcultured in cesium free media after 7 days exposure in cesium spiked media.

The uptake of Cs-137 by Microcoleus grown in a continuous flow of spiked media was proportional to the concentration of Cs-137 in the culture media. The maximum Cs-137 concentrations in algae cultured in media containing 100 d/m, 200 d/m, and 400 d/m of Cs-137 per ml were 16×10^4 d/m, 40×10^4 d/m, and 74×10^4 d/m per gram of algae, respectively.

The uptake of Cs-137 by algae grown in batch cultures was not proportional to Cs-137 concentration in the media. The maximum Cs-137 concentrations were 16×10^4 d/m, 133×10^4 d/m, and 138×10^4 d/m, per gram of algae. Maximum uptake of Cs-137 generally occurred during the first three days exposure in algae grown in both batch and continuous flow cultures. Data from the retention studies show that 90% of the Cs-137 was released from algae grown under each condition within 24 hours after subculturing in cesium free media. Due to an accelerated growth rate, algae grown in a continuous flow of media concentrated and released Cs-137 at a faster rate than algae grown in batch cultures. The initial loss of Cs-137 in the retention tests was a function of osmosis to achieve equilibrium between the cesium content in the algae and media. The continued decrease of cesium activity per gram of algae was a function of biological dilution.

Radioactivity in Savannah River Swamp Fish

Numerous small fish including catfish, bream, bass and pike were collected from standing water in plots 2 through 8 (see figure 13) and were composited by location for radioanalysis. The data in the following table show that significant concentrations of Zn-65 were found in the bones and flesh of fish collected near Four Mile Creek (plots 2 and 8), Pen Branch (plot 7) and Steel Creek (plots 5 and 6).

Radioactivity in Savannah River Swamp Fish, 1×10^{-12} c/g

Plot	Type	Sr-89, $Sr-Y^{90}$		Ru-106		Cs-137		Zn-65	
Number	Sample	Max	Avg	Max	Avg	Max	Avg	Max	Avg
2	Bone	20.4	12.3	*	*	*	*	9.6	*
	Flesh	*	*	*	*	1.7	1.2	1.4	0.7
3	Bone	*	*	*	*	*	*	*	*
	Flesh	*	*	*	*	*	*	*	*
	Whole	*	*	*	*	*	*	*	*
4	Whole	5.8	4.1	*	*	*	*	*	*
5	Whole	5.3	5.2	3.7	*	2.0	1.5	17.5	13.5
6	Bone	29.5	19.9	*	*	*	*	101.0	60.3
	Flesh	*	*	*	*	3.0	2.9	15.3	13.9
	Whole	8.5	7.1	9.6	7.2	3.2	3.1	27.3	22.2
7	Bone	11.6	10.4	*	*	*	*	15.4	11.1
	Flesh	*	*	*	*	1.5	*	2.7	2.2
8	Bone	14.4	14.2	*	*	*	*	23.1	12.0
	Flesh	*	*	*	*	1.3	1.3	1.4	0.7
	Whole	13.1	12.8	5.3	4.8	1.6	1.3	9.9	9.1

* Less than sensitivities listed below.

Type Sample	Avg Wt, g	Minimum Sensitivity, 1×10^{-12} c/g: Sr-89, $Sr-Y^{90}$	Ru-106	Cs-137	Zn-65
Bone	3.2	5.9**	35.8	5.2	4.6
Flesh	24.9	0.2	4.3	0.7	0.6
Whole	33.7	5.9**	3.4	0.5	0.4

** Based on 1-gram samples.

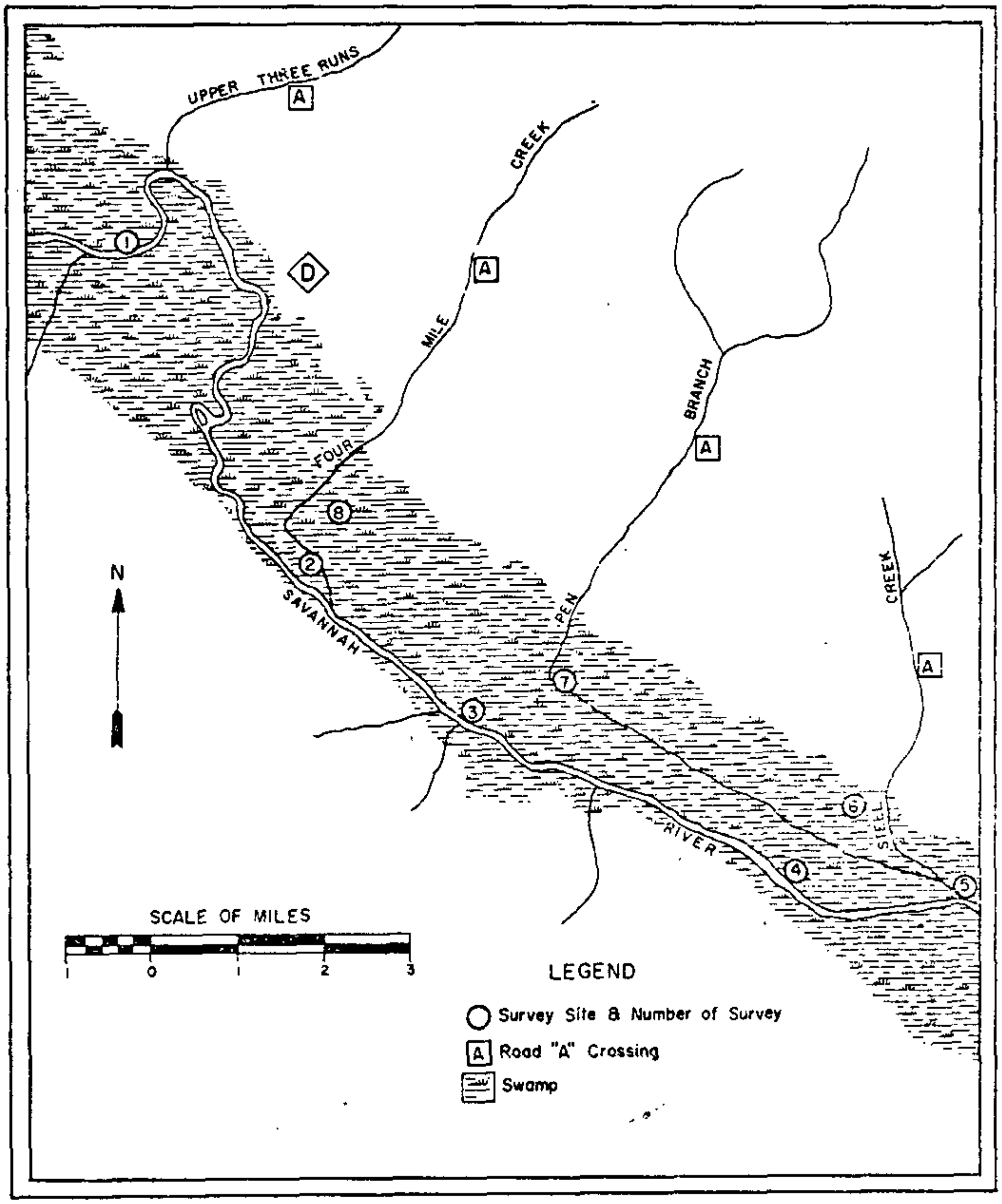

FIGURE 13. SAVANNAH RIVER SWAMP SURVEY LOCATIONS

The Zn-65 concentrations in the bones and flesh of swamp fish were generally in the same range as fish collected from the lower sections of the Plant effluents. However, the Zn-65 concentrations in the bones of fish collected from Steel Creek (in the swamp) were slightly higher than those found in effluent fish to date. Significant concentrations of radiostrontium (Sr-89, Sr-Y^{90}) were found in the bones of all swamp fish except those collected from the river side of the Pen Branch swamp (plot 3). No significant concentrations of radiostrontium were found in the fleshy tissues of any fish collected from the swamp. Low level concentrations of Cs-137 were generally found in the fleshy tissues of swamp fish. Where whole fish were analyzed, trace concentrations of Ru-106 were also found, indicating the presence of Ru-106 in the viscera or stomach contents of some swamp fish. The data also show that the concentrations of radioactivity were lower near the river (plots 2, 3, 4 and 5) than found in fish collected from the Plant side of the swamp (plots 6, 7, and 8).