DPSPU 78-30-1

ENVIRONMENTAL MONITORING IN THE VICINITY OF THE SAVANNAH RIVER PLANT

Annual Report for 1977

DUPONT

E. I. du Pont de Nemours and Company
Savannah River Plant
Aiken, South Carolina 29801

Prepared for the U.S. Department of Energy under Contract AT(07-2).

PREFIXES FOR UNITS OF MEASURE

	PREFIXES	SYMBOLS	NAMES
$0.1 = 10^{-1}$	deci	d	tenth
$0.01 = 10^{-2}$	centi	c	hundredth
$0.001 = 10^{-3}$	milli	m	thousandth
$0.000\ 001 = 10^{-6}$	micro	μ	millionth
$0.000\ 000\ 001 = 10^{-9}$	nano (năn' oh)	n	billionth
$0.000\ 000\ 000\ 001 = 10^{-12}$	pico (pee' ko)	p	trillionth
$0.000\ 000\ 000\ 000\ 001 = 10^{-15}$	femto	f	quadrillionth
$0.000\ 000\ 000\ 000\ 000\ 001 = 10^{-18}$	atto	a	quintillionth

CONVERSION TABLE

Multiply	By	To Obtain	Multiply	By	To Obtain
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft
mi	1.61	km	km	0.621	mi
lb	0.4536	kg	kg	2.205	lb
liq qt - U.S.	0.946	ℓ	ℓ	1.057	liq qt - U.S.
ft^2	0.093	m^2	m^2	10.764	ft^2
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.31	ft^3
mCi/mi^2	0.386	$mCi/km^2 (nCi/m^2)$	mCi/km^2	2.59	mCi/mi^2
d/m	0.450	pCi	pCi	2.22	d/m
nCi	1×10^3	pCi	pCi	1×10^{-3}	nCi
d/m/ℓ	0.45×10^{-9}	μCi/cc	μCi/cc	2.22×10^9	d/m/ℓ
$d/m/ft^2$	0.01256	mCi/mi^2	mCi/mi^2	79.6	$d/m/ft^2$
pCi/ℓ (water)	10^{-9}	μCi/mℓ (water)	μCi/mℓ (water)	10^9	pCi/ℓ (water)
pCi/m^3 (air)	10^{-12}	μCi/cc (air)	μCi/cc (air)	10^{12}	pCi/m^3 (air)
mCi/km^2	1	nCi/m^2	nCi/m^2	1	mCi/km^2

ERRATA
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Please make the following corrections to your copy.

Page 40, Table 13, River Transport and Dose - 1977: Change "33 mrem total calculated individual dose commitment for whole body to 0.33" (column 3, last value).

Page 64, Releases to the Savannah River: Third dingbat, change "the flow rate of the river at the water treatment plants in 1977 averaged about 14,300 cubic feet per second" to "averaged about 11,700 cubic feet per second."

ENVIRONMENTAL MONITORING IN THE VICINITY OF THE SAVANNAH RIVER PLANT

Annual Report

For 1977

Prepared for the United States Department of Energy by the
Health Physics Department of
E. I. du Pont de Nemours & Co.,
Savannah River Plant, Aiken, South Carolina

CONTENTS

FOREWORD

This report summarizes results of the environmental monitoring program at the Savannah River Plant (SRP) during 1977. Environmental monitoring has been an integral part of plant operations since the start of activities at SRP. Extensive monitoring was performed to provide baseline data on radiation levels before plant operations began. Monitoring programs have continued throughout the history of the plant, providing reliable measurement of radioactive materials released at the source and in the environment. This annual report describes in detail the plantsite and facilities and the techniques of sample collection and analysis.

INTRODUCTION

The Savannah River Plant occupies an area of about 300 square miles along the Savannah River, principally in Aiken and Barnwell Counties of South Carolina. Most of the plant's environs are rural. Population density of nearby counties ranges from 10 to over 400 people per square mile with the greatest concentration in Augusta, GA, and its suburbs, which have a population approaching 200,000. The countryside is predominantly forested. Farming is diversified, the main crops being cotton, soybeans, corn, and small grains. Production of beef cattle has rapidly expanded during the past few years. The climate is mild, with an average frost-free season of approximately 246 days. Annual rainfall averages about 45 in. and is fairly evenly distributed throughout the year. The Savannah River plantsite and surrounding area are described in more detail in The Savannah River Plantsite [DP-1323] [9].

Exclusion of the public from the plantsite creates a refuge for many animal species, both terrestrial and aquatic. Growth of the deer population is limited (to prevent range deterioration and to minimize deer/vehicle accidents) by public hunting which was initiated in 1965. Several hundred to over a thousand deer (1271 in 1977) have been taken annually during controlled hunts.

In 1972, the SRP site was designated as the nation's first National Environmental Research Park (NERP). This designation opened the site to investigators from universities and other research organizations who wish to design and conduct research studies on man's impact on the environment. Over 25 research projects were conducted at the SRP site under the NERP program in 1977. These projects were in addition to the DOE-funded environmental research programs normally conducted at the site.

Since 1952, the U.S. Forest Service has planted over 100 million pine seedlings on over 80,000 acres of the plantsite. Great quantities of pine and pulpwood, along with some hardwood sawtimber, have been harvested during this same period.

SRP's primary function is the production of plutonium, tritium, and other special nuclear materials for the national defense, for other governmental uses, and for some civilian purposes. Facilities now operating include three nuclear reactors, a fuel and target fabrication plant, two chemical separations plants, a heavy water production plant, and the Savannah River Laboratory (a process development laboratory to support production operations). The reactors and separations plants are located near the center of the site; the other facilities, near its periphery.

The reactors are fueled with uranium and moderated and cooled by heavy water which is circulated in a closed system through heat exchangers. Savannah River water and water from Par Pond, a manmade cooling water impoundment covering 2640 acres, are used only as a secondary coolant in the heat exchangers. Water from the river or Par Pond does not pass directly through the reactors and so is not subject to neutron activation.

Nuclear fuels and targets, together with other components necessary for the reactors, are manufactured in the fuel and target fabrication facility.

Reactor products are recovered in the fuel separations areas. ^{239}Pu and uranium are separated from each other and from fission products by complex chemical processes. ^{238}Pu and ^{252}Cf are also important SRP products that are processed in the separations areas. These areas also have facilities for the purification and packaging of tritium and for storage of fission product wastes.

The heavy water production plant separates and concentrates heavy water from the raw water of the Savannah River. The basic process for extraction of heavy water from river water is chemical exchange with hydrogen sulfide gas at about 300 psig. Heavy water is not radioactive, but a portion of the heavy water production facility is used for the reconcentration of moderator from the reactors and this heavy water contains some tritium.

SRP production areas and effluent streams are shown in figures 1, 1A, 1B, 1C, and 1D.

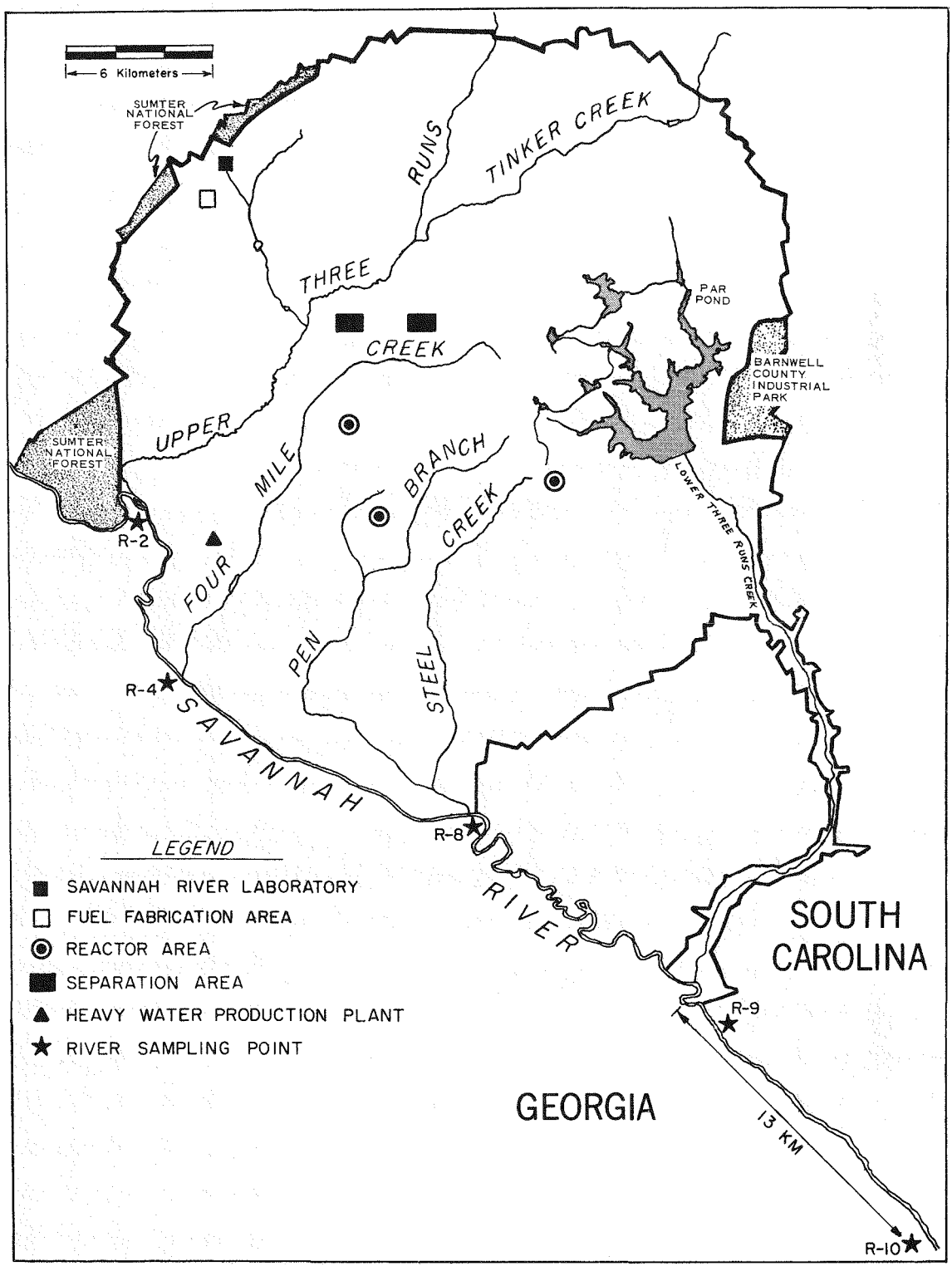

FIGURE 1. SRP PRODUCTION AREAS AND EFFLUENT STREAMS

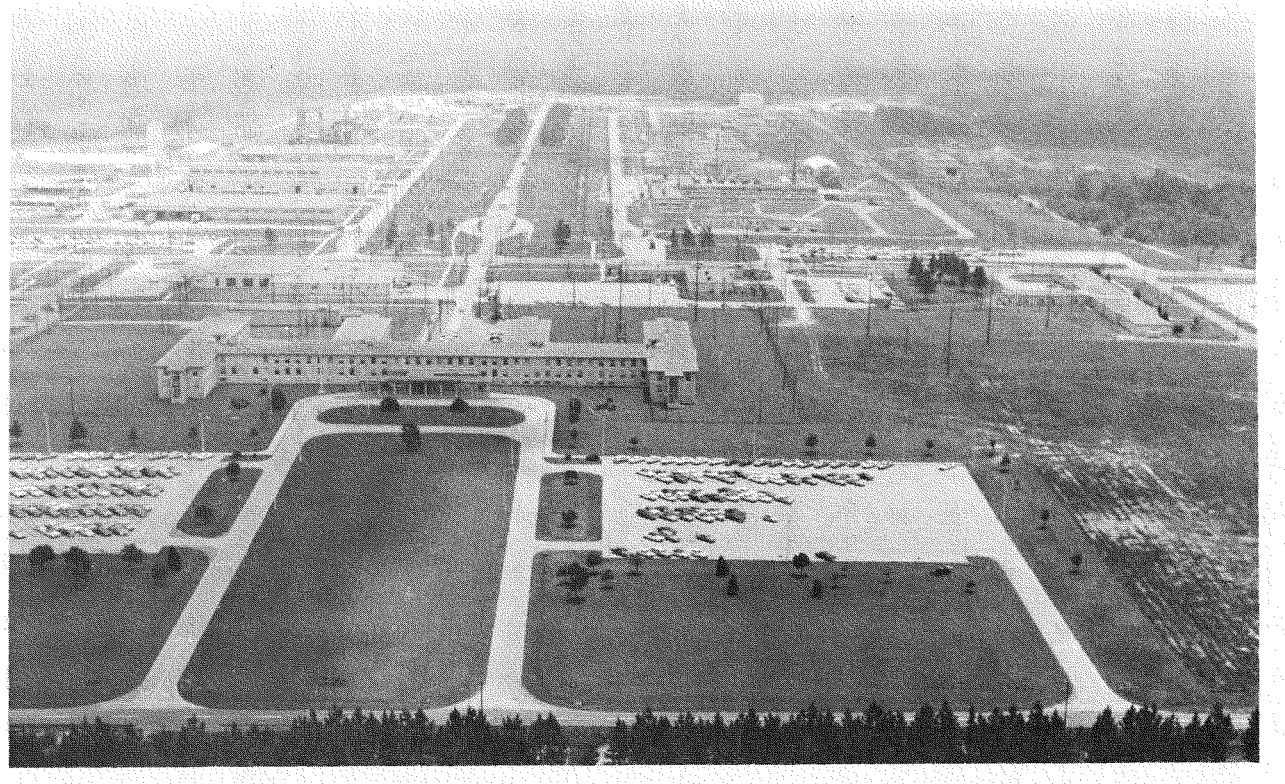

FIGURE 1A. ADMINISTRATION AREA AND FUEL AND TARGET FABRICATION PLANT

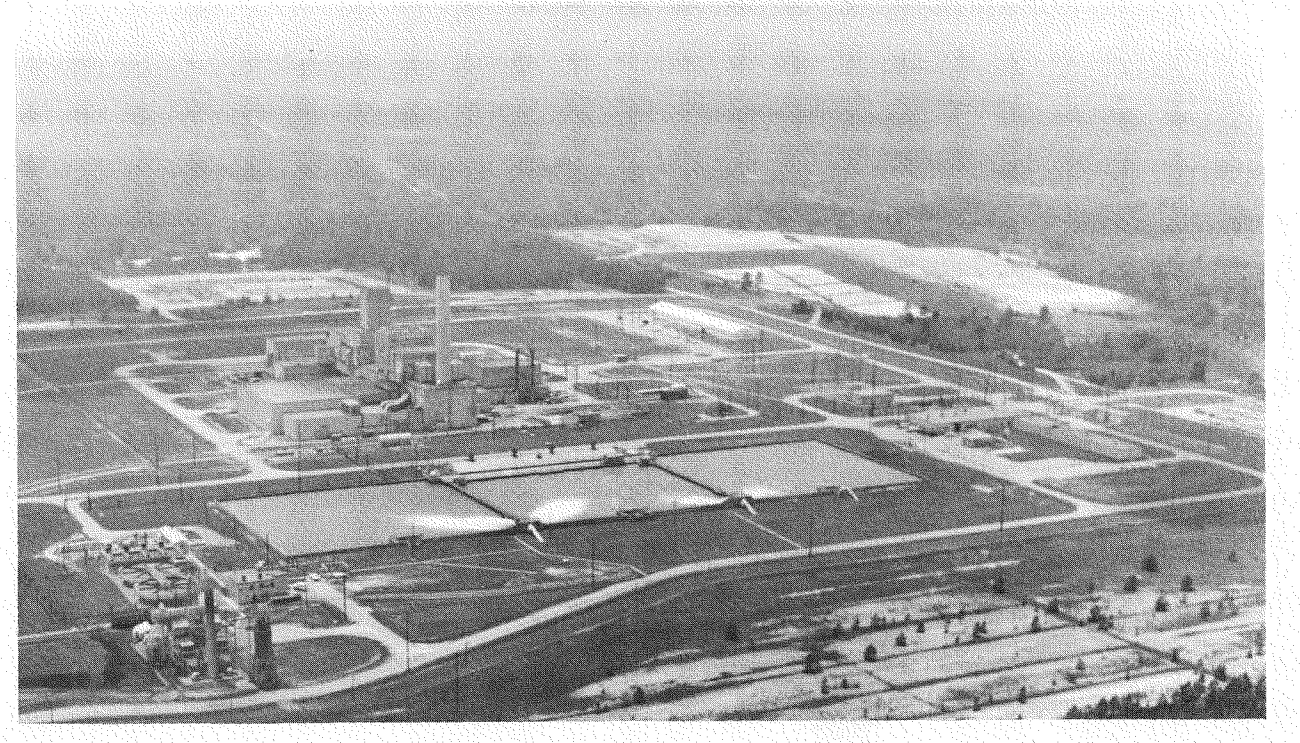

FIGURE 1B. REACTOR PLANT

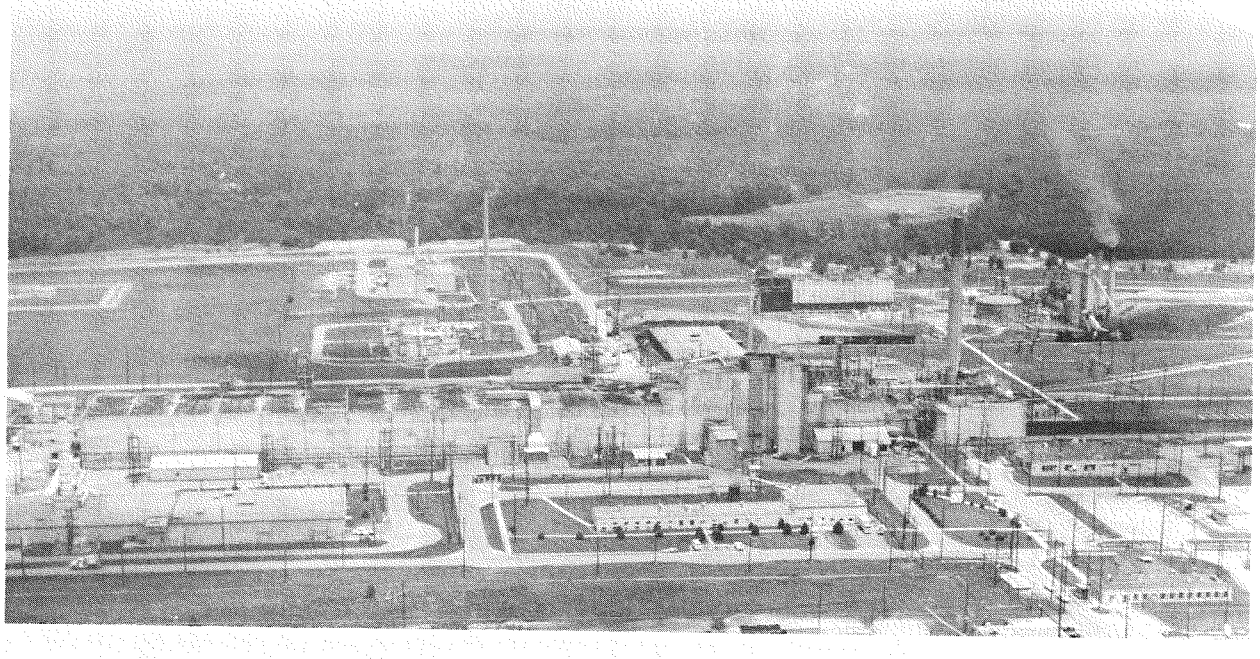

FIGURE 1C. CHEMICAL SEPARATIONS PLANT

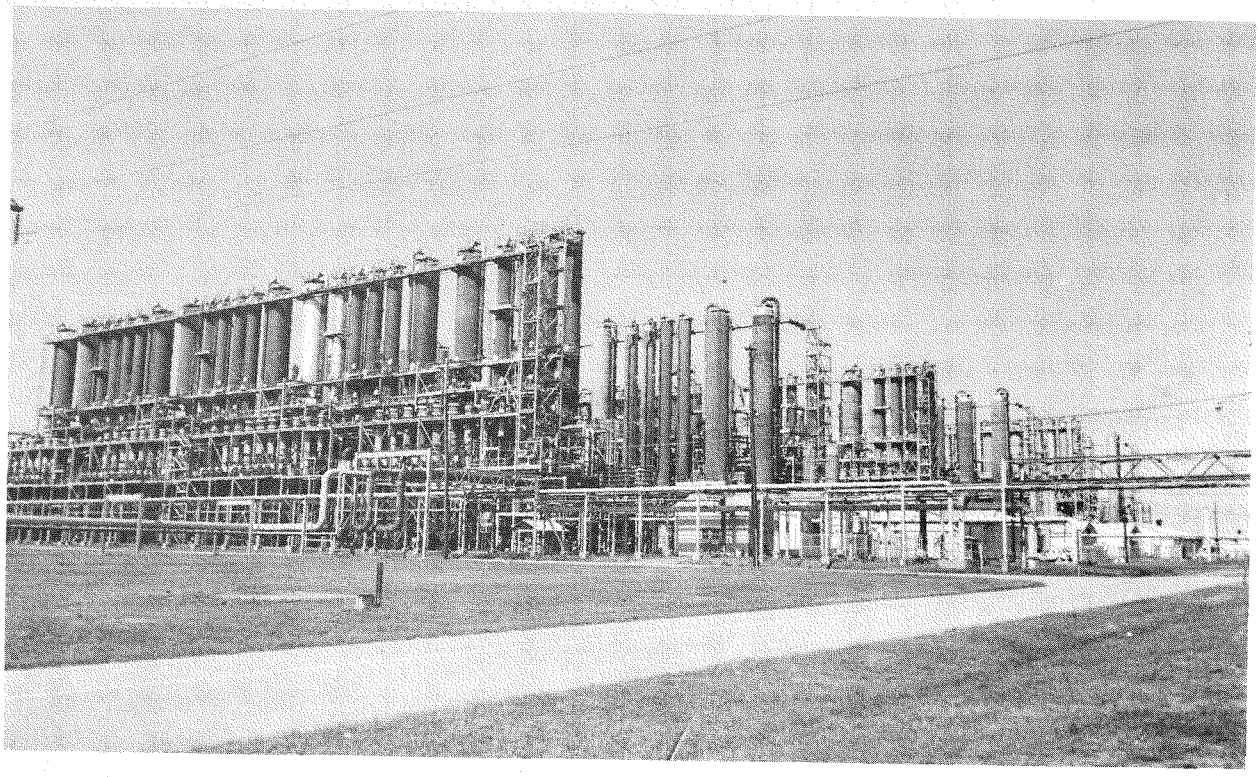

FIGURE 1D. HEAVY WATER PRODUCTION PLANT

SUMMARY

A continuous monitoring program has been maintained since 1951 (before plant startup) to determine concentrations of radioactive materials in a 1200-square-mile area outside SRP. Included are parts of Aiken, Barnwell, and Allendale Counties in South Carolina; Richmond, Burke, and Screven Counties in Georgia. Although some gaseous and liquid radioactive materials are discharged from SRP operations, concentrations and doses to the surrounding population continued to be far below levels considered significant from a public health viewpoint.

The concentration of radioactivity added by SRP to its environs during 1977 was, for the most part, too small to be distinguished from natural background radiation and fallout from worldwide nuclear weapons tests. Beta activity in particulate air filters was about two times the 1976 level and was due entirely to global fallout. This concentration, both at the plant perimeter and 25 miles away (approximately 0.15 pCi/m^3) represents 0.15% of the Concentration Guide (CG) (defined in the Applicable Standards section which follows). Tritium oxide in air at the plant perimeter was greater than in air at more distant locations; the average concentration at the plant perimeter (65 pCi/m^3) was 0.03% of the CG.

Tritium, ^{137}Cs, and ^{90}Sr were the only radionuclides of plant origin detectable in Savannah River water by routine analyses. None of these had an average concentration exceeding 0.2% of the CG in river water sampled 8 mi downstream from the plant.The tritium concentration in river water immediately downstream of the plant (4.8 pCi/ml, including 0.5 pCi/ml background river contribution) represented the highest CG percentage (0.16) of the three radionuclides measured in river water. Special research programs using ultra-low-level techniques may detect trace quantities of other radionuclides of plant origin. Radioactive materials in river fish also continued very low (0.2 pCi/g ^{137}Cs maximum).

Annual analyses of plant perimeter soil samples (0-5 cm deep) showed deposition of ^{137}Cs (52 mCi/km^2) and ^{239}Pu (1.2 mCi/km^2) within the range normally found in global fallout. ^{238}Pu in all soil samples was near the sensitivity of the analysis (approximately 0.1 mCi/km^2)

Monitoring in a 5-square-mile swamp bordering the Savannah River immediately below the SRP boundary has shown radioactivity (primarily ^{137}Cs) above the natural background level in soil and vegetation. Only one-third of the swamp, which is largely uninhabited and inaccessible, is affected. Neither restrictions on use of the swamp nor remedial actions are considered warranted. Radiation measurements with thermoluminescent dosimeters and analysis of soil, vegetation, and wildlife showed radionuclide concentrations similar to those observed for the past several years. All Savannah River swamp monitoring data (1972-1977) are summarized in the appendices of this report.

For 1977, the calculated annual average dose from atmospheric releases of radioactive materials from SRP was 0.8 millirem (mrem) at the plant perimeter. The calculated maximum dose at the plant perimeter was 1.10 mrem, which is 0.2% of the standard as stated in the DOE Manual, chapter 0524. The population dose to people living within 80 km (50 mi) of the center of SRP (population: 465,000) is 114 man-rems. An individual consuming river water downstream from SRP would receive a maximum calculated dose of 0.33 mrem.

Various water-quality analyses of river water samples by SRP during 1977 indicated that Savannah River water was not adversely affected by SRP operations. This was substantiated by surveys of the health of Savannah River biota by the Academy of Natural Sciences of Philadelphia and pesticide analyses of river water and sediment by the U.S. Geological Survey Water Quality Laboratory, Atlanta, GA.

APPLICABLE STANDARDS

The standards applicable to concentration of radionuclides in air and water at SRP are the Concentration Guides (CG's) given in chapter 0524 of the DOE Manual, and are derived for the most part from the whole body annual dose standard of 500 mrems to individuals at points of maximum probable exposure [1]. These CG's are based on recommendations of the International Commission on Radiological Protection (ICRP), the National Council on Radiation Protection and Measurements (NCRP), and the Federal Radiation Council (the latter is now a part of the Environmental Protection Agency). Concentration guides are summarized in table 1. For whole-body dose calculations from ingestion of tritium, ICRP values for translating intake to dose are used [2] Specific guidance of the Federal Radiation Council (Report 7) is used in translation of a given intake of cesium-137 to radiation dose [3].

The National Pollutant Discharge Elimination System (NPDES) permit for SRP, effective November 19, 1976, through November 19, 1981, requires plume temperature monitoring at three locations in the Savannah River. Limitations of maximum plume temperature and the rise above ambient temperature are the same as those in the South Carolina water quality standards.

Chemical and biological quality standards for the Savannah River are the requirements of the State of South Carolina for Class B streams [4] which are: "Waters suitable for domestic supply after complete treatment in accordance with requirements of the South Carolina Board of Health. Suitable also for propagation of fish, industrial and agricultural uses, and other uses requiring water of lesser quality." Specifications are summarized in table 2.

Principal nonradioactive releases to the atmosphere are sulfur dioxide (SO_2), oxides of nitrogen (NO_x), and fly ash. South Carolina emission standards [5] and South Carolina [5] and Georgia [6] ambient air quality standards are summarized in table 3.

TABLE 1
CONCENTRATION GUIDES (CG's)

	In Water, pCi/l	In Air, pCi/m^3
Alpha	30	0.02
Nonvolatile beta	3,000	100
Tritium	3,000,000	200,000
^{239}Np	100,000	20,000
^{131}I	300	100
^{140}Ba-^{140}La	20,000	1,000
^{137}Cs	20,000	500
^{144}Ce	10,000	200
$^{103,106}Ru$	10,000	200
^{95}Zr-^{95}Nb	60,000	1,000
^{65}Zn	100,000	2,000
^{60}Co	30,000	300
^{89}Sr	3,000	300
^{90}Sr	300	30
^{54}Mn	100,000	1,000
^{51}Cr	2,000,000	80,000
^{35}S	60,000	9,000

TABLE 2
SOUTH CAROLINA WATER QUALITY STANDARDS

1. Fecal coliform. Not to exceed a log mean of 1000/100 ml based on five consecutive samples during any 30-day period; not to exceed 2000/100 ml in more than 20% of the samples examined during such period (not applicable during or following periods of rainfall).
2. pH. Range between 6.0 and 8.5, except that swamp waters may range from pH 5.0 to pH 8.5.
3. Dissolved oxygen. Daily average not less than 5.0 mg per liter with a low of 4.0 mg per liter, except that swamp waters may have an average of 4 mg per liter.
4. Temperature. Maximum temperature increase after mixing: 2.8°C (5°F). Maximum temperature after mixing: 32.2°C (90°F).
5. Phenolic compounds. Not greater than 1 microgram per liter unless caused by natural conditions.

TABLE 3
SOUTH CAROLINA EMISSION STANDARDS

Fly ash - 0.6 lb/10^6 Btu heat input

SO_2 - 3.5 lb/10^6 Btu heat input

SOUTH CAROLINA AND GEORGIA AMBIENT AIR STANDARDS
FOR PARTICULATES, SO_2, NO_x

	South Carolina	Georgia
Suspended particulates, $\mu g/m^3$		
24 hours	250	150
Annual geometric mean	60	60
SO_2, $\mu g/m^3$		
1 hour	-	715
3 hours	1300	-
24 hours	365	229
Annual	80	43
NO_x, $\mu g/m^3$		
24 hours	-	300
Annual	100	100

- No standard.

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES

Air Collection

Particulate airborne radioactivity is sampled continuously by drawing air through 2-in.-dia high-efficiency asbestos paper filters that are collected weekly. The air is sampled at about 7×10^4 ml/min (2.5 cu ft/min) with an auxiliary running-time meter and airflow meter at each station providing data on the volume sampled. A cartridge of activated coconut charcoal for collection of gaseous radioiodine is located downline from each paper filter. Moisture is concentrated from the atmosphere for determination of its tritium oxide content by pumping air through a silica gel column at a continuous rate of 100 ml/min (operated off the manifold of each vacuum pump). The column contains nonindicating silica gel; a backup column of indicating silica gel is used for evidence of any saturation of the desiccant. The concentration of tritium oxide in the air is calculated from the concentration in atmospheric moisture and the absolute humidity.

Deposition rates of radioactive materials are also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). Fallout collection pans (2 × 2 ft) are located at offplant monitoring stations and at stations around the plant perimeter.

Rainwater flows by gravity from the collection pan through an ion exchange column (cation and anion resin). The columns are analyzed directly by gamma spectrometry for gamma emitters. Alpha and beta emitters are removed from the column with acid and analyzed by chemical methods. The rainwater passing through the ion exchange column is collected for weekly tritium analyses by liquid scintillation counting.

Alpha-, Beta-, and Gamma-Emitting Radionuclides are measured by a direct count of the asbestos paper filter; alpha on a ZnS scintillation counter, beta on a gas flow proportional counter, and gamma on a 9- × 9-in. NaI(T1) well detector with a 400-channel gamma spectrometer.

Strontium-89,90 collected on filter papers is leached with 8N nitric acid, precipitated with fuming nitric acid, dissolved in 8N nitric acid, scavenged first with ferric hydroxide and then with barium chromate, precipitated as an oxalate and transferred to a stainless steel planchet (holder) for beta count on a gas flow proportional counter.

Uranium and Plutonium are leached from the filter paper in 8N nitric acid, dried, dissolved in 8N hydrochloric acid, and extracted into triisooctylamine (TIOA) by liquid ion exchange. The alpha emitters are stripped from the TIOA organic layer with 0.1N hydrochloric acid and evaporated to dryness. The residue is dissolved in 4N nitric acid and transferred to a stainless steel planchet for count on a ZnS alpha scintillation counter.

Iodine-131 is measured by a direct count of the charcoal canister using a 9- × 9-in. NaI(T1) well detector with a 400-channel gamma spectrometer.

Tritium in atmospheric moisture and rainwater samples are collected as described in the sample collection section. Tritium is determined by liquid scintillation counting of a distilled aliquot of each sample.

Plutonium is leached from the filter paper with 8N hydrochloric and 0.3N hydrofluoric acids, evaporated to dryness, dissolved in 7.2N nitric acid, and passed through an anion exchange resin ("Dowex" 1-X4). The resin column is eluted with 0.35N hydrochloric and 0.01N hydrofluoric acids and the plutonium in the eluate is electrodeposited on a platinum disk for alpha spectrometric analysis on silicon surface barrier detectors.

Water Collection

Continuous sampling of the Savannah River is accomplished with a sampler consisting of a "Plexiglas" water wheel suspended on two pontoons. As the water wheel is turned by flowing water, a small cup (or cups) on one paddle picks up a sample of water and deposits it into a trough. The sampled water flows by gravity from the trough through connecting tubing into a large polyethylene jug connected to the sampler. The sampled water (up to 6 gal) is collected weekly at river locations above and below SRP. Increased analytical sensitivity for water samples (containing insufficient radioactivity for direct processing) is achieved through concentration of radionuclides by ion exchange. The ion exchange column is counted directly for gamma-emitting radionuclides.

Alpha- and Beta-Emitting Radionuclides are measured by direct count of dried residue (in planchet) the same as for air.

Gamma-Emitting Radionuclides are measured by passing 25 liters of water through a cation-anion resin column and a direct count of the column using a 9-× 9-in. NaI(T1) well detector with a 400-channel gamma spectrometer. The resin column is then eluted with nitric acid, first with 2N nitric acid and then with 14N nitric acid for subsequent strontium analysis.

Strontium-90 is recovered from an aliquot of the above eluate. The acid is evaporated to dryness, and dissolved in 0.08N hydrochloric acid. ^{90}Y is stripped from the strontium by liquid ion exchange using di-2-ethylhexyl phosphoric acid. Equilibrium of ^{90}Y is allowed over a 15-day period and then the short-lived ^{90}Y daughter is stripped once again and transferred to a stainless steel planchet and counted in a low-background gas flow beta proportional counter.

Uranium/Plutonium and Plutonium After evaporation, both analyses are the same as for air filters.

Strontium-89,90 analysis of an aliquot of the above eluate is the same as for air.

Tritium is measured in distilled water samples with a liquid scintillation spectrometer.

Milk

Strontium-90 is removed by a slurry of the whole milk with a cation resin ("Dowex" 50 W-X4). The resin is leached with 8N nitric acid and then analyzed the same as for water.

Cesium-137 is removed by passing approximately 2 liters of whole milk through a potassium-cobalt-ferro-cyanide resin column and a direct count of the column using a 9-× 9-in. NaI(T1) well detector with a 400-channel gamma spectrometer.

Iodine-131 is the same as for ^{137}Cs except an anion resin ("Dowex" 1-X8) column is used.

Bone

Strontium-90. Bone is ashed in a furnace at 700° to 900°C, leached with 6N hydrochloric acid, evaporated to dryness, dissolved in 0.08N hydrochloric acid, and analyzed the same as for water.

Food

Uranium and Plutonium analysis is the same as for air after drying, ashing in furnace, and wet ashing with hydrochloric acid.

Strontium-90 analysis is the same as for water after the pretreatment described for uranium and plutonium.

Gamma-Emitting Radionuclides are determined by counting a bottled sample of the hydrochloric acid solution.

Tritium is measured in water obtained by freeze-drying samples and counting in a liquid scintillation counter.

Vegetation

Uranium/Plutonium and Strontium-90 analyses are the same as for food.

Gamma-Emitting Radionuclides are determined by counting dried vegetation in a standard geometry using a 9- X 9-in. NaI(T1) well detector and 400-channel gamma spectrometer.

Soil

The technique used for collection and preparation of soil samples generally follows that used by the DOE Environmental Measurements Laboratory (EML) [7].

Plutonium. Dried soil is blended in a Z-blender, pulverized in a hammer mill to size approximately 20 mesh. Fifty grams of the soil is then leached with 8N hydrochloric acid, evaporated to dryness, dissolved in 7.2N nitric acid, and passed through an anion exchange resin ("Dowex" 1-X4). The resin column is eluted with 0.35N hydrochloric acid - 0.01N hydrofluoric acid and the plutonium in the eluate is electrodeposited on a platinum disk for alpha spectrometric analysis.

Gamma-Emitting Radionuclides. Approximately 800 g of the pulverized soil is bottled in a 500-ml plastic bottle and counted as described for vegetation.

Strontium-90. 300 g of the pulverized soil is leached with 1N ammonium acetate, evaporated to dryness, dissolved in 0.08N hydrochloric acid, and analyzed the same as water.

Penetrating Radiation Measurements

External radiation is measured with thermoluminiscent dosimeters (TLD's) mounted 1 m aboveground. The primary dosimeter is a CaF_2 (dysprosium) crystal (0.63 X 0.63 X 0.09 cm) positioned behind a silver filter to measure dose from photons with energies above 100 keV. LiF TLD's are positioned behind a paper filter to detect the presence of photons with energies below 100 keV. The TLD's are annealed, calibrated, and read by standard procedures (IEEE, *Transactions on Nuclear Sicence,* vol NS-21, No. 1, 1977).

ATMOSPHERIC MONITORING – NONRADIOACTIVE

Atmospheric emissions of SO_2, NO_x, fly ash, and smoke are presently within applicable standards with the exception of fly ash and opacity from several steam power plants. There are seven coal-fired power plants at SRP, which burn about a total of 500,000 T of coal per year. Sulfur content of the coal averages 0.9%. The South Carolina standard for SO_2 emission is 3.5 lb/10^6 Btu input. Compliance with this standard is determined from analysis of coal received; all monthly average values were within the standard as shown in the following table. At the largest plant, which used 65% of the coal burned at SRP, atmospheric emissions of fly ash are now within applicable standards. Electrostatic precipitators, put into operation in November 1975, reduced fly ash emission from 2.75 to less than 0.03 lb/10^6 Btu input. The two-stage mechanical dust collectors have been installed on each of the two boilers in the 700-A Administration Area; similar units are planned for the remaining five plants.

1977 MONTHLY SO_2 EMISSION RATE[a]

Month	lb/10^6Btu	Month	lb/10^6Btu
January	1.68	July	2.12
February	1.82	August	1.63
March	2.03	September	1.78
April	1.99	October	1.81
May	1.98	November	1.70
June	1.86	December	1.63

[a] Weighted annual average, 1.87 lb/10^6Btu for all power plants.

Section 110 of the Clean Air Act Amendments of 1970 requires each state to establish, as part of its State Implementation Plan, a network to monitor the ambient air quality within that state. South Carolina and Georgia have each implemented air-sampling networks within the respective state. Air quality measurements of the South Carolina and Georgia Air Quality Surveillance Networks in the vicinity of SRP for 1976 are summarized in table 3A.

TABLE 3A
GEORGIA AND SOUTH CAROLINA AMBIENT
AIR QUALITY MEASUREMENTS, MICROGRAM/CUBIC METER

	Suspended Particulates					Sulfur Dioxide							Nitrogen Dioxide				
				Exceeds Std					Exceeds Std							Exceeds Std	
Locations[a]	No of Obs	24 hr Max	Geom Mean	GA[d] <150 (24 hr)	GA-SC <60 (yr)	No. of Obs	24 hr Max	Arith Mean	GA <715 (1 hr)	SC <1300 (3 hr)	GA[d] <229 (24 hr)	GA[d] <43 (yr)	No. of Obs	24 hr Max	Arith Mean	GA <300 (24 hr)	GA-SC <100 (yr)
South Carolina																	
1	50	91.0	41.7	0	No	59	67	4.6			No	No	62	76	27	0	No
2	60	91.0	45.2	0	No	60	127	10.6			No	No	60	74	38	0	No
3	56	142.0	37.8	0	No	-	-	-	-	-	-	-	-	-	-	-	-
Georgia																	
1	48	174	61.6	3	Yes	48[b]	22	2.2			0	No	48	64		0	No
2	52	178	49.8	2	No	5589[c]	177	14.8	0	0	0	No	-	-		-	-
3	55	129	52.1	0	No	35[b]	30	[illegible].6			0	No	48	72		0	No
4	22	96	48.0	0	No	17[b]	27	[illegible].7			0	No	18	67		0	No
5	23	116	61.6	0	Yes	17[b]	47	14.5			0	No	20	51		0	No

[a] South Carolina locations: 1) Eustis Park School, Aiken; 2) Fire Station Beach Island (Aiken Co.); 3) SC National Guard Armory, Allendale. Georgia locations: 1) Richmond Co. Health Dept., Augusta; 2) Reg. Yth. Dev. Cent., Augusta; 3) Sandbar Ferry Jr. High School, Augusta; 4) Bungalow Road School, Augusta; 5) Clara Jenkins School, Augusta.
[b] Twenty-four-hour bubbler analysis.
[c] Instrumental continuous analysis.
[d] See table 3 for less restrictive SC standard.

ATMOSPHERIC MONITORING – RADIOACTIVE

Concentrations of radioactive materials in the atmosphere are measured by weekly analyses of air filter contents collected at 13 monitoring stations near the plant perimeter and 12 stations around a circle of about 25 mi from the center of the plant (figure 2). Stations are spaced to permit continuous monitoring within every 30-degree sector on the plant perimeter and at 25-mi radius, thereby increasing the probability of detecting a significant release of airborne activity by SRP regardless of wind direction. Deposition rates of radioactive materials at each station were also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). Four

additional air monitoring stations at Savannah and Macon, GA, and at Columbia and Greenville, SC (designated 100-mi-radius stations), are so distant from SRP that the effect of SRP operations is negligible; they serve as reference points for determining background (figure 3). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between global fallout and SRP releases.

The small amount of particulate beta activity released to the atmosphere, primarily from the fuel separations areas, is obscured in the area surrounding the plant by worldwide fallout. The influence of nuclear tests, which were resumed in September 1961, is shown in figure 4. The slightly increasing trend (1967 through mid-1972 and again in 1974, 1975, and 1977) is attributed to fallout from atmospheric testing by nonparticipants in the testing moratorium. Some increase occurs each spring as a result of the mixing of the stratosphere with the trophosphere. The spring increase which usually occurs as a result of mixing of the two atmospheric regions was not observed during 1976 and was also absent in 1973. Radioactivity in air determined from filter analysis and atmospheric moisture analysis of tritium is shown in table B-1. The major component, ^{7}Be, in air filters is a naturally occurring radionuclide formed by interaction of cosmic rays with oxygen and nitrogen in the upper atmosphere. Annual tritium oxide concentration in air at plant perimeter stations did not exceed 0.1% of the CG. The average of all plant perimeter stations was 65 pCi/m^3 (0.03% CG) compared with 18 pCi/m^3 at the 25-mi-radius stations and 7 pCi/m^3 at 100-mi-radius stations. Plant releases of airborne beta or gamma activity, with the exception of tritium, are not detectable at the plant perimeter. Therefore, concentrations are calculated by standard meteorological dispersion equations [8], normalized to agree with measured dispersion of tritium. These calculated concentrations are listed in table 12, along with the annual releases and dose estimates.

Particulate beta activity in air averaged 0.15 pCi/m^3 in 1977 as compared with 0.07 pCi/m^3 in 1976. The increase is attributed to higher levels of global fallout in the atmosphere beginning in mid-March 1977. The 1977 concentrations of beta and alpha activity in air are 0.15% and 4.0% of the respective CG's. Alpha activity in air averaged 0.0008 pCi/m^3, the same as in 1976.

The presence of elevated levels of fallout materials in the spring of 1977 may be attributed to a November 1976 Chinese atmospheric detonation of a nuclear device. Fallout from the November 1976 test was not previously identified at SRP. This device was reported to have been in the megaton range and therefore may have injected most of the radioactive debris into the stratosphere. Once the debris is in the stratosphere, the radioactive dust may travel around the world for months before descending to the troposphere and earth. Nuclear devices in the low kiloton range (September 1976 and September 1977) inject most of the debris into the troposphere. Radioactive debris injected into the troposphere is detected much earlier and therefore contains radionuclides having comparatively short radioactive half-lives.

Gamma-emitting radionuclides of global fallout origin in air during the first half of 1977 were primarily ^{95}Zr-Nb, detected throughout the 6-month period, ^{144}Ce with trace quantities of ^{137}Cs beginning in mid-March, and ^{106}Ru beginning in April. During the period September 26 through November 1977, concentrations of particulate beta activity in air increased further as a result of the September 1977 Chinese nuclear device test. Peak monthly concentrations of beta activity in air, ranging from 0.26 to 0.78 pCi/m^3, were measured in October (see Chinese Fallout Monitoring, p 24). Radionuclides detected in air following the September Chinese nuclear test and throughout the fourth quarter 1977 were primarily ^{95}Zr-Nb, ^{141}Ce, and ^{103}Ru. Radionuclides with shorter radioactive half-lives (primarily ^{131}I, ^{140}BaLa, and ^{239}Np) were only detectable during October.

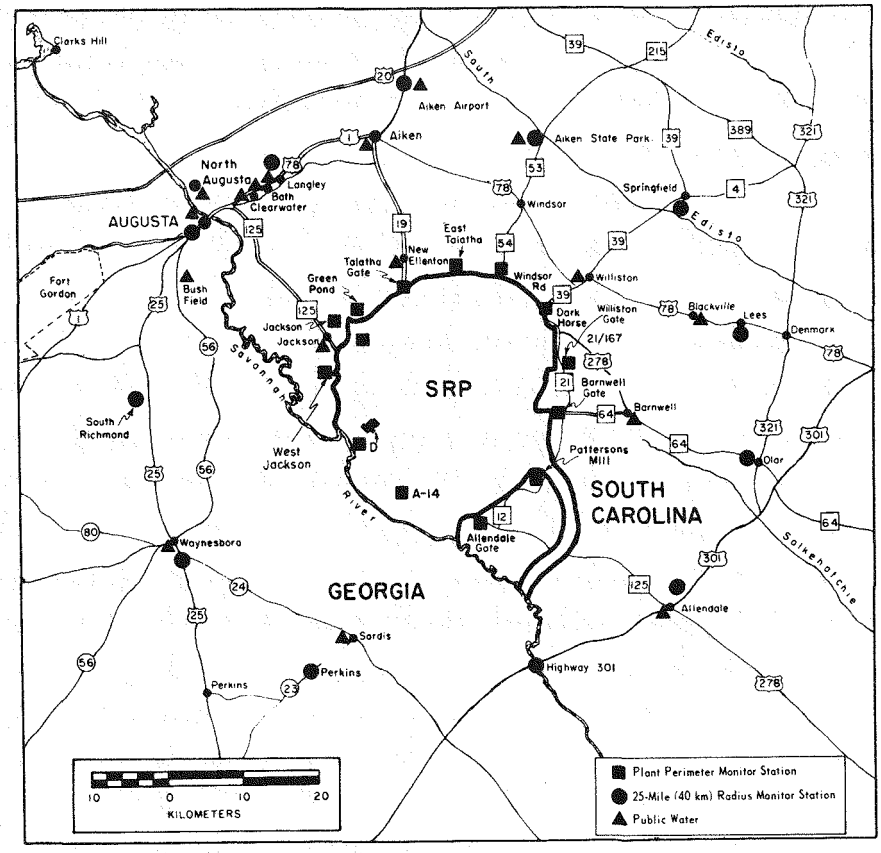

FIGURE 2. CONTINUOUS AIR MONITORING STATIONS AND PUBLIC WATER SAMPLE LOCATIONS

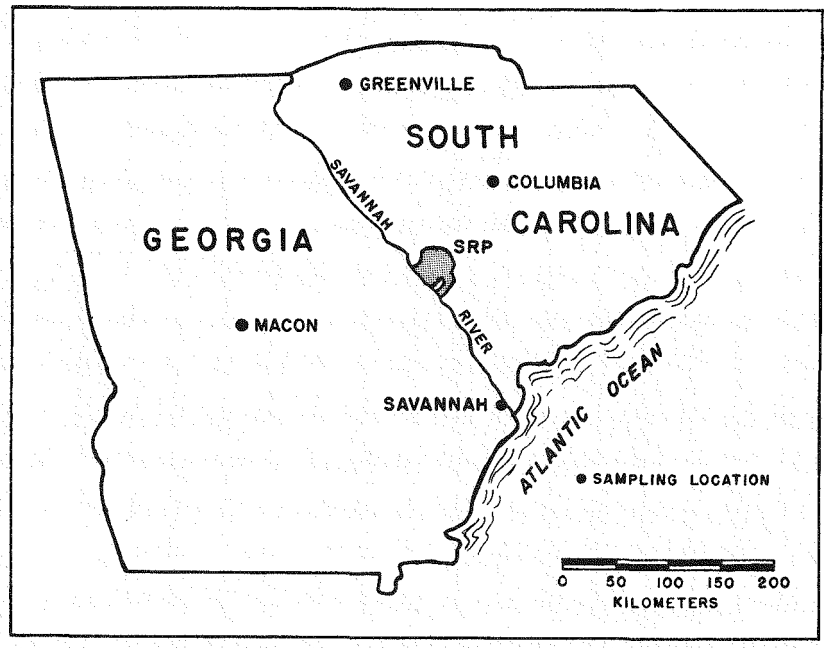

FIGURE 3. DISTANT AIR MONITORING STATIONS

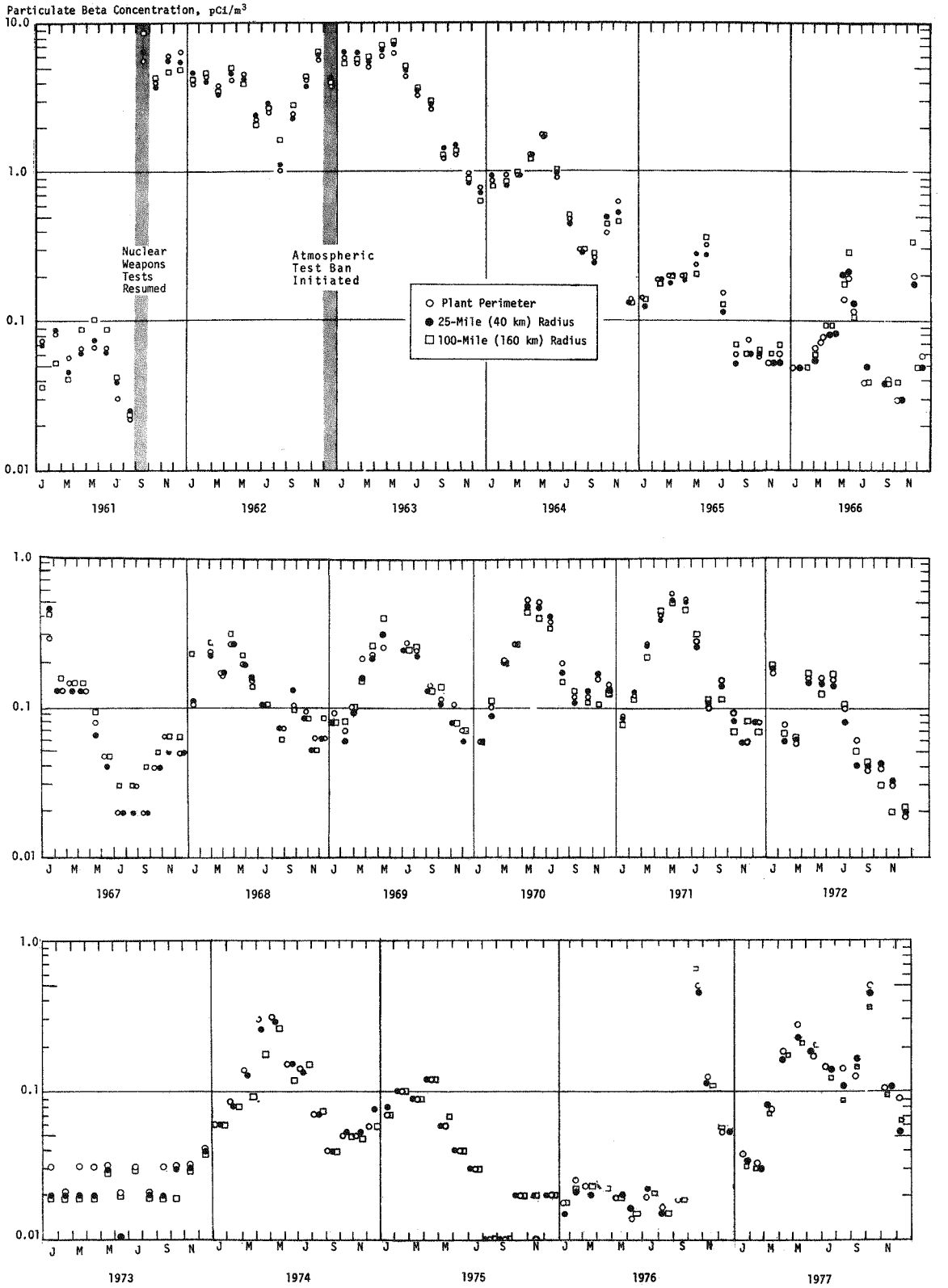

FIGURE 4. ATMOSPHERIC RADIOACTIVITY

After being measured for particulate alpha, beta, and gamma activities, weekly filters from each of the location groups (plant perimeter, 25-mi radius, and 100-mi radius) are combined and dissolved to produce three composite monthly samples for isotopic plutonium analyses. Plutonium is separated by ion exchange, electrodeposited, and counted for alpha emitters. ^{238}Pu and ^{239}Pu concentrations in air are listed in table B-1. The concentrations of ^{239}Pu in air averaged 20 aCi/m^3 at the plant perimeter, 18 aCi/m^3 at the 25-mi-radius stations, and 21 aCi/m^3 at the 100-mi-radius stations. The respective ^{238}Pu concentrations were 4.3, 2.5, and 2.3 aCi/m^3. The average ^{239}Pu concentrations in air were more than three times the 1976 concentrations; the increased plutonium concentrations in air were coincident with the spring rise in particulate beta activity in 1977. This corresponding rise in plutonium activity was more evident in 1977 than observed in previous years. There was also an apparent correlation between the September 1977 Chinese weapons test and increased ^{239}Pu concentrations in air. This influence of a specific weapons test on ^{239}Pu activity in air was more pronounced than observed earlier. Monthly concentrations of particulate beta and ^{239}Pu in air during 1977 are compared in figure 5. Unlike the ^{239}Pu concentrations, ^{238}Pu concentrations did not rise during the spring months.

Deposition rates of plutonium were also determined from rainwater ion exchange columns (fallout collectors). Monthly samples were composited according to two groups: plant perimeter and 25-mi radius (table B-2). ^{239}Pu deposition at the plant perimeter for 1977 was 1.1 pCi/m^2 and 1.2 pCi/m^2 at 25-mi radius. The respective ^{238}Pu depositions were 0.3 pCi/m^2 and 0.7 pCi/m^2.

Deposition of other radionuclides in fallout collectors from weapons tests fallout during 1977 averaged 65 nCi/m^2 at the plant perimeter and 63 nCi/m^2 at 25-mi-radius stations (table B-2); comparable values for 1976 were 15.2 nCi/m^2 at the plant perimeter and 14.6 nCi/m^2 at 25-mi-radius locations. Naturally occurring ^{7}Be (deposition of 44 nCi/m^2 at plant perimeter and 37 nCi/m^2 at 25-mi radius), as in air filter samples, is the major gamma emitter in rain deposition. Trace quantities of ^{95}Zr-Nb, ^{137}Cs, ^{144}Ce, and ^{90}Sr were deposited in rain prior to March 1977. These fallout radionuclides in rain deposition, as in air filters, began increasing in March. Deposition of ^{106}Ru was measurable in only a few samples. Following the September Chinese weapons test, fresh fallout radionuclides (primarily ^{95}Zr-Nb, ^{103}Ru, ^{131}I, ^{141}Ce, ^{144}Ce, and ^{239}Np) appeared in rain samples. Rainwater is analyzed biweekly for tritium. The average concentration during 1977 at the plant perimeter was 2.4 pCi/ml as compared with 0.7 pCi/ml at 25-mi-radius locations (table B-2). Tritium in rain at the 100-mi-radius locations averaged 0.3 pCi/ml (near or less than the sensivitity of the analysis).

Gamma radiation is measured continuously for quarterly periods with thermoluminescent dosimeters at the plant perimeter, 25- and 100-mi-radius air monitoring locations (figures 2 and 3). Environmental gamma radiation data for 1977 (table B-3) were characteristic of measurements observed at individual stations for the past several years (average 70 mR/yr). An environmental gamma radiation monitoring program, utilizing thermoluminescent dosimeters (TLD's), was initiated during 1973 to measure background radiation at 79 stations selected at 1-mi intervals along the plant perimeter. Exposure rates at the 79 perimeter stations averaged 69.0 mR/yr ± 13.1 mR/yr for the two 1977 semiannual cycles monitored. All measurements are taken at 1 m aboveground. The contribution of cosmic radiation to the annual background radiation exposure rate is 29 mR ± 1.5 mR [DPSPU 76-30-1]

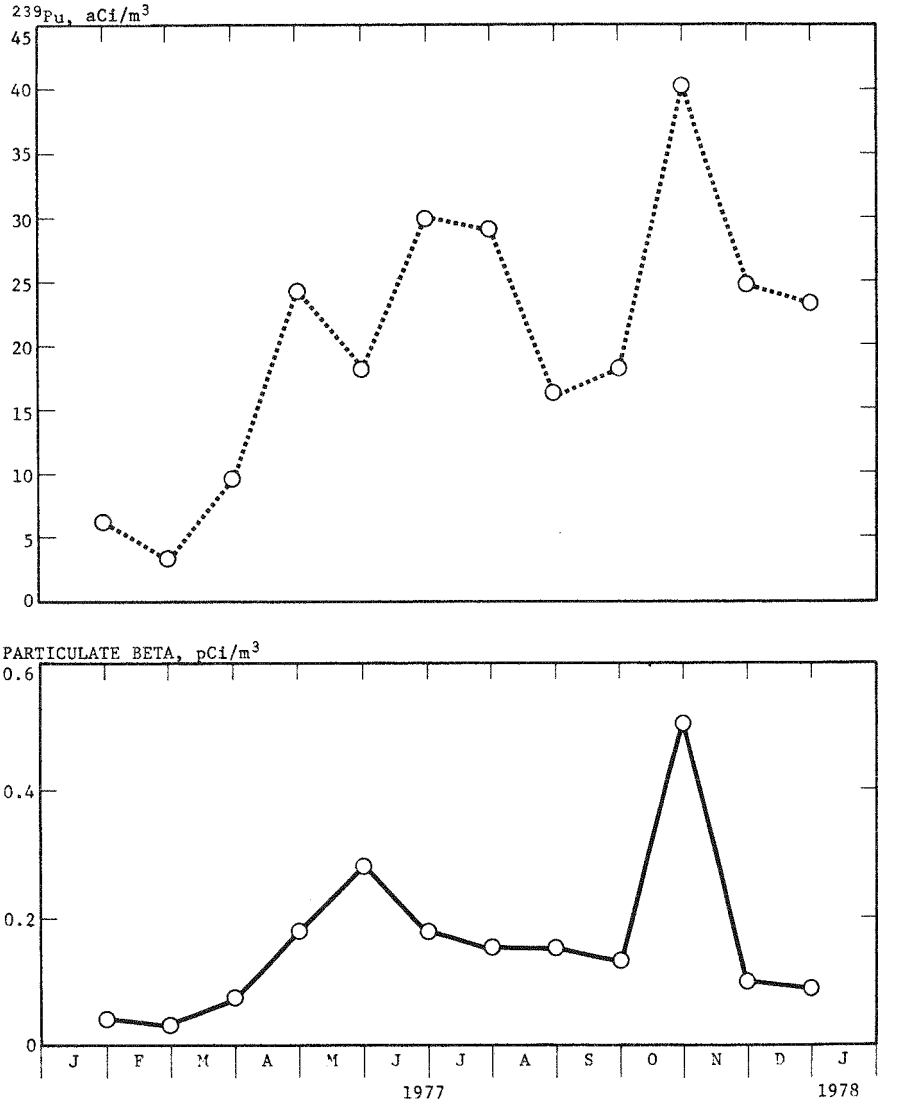

FIGURE 5. COMPARISON OF ^{239}Pu AND PARTICULATE BETA ACTIVITY IN AIR AT PLANT PERIMETER

VEGETATION AND FOOD MONITORING

Vegetation

Radioactive contamination of growing plants may result from sorption of radioactive materials from the soil or from foliar deposition. Bermuda grass is selected for analysis because of its importance as a pasture grass for dairy herds and its year-round availability.

Grass samples are routinely collected at seven locations on the plant perimeter and at seven other locations on a 25-mi radius (figure 6). Samples are analyzed individually for alpha, nonvolatile beta, and tritium and composited monthly for analyses for specific gamma emitters. Trace quantities of ^{95}Zr-Nb and ^{144}Ce from general fallout were detectable in vegetation from January through September 1977. Increased ^{95}Zr-Nb with ^{103}Ru and ^{141}Ce appeared in vegetation during the fourth quarter 1977, following the September Chinese nuclear test. Radioisotopic concentrations found in vegetation are shown in table B-4. Naturally occurring ^{7}Be is the major component. Alpha emitters in vegetation collected at the plant perimeter, 25-mi radius, and 100-mi radius averaged 0.3 pCi/g, and beta emitter averages ranged from 28 to 30 pCi/g. These levels of activity are essentially the same as in 1976.

Tritium is the only radionuclide of plant origin detected in vegetation. The average concentration in the free water from vegetation collected at the plant perimeter is 3 pCi/ml as compared with 0.6 pCi/ml at a 25-mi radius and 1.4 pCi/ml at a 100-mi radius.

Milk

Milk is sampled at three dairies (North Augusta, SC, Denmark, SC, and Waynesboro, GA) within a 25-mi radius of SRP. Samples are collected twice monthly and analyzed for tritium and radioiodine. Analyses are made quarterly for ^{90}Sr and monthly for ^{137}Cs. Milk produced in the area and sold by a major distributor is also analyzed for these radionuclides. Results are summarized in table B-5.

^{90}Sr and ^{137}Cs in milk are attributed to fallout. Average concentrations of the radionuclides in milk were essentially the same as in 1976: 17 pCi/l for ^{137}Cs and 9 pCi/l for ^{90}Sr. ^{131}I in milk samples was less than the sensitivity of analysis (1 pCi/l) throughout the first three quarters of 1977. Fallout ^{131}I from the Chinese weapons test was detected in milk during the fourth quarter (see p 24). Strontium, cesium, and iodine (January-September) values represent 3.0, 0.08, and less than 0.3% of the respective CG's for water. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level (0.5 pCi/ml) is 0.02% of the CG for water.

Food

Over 60 samples of farm produce representing five food categories (grain, fruit, leafy vegetables, poultry, and beef) are collected at 14 localities in the six counties surrounding SRP. Six locations are near the plant perimeter and eight at a distance of approximately 25 mi (figure 7). The samples of local beef were collected near Aiken and Ehrhardt, SC, and Louisville and Girard, GA. All samples were analyzed by gamma spectrometry for gamma-emitting radionuclides. Radiochemical analyses are used for ^{90}Sr and alpha emitters (uranium and plutonium). Liquid scintillation counting is used for tritium. With exception of grains, all foods are prepared as though for human consumption. Peelings, seeds, and other nonedible parts are removed. Wheat containing the whole grains only and oats containing both grains and husks are processed unwashed. Results for 1977 are summarized in table B-6.

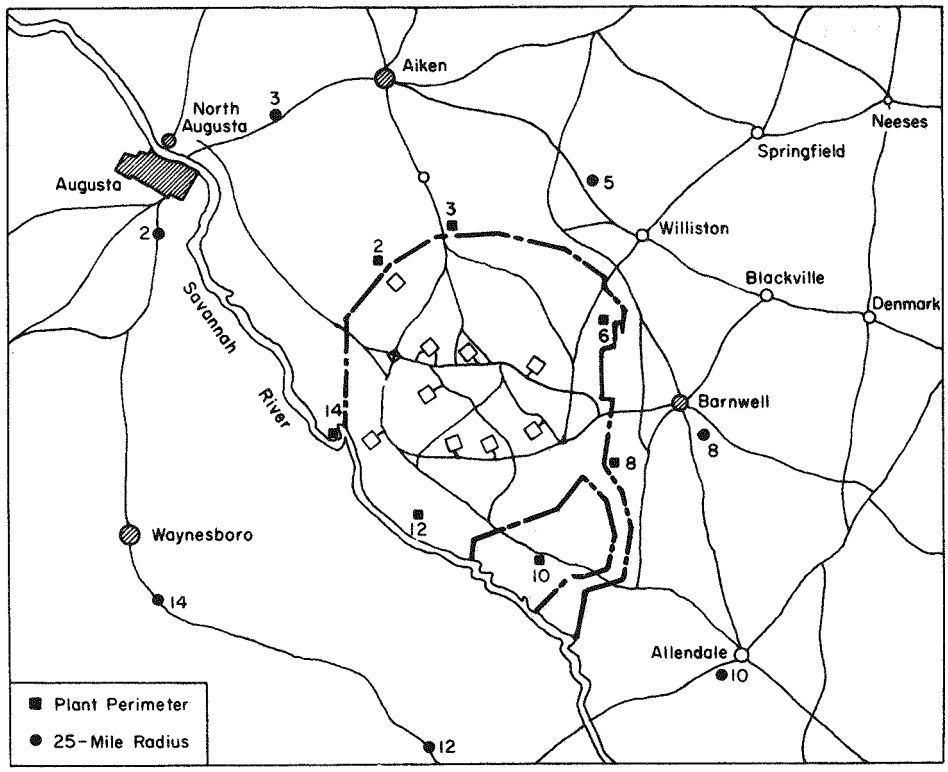

FIGURE 6. VEGETATION SAMPLE LOCATIONS AT PLANT PERIMETER AND 25-MILE RADIUS

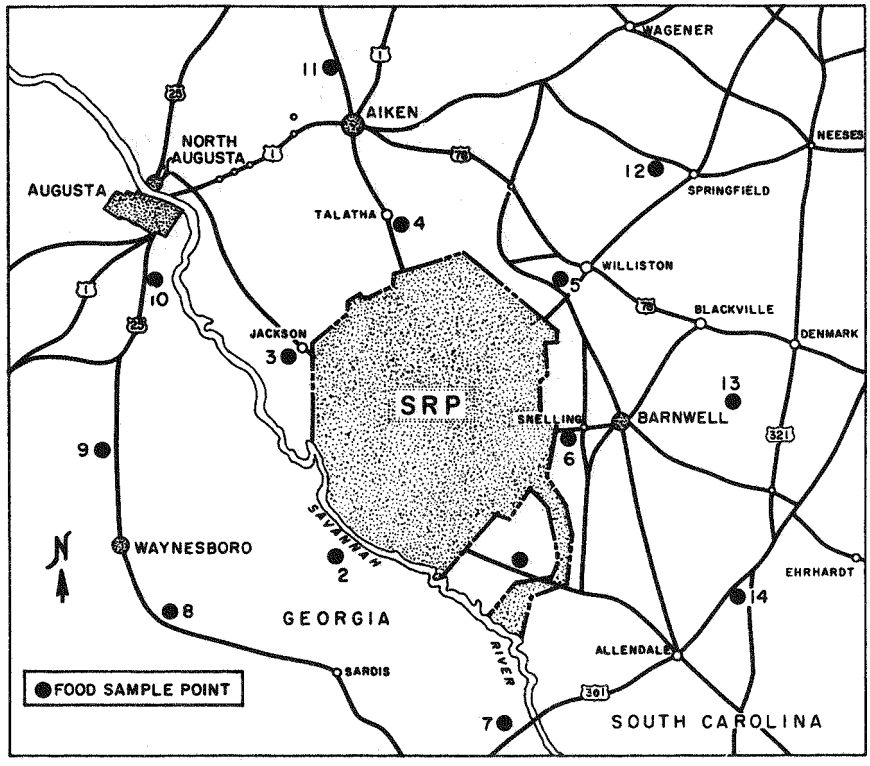

FIGURE 7. FOOD SAMPLE LOCATIONS

SRP contributions to the levels of radioactivity (excluding tritium) in farm produce were so low in 1977 that they were indistinguishable from fallout. All radionuclides in food were near or below the levels of detection. Collards, as during previous years, contained the highest concentration of ^{90}Sr. Because the collards were collected after the arrival of fallout from the September Chinese weapons test, other low level fission product activity was also detected.

Fish

Fish are trapped in the Savannah River upstream, adjacent to, and downstream from the SRP effluents. Individual whole fish are analyzed by gamma spectrometry for ^{137}Cs and other gamma-emitting radionuclides; bone from each specimen is composited monthly for $^{89,90}Sr$ analysis. Fish flesh samples are also freeze-dried for tritium analysis. Fish analysis data for 1977 are presented in table B-7.

During 1977 the radioactivity in fish showed only minor contribution by SRP and concentrations are of minor significance from a radiation dose viewpoint. Thirty-seven fish (20 collected above, 7 adjacent to, and 10 below the plant) were radioanalyzed. Concentrations of ^{137}Cs in all fish were near or less than the sensitivity of analysis (approximately 0.2 pCi/g).

Tritium in fish from the river reflect tritium concentrations in the water. The 1977 results are similar to those observed during the past 8 years as shown in table 4.

TABLE 4
TRITIUM IN FISH

	River Fish, pCi/ml (free water)					
	Above Plant		Adjacent to Plant		Below Plant	
Year	Max	Avg	Max	Avg	Max	Avg
1970	6	4	8	5	11	5
1971	7	3	15	8	11	7
1972	9	4	16	7	17	8
1973	5	2	16	6	12	6
1974	8	4	54	12	12	8
1975	33	5	6	3	12	6
1976	9	5	10	5	16	8
1977	26	8	24	11	20	13

Fish, representative of the Savannah River commercial fishing industry (collected near the mouth of the Savannah River), were supplied by the Georgia Game and Fishing Commission and analyzed for tritium, alpha, and gamma emitters. Except for tritium, all analyses were near or below minimum levels of detection. Four of the seven samples contained low level tritium concentrations with a maximum of 27 pCi/ml in a striped bass. These results are similar to analyses of fish in 1977 from the Savannah River above the plant. Individual results are shown in table 5.

TABLE 5
RADIOACTIVITY IN COMMERICAL SAVANNAH RIVER FISH

Species	pCi/g (wet weight) Flesh Alpha	^{137}Cs[a]	T (pCi/ml H_2O)
Blue Crabs[b]	-	<0.1	<2
Carp	<0.1	<0.1	<2
Carp	<0.1		4
Striped Bass	<0.1		15
Striped Bass	<0.1	<0.1	<2
Striped Bass	<0.1		27
Shad	<0.1	<0.1	21
Control River Fish			
Average	-	<0.1	9
Maximum	-		26

[a] Composite
[b] Commercial supplier in Savannah, GA
- No analysis

Fish flesh samples are also analyzed for mercury content. Studies have shown that SRP operations do not significantly contribute to the mercury values in fish from the Savannah River above and below the plant boundaries.

Mercury was detected in river and stream fish in analyses beginning July 1971, and the levels in fish have changed very little since that time. Initially, individual fish were analyzed; in 1972 fish samples were analyzed quarterly by species composites – bream, bass, and catfish. From 1973 through 1975, species composites were analyzed semiannually, and in 1976 and 1977, plant streams and river fish were again analyzed individually. Annual mercury averages for three species of river fish, bass, bream, and catfish are shown in table 6; individual mercury data for river fish for 1977 are presented in table B-7.

TABLE 6
MERCURY IN FISH, ug/g

	1971	1972	1973	1974	1975	1976	1977
River above Plant							
Bass	0.3	1.4	1.1	0.8	0.2	0.2	-
Bream	0.3	0.4	0.6	0.3	0.1	0.2	0.6
Catfish	0.3	0.6	0.3	0.2	0.2	0.2	1.5
River below Plant							
Bass	-	-	2.8	1.1	0.4	0.4	0.5
Bream	0.4	0.4	0.4	0.4	0.2	0.4	0.4
Catfish	0.4	0.7	0.4	0.5	0.3	0.4	0.6

Annual analyses of sediment collected from the Savannah River and plant effluent streams have shown some low concentrations (0.3 μg/g maximum) of polychlorinated biphenyls (PCB's). The positive results were detected in the river both upstream and downstream of the plant. Because fish concentrate PCB's, fish samples, collected from both plant effluent streams and the Savannah River in March, were analyzed by an offplant commercial laboratory. All PCB fish results were less than the sensitivities of the analyses (<0.1 and <0.5 μg/g). The Environmental Protection Agency has not established regulations for maximum contaminant levels for PCB's in drinking water; the Food and Drug Administration has recommended a 5-ppm (μg/g) tolerance level for PCB's in fish and recently proposed a change to 2 ppm.

Deer and Hogs

Concentrations of ^{137}Cs in 1271 deer and 57 hogs killed during the autumn 1977 hunts (figure 8) were estimated with a portable, single-channel scintillation instrument before release of the animals to hunters. The estimated ^{137}Cs content was verified by gamma spectrometric analysis of muscle tissue from 80 deer.

^{137}Cs concentrations in deer originated almost entirely from fallout deposits from nuclear weapons tests. Average ^{137}Cs concentration in deer was 10 pCi/g with a maximum in one deer of 42 pCi/g. Edible meat from that deer weighed about 52 lb and would therefore contain about 0.99 μCi of ^{137}Cs. An adult eating all of this deer meat would receive a radiation dose of 59 mrems to the whole body – less than the annual dose South Carolina residents receive from natural radiation [9]. Deer and hog data are shown in table B-8. A summary of ^{137}Cs concentrations detected in deer during all of the public hunts, beginning in 1965, is summarized in table 7. ^{137}Cs in SRP deer since 1968 is also compared with data of South Carolina Coastal Plain (SCCP) deer provided by the School of Forest Resources, University of Georgia, Athens, GA.

Thyroids from 70 deer were analyzed for ^{131}I. Concentrations of ^{131}I ranged from <3 to 410 pCi/g. The elevated ^{131}I concentrations are attributed to Chinese weapons test fallout. Bone from 13 deer were analyzed for radiostrontium; concentrations were less than the sensitivity of the analysis (5 pCi/g).

TABLE 7
CESIUM-137 IN DEER, pCi/g

Year	No. of Deer Killed		Average		Maximum	
	SRP	SCCP[a]	SRP	SCCP[a]	SRP	SCCP[a]
1965	198		<10		10	
1966	541		6		24	
1967	1032		9		104[b]	
1968	699	34	11	23	74[c]	80
1969	889[d]	31	15	15	204[c]	72
1970	864	33	18	20	77[c]	57
1971	865	42	11	21	48	42
1972	808	72	8	11	38	32
1973	1158	78	6	16	31	49
1974	1551	89	5	9	52	23
1975	1391	42	9	17	36	38
1976	1357	35	11	16	41	36
1977	1271	[e]	10	[e]	42	[e]

[a] South Carolina Coastal Plains.
[b] Killed along Four Mile Creek.
[c] Killed near Steel Creek.
[d] Approximately 20% of deer monitored before 1969; each deer monitored since 1969.
[e] Data not available.

FIGURE 8. U.S. FOREST SERVICE PERSONNEL – PUBLIC DEER HUNT

Game Birds

Waterfowl collected onplant for analysis included eight ducks (seven wood ducks and one ring neck), three coots, and two marsh hens from Par Pond, two wood ducks from Steel Creek, and one coot from a separations area seepage basin. Average ^{137}Cs concentrations in all waterfowl were 0.2 pCi/g. The maximum concentration of ^{137}Cs was 0.5 pCi/g, measured in a Par Pond wood duck. The ^{137}Cs concentration in the Steel Creek wood duck and seepage basin coot was less than 0.1 pCi/g. One quail trapped near the center of the plantsite showed less than 0.1 pCi/g ^{137}Cs.

CHINESE FALLOUT MONITORING

An extensive special monitoring program was initiated in September following the announcement of a Chinese atmospheric nuclear detonation (September 17, 1977). The arrival of fresh fallout (September 26) occurred 9 days after the announced date of detonation; this length of time corresponds to a 9.5-day average of earlier Chinese tests. Particulate beta activity in a high volume air sample showed a maximum gamma concentration of 6.4 pCi/m^3 during a 24-hour period ending September 2. Particulate beta activity in routine weekly air filters both onplant and offplant, increased from 0.11 pCi/m^3 during August to 0.34 pCi/m^3 during the week ending September 29, and reached a weekly maximum of 1.46 pCi/m^3 during the week ending October 5. Total deposition of gamma emitters in routine monthly rain ion-columns for the period September 14 to October 13 ranged from 6.9 nCi/m^2 to 45.2 nCi/m^2, averaging 23.2 nCi/m^2. Prior to the arrival of fresh fallout (August 8 to September 14), the total gamma deposition averaged 0.3 nCi/m^2. Eight fresh fallout radionuclides were identified in daily rain collections.

Maximum ^{131}I levels in environmental samples were 160 pCi/l in milk (farm cow sample), 8 pCi/g in vegetation, and 410 pCi/g in deer thyroid (killed during the public hunt on October 14). The maximum ^{131}I air concentration measured in daily filters was 0.5 pCi/m^3; and the maximum ^{131}I deposited in a daily rain sample was 1.2 nCi/m^2. Individual fallout concentrations measured in environmental samples are shown in tables B-18 through -20.

The reported yield of the September 1977 Chinese nuclear device test was 20 kilotons (or less) and the Chinese atmospheric test in September 1976, 200 kilotons. Figures 9 and 10 compare daily concentrations of gamma activity measured in air filters, and the deposition of gamma activity in rain following the two tests. Maximum fallout concentrations (total gamma) in the atmosphere in 1976 and 1977 were fairly comparable, 9.5 pCi/m^3 and 6.4 pCi/m^3. Fresh fallout, however, was detectable in air samples for a longer period in 1976. Deposition of radioactivity in 1976 was larger than usual and was due in part to heavy rains occurring soon after the arrival of the fallout. Total deposition of gamma activity measured at all monitoring stations averaged twice the gamma deposition in 1977 (comparison at one location; 63 nCi/m^2 in 1976, 21 nCi/m^2 in 1977). This scavenging of radionuclides from the atmosphere by rain explains the fairly comparable fallout concentrations in air during the 1976 and 1977 fallout periods. Table 8 summarizes the maximum fallout levels in the environment for both years.

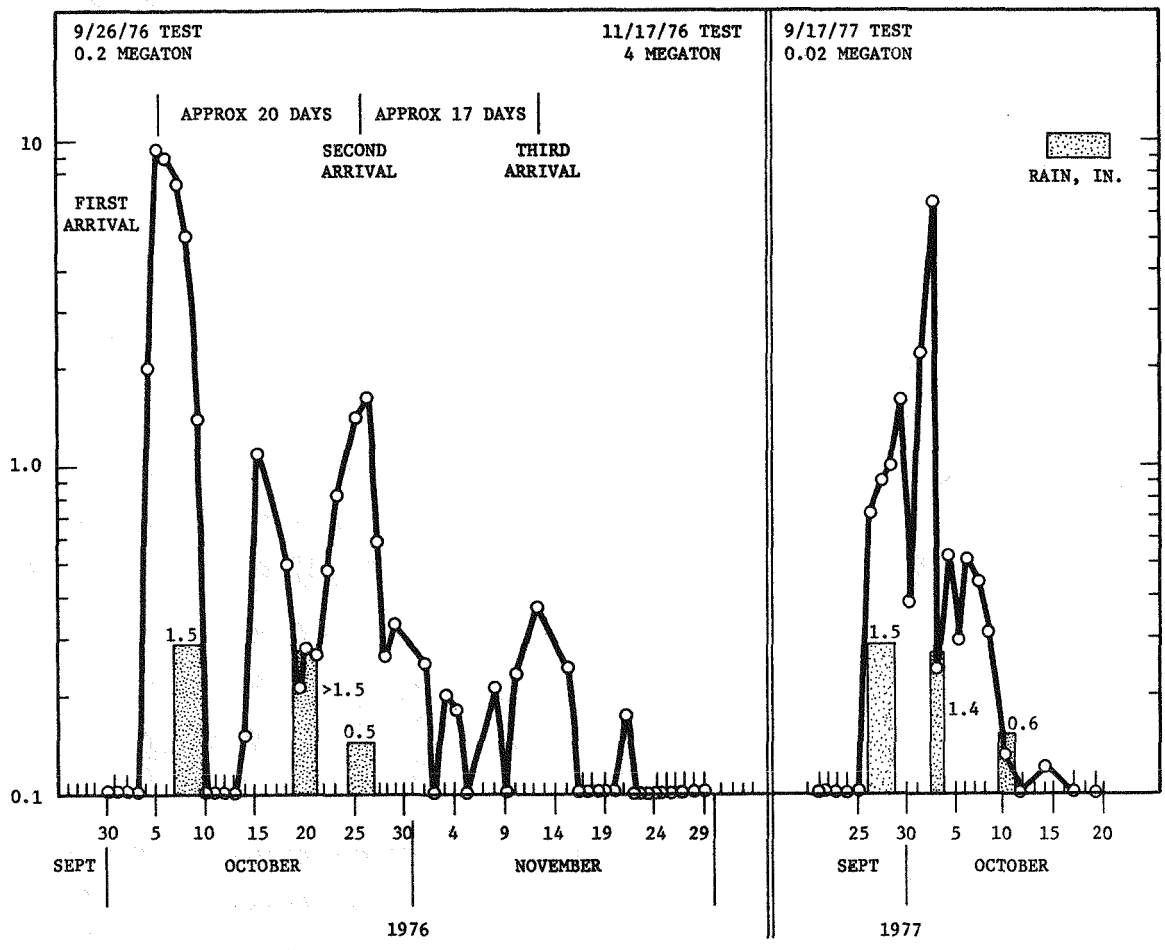

FIGURE 9. GAMMA ACTIVITY IN AIR, pCi/m^3

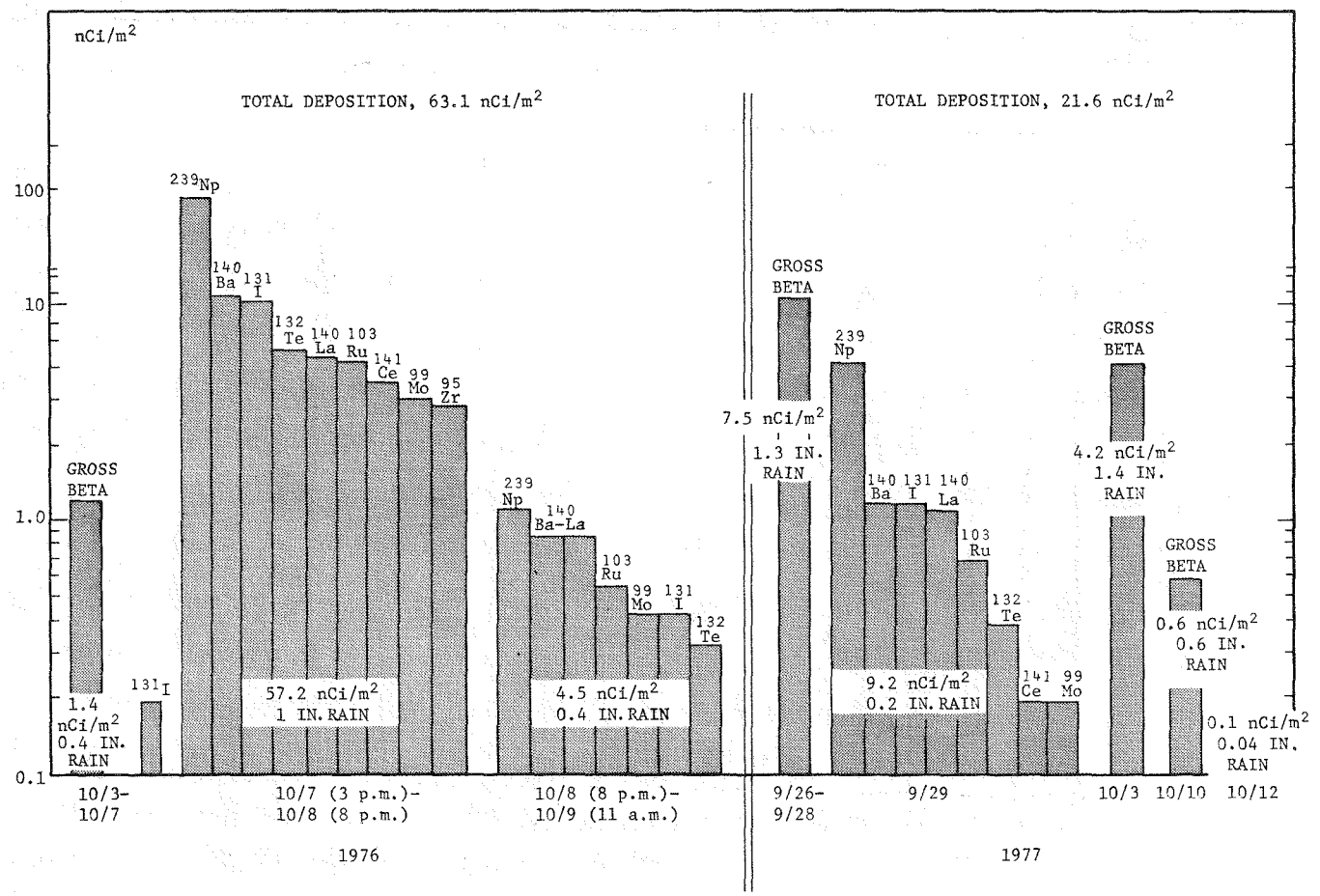

FIGURE 10. RADIOACTIVITY DEPOSITED IN RAIN

TABLE 8
COMPARISON OF FALLOUT LEVELS FOLLOWING
THE SEPTEMBER 1976 AND SEPTEMBER 1977 TESTS

Special Sampling	1976	1977
Maximum daily gamma activity in air, pCi/m³	9.5	6.4
Maximum daily gamma deposition in rain, nCi/m²	57.2	9.2
Maximum daily ^{131}I deposition in rain, nCi/m²	7.4	1.2
Maximum ^{131}I in vegetation, pCi/g	8.8	9.4
Maximum ^{131}I in deer thyroids (public hunts), pCi/g	670	410
Maximum ^{131}I in farm cow milk samples, pCi/l	780[a]	160[a]
Routine Sampling		
Maximum weekly particulate beta activity in air, pCi/m³	2.1	1.9
Maximum weekly ^{131}I in air, pCi/m³	0.07	0.04

[a] Maximum ^{131}I in dairy milk samples, 67 pCi/l in 1976 and 14 pCi/l in 1977.

WATER MONITORING

Savannah River – Radioactivity

The plantsite is drained by five streams that flow to the Savannah River (figure 1). The primary sources of the very small amount of radioactivity that reaches the river are the reactor facilities. Tritium accounts for the largest quantity of radioactivity released by the reactors to the effluent streams. However, the SRP contribution of tritium to the Savannah River amounts to only 0.16% of the CG.

River water is sampled above and below the plant (sampling method described earlier) and analyzed weekly. Concentrations of gross alpha, nonvolatile beta emitters, and tritium in river water for 1977 are summarized to appendix B, table B-9. The alpha and beta values represent the radioactivity associated with dissolved and suspended solids and are all near or less than the sensitivity of analysis. Upstream measurements are attributed to natural radioactivity and worldwide fallout from nuclear weapons tests. Downstream measurements reflect these sources plus releases from SRP.

Tritium, trace amounts of ^{137}Cs, and ^{90}Sr were the only radionuclides of SRP origin detected in river water at the downstream location. ^{90}Sr and tritium from worldwide fallout were also detected in river water upstream from SRP effluents. Average concentrations of all radionuclides found in river water during 1977 (table B-10) are only small fractions of the CG's. The tritium concentration in river water below the plant (4.8 pCi/ml, including 0.5 pCi/ml background river contribution) represented the highest CG percentage (0.16%).

Savannah River – Chemical Water Quality and General River Health

The water quality of the Savannah River (table B-11) is not adversely affected by the operation of the Savannah River Plant More fecal coliform bacteria are found in the river water entering the plant than in the effluent water re-entering the river. With respect to thermal effect, several miles of onsite streams and a large swamp permit dissipation of almost all heat generated at SRP. Results of temperature profile surveys of the Savannah River relative to the NPDES Permit limitations are shown on pages 31 and 32.

The Limnology Department of the Academy of Natural Sciences of Philadelphia (ANSP), under contract to Du Pont, has performed a continuing survey of aquatic environment and water quality of the Savannah River upstream (station 1) and downstream (station 6) from SRP since 1951. The purpose of this survey is to determine the effect, if any, of SRP effluent discharges on general river health.

Diatometers are positioned in the river at three locations (one above and two below the SRP site) to provide a continuous monitor of the effects of plant effluents on one major group of river organisms. The diatometers contain glass slides on which diatoms accumulate. The slides are replaced biweekly, and the slides containing dried diatoms are sent to ANSP for analysis.

In rivers adversely affected by pollution, the number of species will be reduced in varying amounts corresponding to the degree of pollution. The less tolerant species are eliminated while the more tolerant species become dominant. Thus, while total populations may increase in size, the number of different species will be reduced. Detailed readings and summaries of the diatometer surveys are issued quarterly by ANSP. There is no evidence that the operation of the Savannah River Plant affected the diatom flora of the Savannah River.

Quarterly surveys of other algae, insects, invertebrates, and fish are also conducted by ANSP. Specialists in entomology, algology, invertebrate zoology, and ichthyology sample river biota during times of the year most suitable to their specialty. An algologist or entomologist accompanies every survey to provide continuity of collecting and methodology and to observe environmental conditions. Results of the quarterly surveys are summarized and published annually.

In 1977, the surveys were conducted in March, July, September, and December. Insects were collected on all four surveys, algae in March and December, invertebrates other than insects in July, and fish in September. A preliminary evaluation of results of the 1977 surveys shows very little change, from the past, in the areas of the Savannah River studied. Both stations show evidence of considerable organic enrichment. The algae, fish, and invertebrate collections show little difference between the stations. The insects are more diverse and abundant at station 6 than at station 1. There is no evidence of damage to the aquatic life surveyed resulting from the operations of the Savannah River Plant.

Periodically, or as a result of major changes in the physiography of the river, ANSP makes comprehensive surveys of the biota and chemical water quality above, adjacent to, and below SRP to ascertain effects of SRP operations on river conditions. Determinations obtained during the last comprehensive survey (1976) showed no marked changes in the number of species in the various classes of organisms studied. All indications are that the condition of the river was better at all stations than it was during the last comprehensive survey in 1972. For example, three species of fish, previously unrecorded at river stations, were collected during the 1976 survey. Although these species are represented by few individuals, their occurrence suggests water quality improvement. Also, the beds of rooted aquatic plants, which indicated degraded water quality, are no longer dominating the shallows in 1976 as in 1972.

Savannah River – Pesticides

Arrangements were made in 1971 for the United States Geological Survey (USGS) Water Quality Laboratory, Washington, DC (now located in Atlanta, GA), to analyze water and sediment from SRP streams and the Savannah River for pesticides. Water samples were previously analyzed for pesticides by the Federal Water Pollution Control Administration (now Environmental Protection Agency) at Athens, GA, and all results were less than sensitivity of analyses. Gas chromatographic water analyses in 1977 also show concentrations of pesticides in river water both upstream and downstream from the plant less than sensitivity of analyses (<0.05 μg/l). Previously, trace quantities of pesticides (approximately 0.05 μg/l, primarily dieldrin) were detected in river water both upstream and downstream from SRP. Dieldrin is an agricultural pesticide and is not used at SRP. River sediment collected upstream from SRP in 1977 showed trace quantities of dieldrin, DDD, DDE, and DDT; these pesticides are not used at SRP. Some pesticides and herbicides are used moderately in areas where insect and vegetation control is necessary for security and safety. Some herbicide and chemical treatment is also carried on by the U.S. Forest Service in timber management. Upstream river sediment in 1977 also showed a detectable PCB concentration. Results of the river sediment analyses by the USGS laboratory are shown in table 9. The pattern of concentrations detected in sediment continues to indicate that offplant sources are the primary contributors. Possible offsite sources for pesticides found in the river include domestic and industrial discharges and drainage from urban and agricultural areas.

TABLE 9
1977 SAVANNAH RIVER SEDIMENT, µg/kg[a]

	River 2 (Upstream)	River 10 (Downstream)
DDD	1.9	-
DDE	0.5	-
DDT	3.5	-
Dieldrin	2.0	-
PCB	8.0	-

[a] River water results were less than the sensitivity of the analysis.
- Not detected.

Temperature Survey – National Pollutant Discharge Elimination System Permit (NPDES)

Temperature profile studies of the Savannah River were made in February, May, August, and November. In August and November, temperature surveys were made only below the mouths of Beaver Dam Creek and Four Mile Creek; a temperature profile survey below the mouth of Steel Creek was not conducted because of the extended outage of the K-Area reactor. With the exception of one survey, all temperature profiles showed that the thermal plumes in the river meet the NPDES Permit requirements established by the U.S. Environmental Protection Agency. The temperature profile survey of the Savannah River made in May showed that the thermal plume from Four Mile Creek did not meet the NPDES Permit requirements, although it did meet South Carolina requirements. The Permit specifies a maximum temperature above ambient of 2.8°C, measured at 300 yd downstream of Four Mile Creek; the measurements showed a maximum tempertature above ambient of 3.7°C at 300 yd, decreasing to 2.8°C at 350 yd. The maximum plume temperature at 300 yd was 21.1°C (72°F); the above-limit temperatures at the 300-yd location were in a shallow plume, less than 30 ft wide and 2 ft deep. The survey will be repeated during May 1978. The standard applicable to the Savannah River as stated in the U.S. DOE NPDES Permit SC 00000175, 1976, is as follows.

During the period beginning on effective date and lasting through expiration, the permittee is authorized to discharge from outfalls-once-through cooling water.
Such discharges shall be limited and monitored by the permittee as specified below.

Effluent Characteristic	Discharge Limitations Instantaneous Maximums	Monitoring Requirements Measurement Frequency	Monitoring Requirements Sample Type
Plume Temp, °C	32.2[a]	1/quarter	Grab
Plume Temp Rise Above ambient, °C	2.8[a]	1/quarter	Grab

[a] Measured at the edge of the approved mixing zone. The zone for mixing shall be limited to not more than 25% of the cross-sectional area and/or flow of the Savannah River and shall not include more than one-third of the surface area measured from shore to shore. Mixing zone lengths shall not exceed 100 yards below the mouth of Beaver Dam Creek, 300 yards below the mouth of Four Mile Creek, and 100 yards below the mouth of Steel Creek. Ambient temperature shall be determined upstream from Beaver Dam Creek. Monitoring shall be conducted for a period of one year, during the months of May, August, November, and February and shall include three-dimensional data collection and plots. Data collection should be at low river flow to the extent practicable.

Figures 11, 12, and 13 show cross-sectional temperature profiles in the Savannah River at the edge of the three approved mixing zone lengths: 100 yd below the mouth of Beaver Dam Creek, 300 yd below the mouth of Four Mile Creek, and 100 yd below the mouth of Steel Creek. The river cross sections selected are the temperature profiles showing the zones of the highest above ambient temperatures during 1977. The temperature measurements at each location extended from the South Carolina (SC) shore, at 10-ft intervals for a distance of about one-half the river width. The locations of the maximum above ambient temperatures measured in each of the three mixing zones are as follows: 27°C (2.6°C above ambient) below Beaver Dam Creek, 10 ft from SC shore at 0-ft depth (water's surface); 22°C (3.7°C above ambient) below Four Mile Creek, 60 ft from SC shore at 0-ft depth; and 19.3°C (1.7°C above ambient) below Steel Creek, 10 ft from SC shore at 0-ft depth. The cross-sectional areas of the temperature measurements at the edge of each mixing zone in relationship with the total river cross-sectional areas are as shown in figure 14.

Beaver Dam Creek which receives heated cooling water from D and C Areas, and Four Mile Creek which receives heated cooling water from C Area are the streams of most interest. Other effluent streams are more effectively cooled before entering the river. K-Area reactor cooling water is cooled in the swamp before entering the river at Steel Creek, and P-Area reactor cooling water is returned to Par Pond.

Drinking Water

Communities near SRP get drinking water from deep wells or surface streams. Public water supplies from 14 surrounding towns are sampled and analyzed semiannually. Radiological data from analyses of all public water samples from the immediate vicinity of the plant are shown in table B-12. Drinking water wells onplant show concentrations of radioactivity similar to those offplant.

Average alpha activity (0.6 pCi/l) and beta activity (2 pCi/l) are essentially the same as those observed before plant startup. The sensitivity of the alpha analysis is 0.2 pCi/l and beta analysis, 7 pCi/l. Very low levels of tritium are found in drinking water of several of the towns that use surface water (annual maximum 0.7 pCi/ml). Concentrations of tritium in water from deep wells are near or less than the sensitivity of the analyses (0.3 pCi/ml).

The Beaufort-Jasper Water Authority operates a treatment facility to furnish drinking water, partially obtained from the Savannah River, to most of Beaufort County, SC. Water is supplied through a canal from the river at a point about 90 mi below SRP. A water treatment plant at Port Wentworth, GA, supplies water to a business-industrial complex near Savannah. Locations of the water treatment plants are shown in figure 15. These two water supplies are analyzed monthly for tritium content.

Tritium concentrations in water collected from the Beaufort-Jasper plant averaged 3 pCi/ml (0.10% CG, as defined in the foregoing section on Applicable Standards), and 4 pCi/ml in water from the Port Wentworth plant (0.13% CG) during 1977.

SAVANNAH RIVER SWAMP MONITORING

During the 1960's radioactive materials from SRP releases were deposited in about 1.7 square miles of offsite swamp downstream from SRP. Waterborne sediments settle in the swamp during periods of high flow in the river when the river overflows its natural banks into the swamp. When the

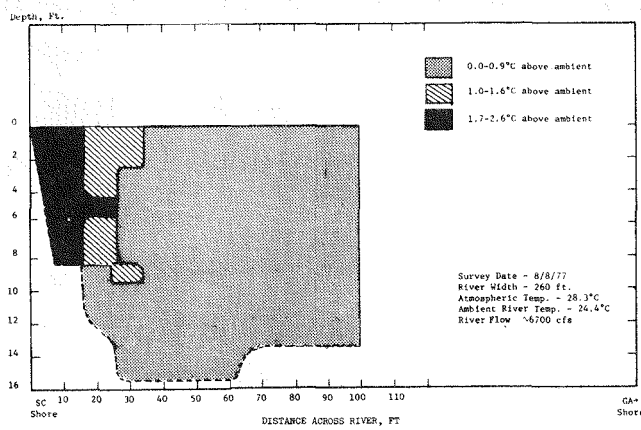

FIGURE 11. TEMPERATURES IN RIVER 100 YARDS BELOW BEAVER DAM CREEK

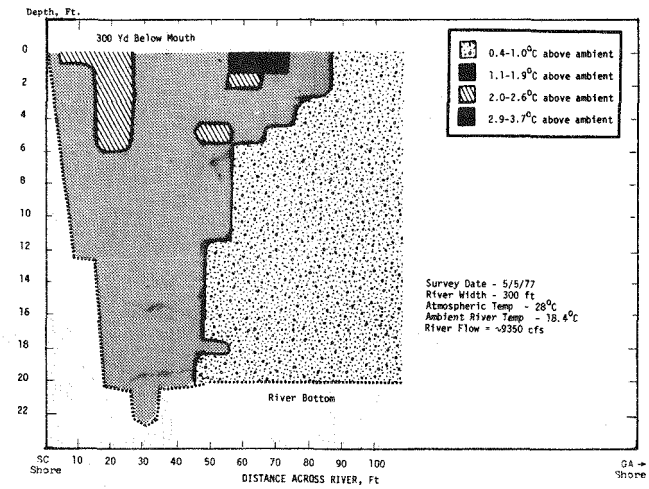

FIGURE 12. TEMPERATURES IN RIVER 300 YARDS BELOW FOUR MILE CREEK

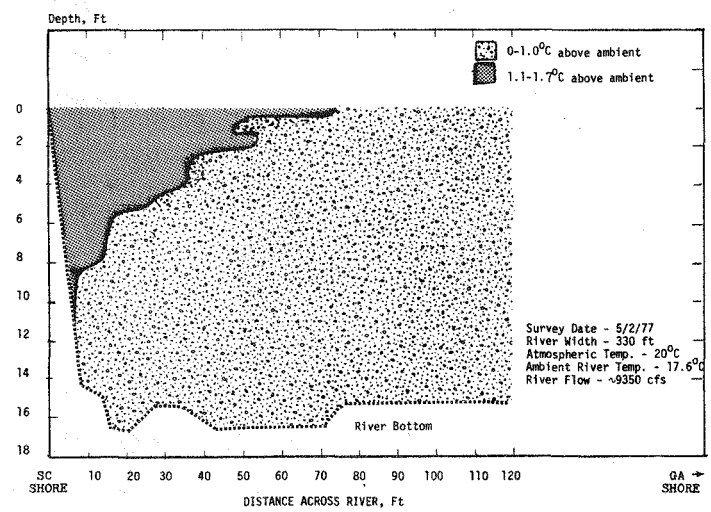

FIGURE 13. TEMPERATURES IN RIVER 100 YDS BELOW STEEL CREEK

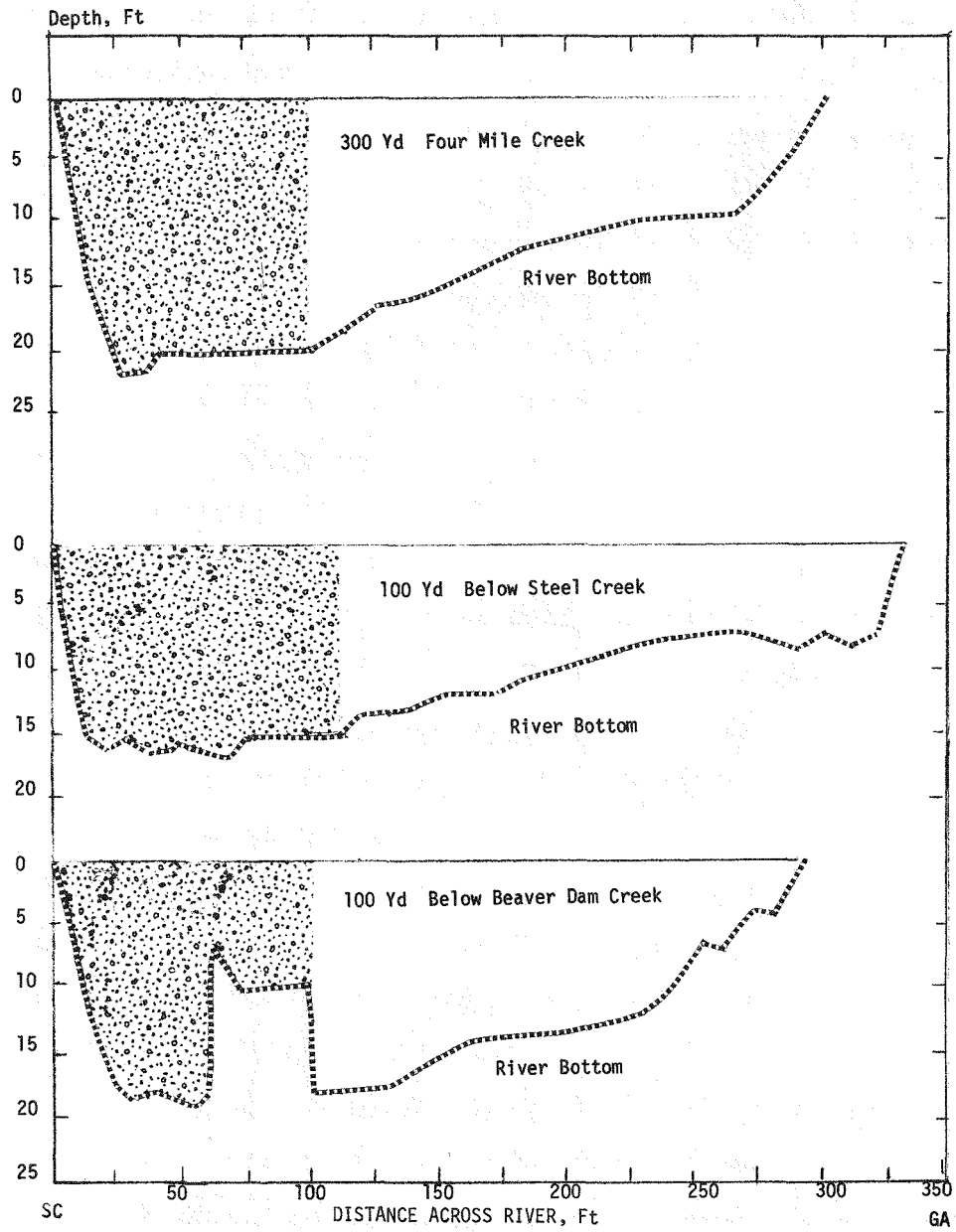

FIGURE 14. MIXING ZONE CROSS SECTIONS SHOWING MEASURED TEMPERATURE AREAS VERSUS TOTAL AREA

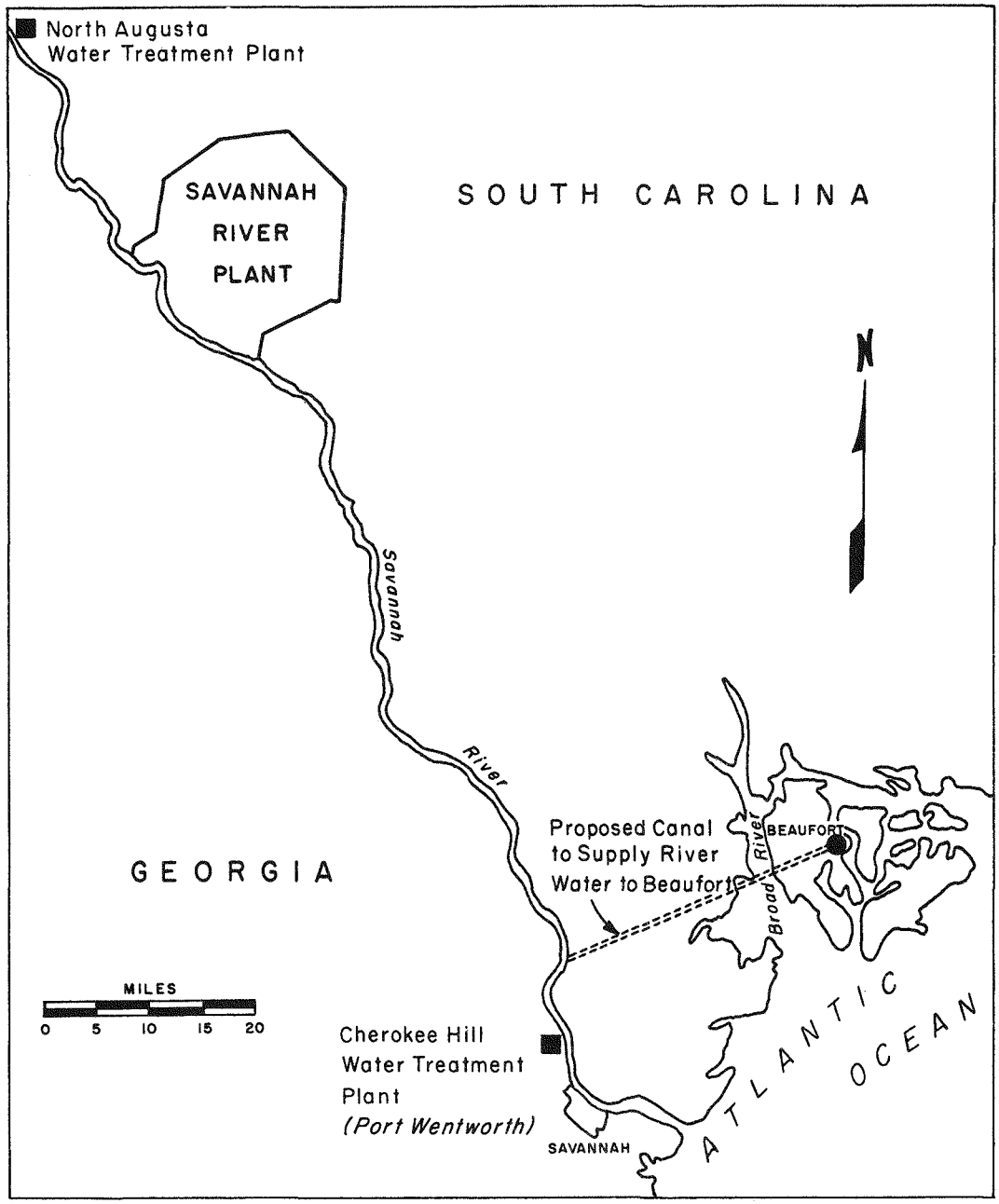

FIGURE 15. WATER TREATMENT PLANTS USING SAVANNAH RIVER WATER

swamp is flooded, the flow from SRP surface streams generally follows a path through the swamp paralleling the main river channel and bordering the north swamp margin. This swamp flow does not enter the main river channel until high ground is encountered at Little Hell Landing, approximately 4 mi from the SRP boundary (figure 16).

Associated with the deposit in the offsite swamp were approximately 25 Ci ^{137}Cs and less than 1 Ci ^{60}Co. Most of the ^{137}Cs and ^{60}Co in the swamp were from releases from L- and P-Area reactor fuel basins to Steel Creek. The discharges to Steel Creek were substantially reduced in 1970 following modifications to one reactor and shutdown of the other reactor. Aerial radiological surveys and ground surveys conducted in 1974 [10,11] showed that approximately 4.8 Ci ^{137}Cs and most of the ^{60}Co were deposited in a quarter-mile-long section of swamp (43 acres) immediately adjacent to the SRP boundary (figure 16). The remainder of detectable radioactivity was deposited in a 4-mile-long band bordering the north swamp margin, terminating at the Little Hell Landing area. The 1977 radiation survey of the swamp showed no significant change in levels of radioactivity from those measured and reported for the past several years.

Fifty-two locations on private property were selected along 10 trails transecting the swamp were selected for sampling vegetation and soil and radiation (TLD) measurements (figure 16). The trails were established in 1974 and samples are collected annually as near as possible to locations used in the 1974 survey.

The annual survey of the Savannah River swamp between Steel Creek and Little Hell Landing was completed in August. Radiation measurements with thermoluminescent dosimeters (TLD's) and analyses of soil and vegetation along 10 trails that transect the swamp (figure 16) indicate that radioactivity concentrations are similar to those observed during the last several years. In addition, animals collected along trails 1 and 2 and fish from lakes near trails 2, 7, and 8 contained very low levels of radioactivity that are, except for tritium, within levels observed in control samples and are attributed to worldwide fallout.

TLD radiation measurements were made at 1 m aboveground at specified intervals along each trail. Gamma radiation measurements in 1977 ranged from 0.20 to 1.51 mR/day compared to a 1976 range of 0.20 to 1.85 mR/day. When individual 1977 measurements are compared to 1976 measurements, fluctuations are observed at several locations. These variations become very small however, when taking into account the errors associated with each 1977 measurement as shown in appendix B, table B-14. Radiation measurements are also influenced by water level fluctuations in the swamp. This is evidenced by the lower radiation measurements observed in 1975 when high water levels were observed in the swamp. In 1976 and again in 1977, when water levels were lower, radiation measurements returned to levels previously recorded in 1974. Any significant increased radiation in the swamp would be indicated by an increasing trend over several years.

Soil samples were analyzed for gamma-emitting radionuclides at three locations on each trail; for plutonium at three locations on trail 1 and one location on trails 2-9, and for ^{90}Sr at three locations on trail 1. At each soil sample site, 10 cores, 8 cm deep, were taken in a straight line 30 cm apart and composited for analyses. Radionuclides detected in soil were ^{90}Sr, ^{137}Cs, ^{238}Pu, ^{239}Pu, and trace quantities of ^{60}Co (1-4 pCi/g on six trails). Individual ^{137}Cs and ^{90}Sr concentrations are presented in table B-15 and plutonium in table B-16. The range of 1977 cesium and plutonium concentrations are compared with ranges observed in 1975 and 1976 in table 10. Soil was analyzed for ^{90}Sr only in 1977 (0.7 pCi/g max). The elevated concentrations of ^{90}Sr, ^{137}Cs, and $^{238,239}Pu$ are attributed to previously deposited radioactivity.

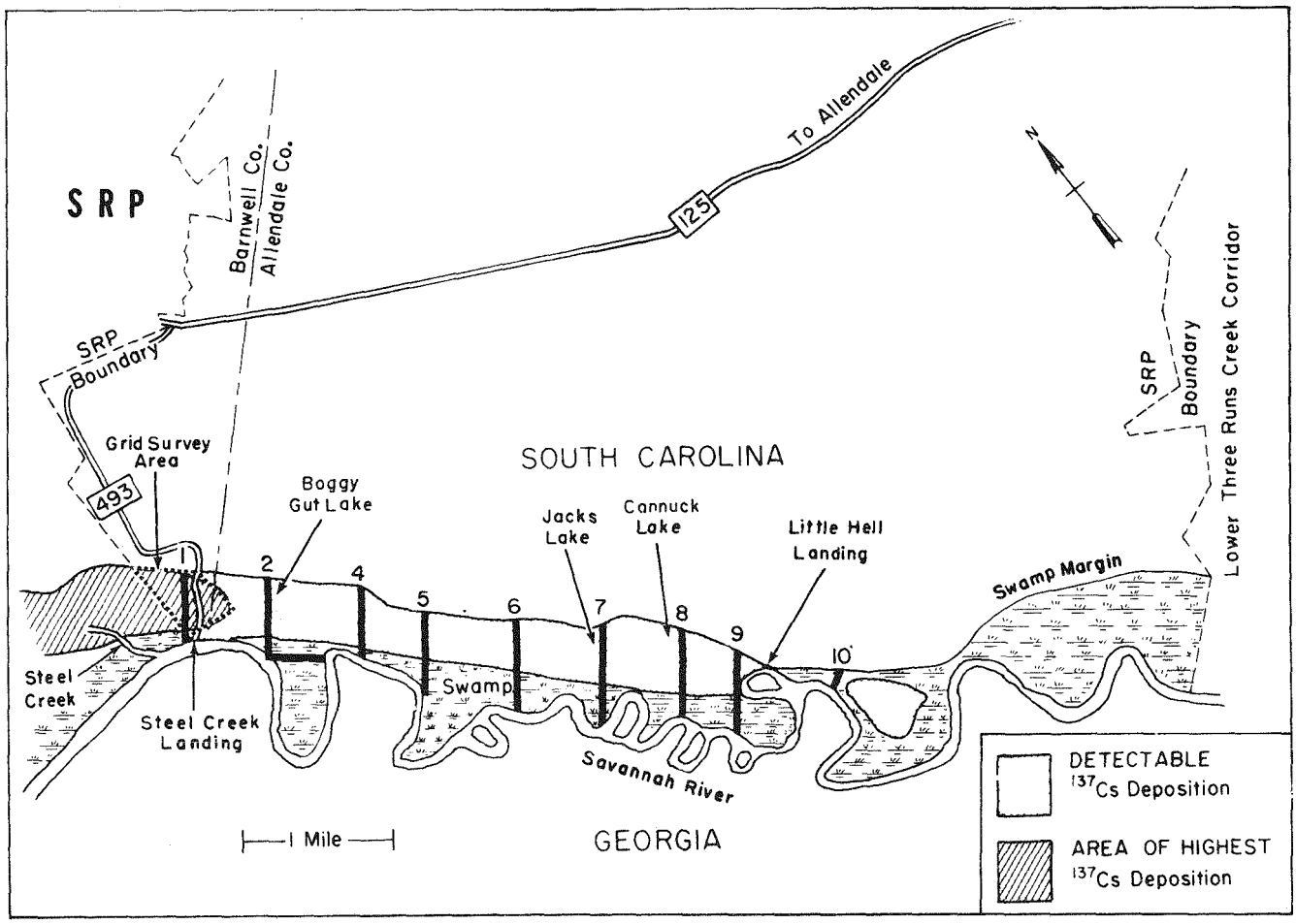

FIGURE 16. RADIOACTIVITY DEPOSITION IN THE SAVANNAH RIVER SWAMP

TABLE 10
SAVANNAH RIVER SWAMP SEDIMENT CORES
RADIOACTIVITY CONCENTRATION RANGES – 1975-1977

Radionuclide	Range, pCi/g 1975	1976	1977
^{137}Cs	1-261	<1-174	1-196
^{238}Pu	0.003-0.052	<0.001-0.054	<0.001-0.032
^{239}Pu	0.022-0.096	0.003-0.123	<0.002-0.096

Vegetation samples from three locations along each trail (generally locations with highest TLD measurements) showed ^{137}Cs concentrations from <1 to 132 pCi/g compared to a 1976 range of from <1 to 119 pCi/g. Alpha concentrations in vegetation were near or below minimum levels of detection. Tritium analysis of vegetation from trail 1 showed a maximum of 32 pCi/ml (free water). Individual vegetation sampling results are shown in table B-17. Nine fish from lakes at trails 2, 7, and 8 contained traces of ^{137}Cs (0.2 pCi/g max) in flesh, from <4 to 9 pCi/g of strontium in bone and from <1 to 24 pCi/ml of tritium (free water). Four opossums and one rabbit from trail 1 showed <1 pCi/g ^{137}Cs.

SOIL MONITORING

Concentrations of radiocesium and plutonium in soils collected at four locations near the plant perimeter and two locations approximately 100 mi distant during 1977 are similar to the deposition values reported for previous years. The average concentration of ^{137}Cs in the top 5 cm at both the plant perimeter and 100-mi distance averaged 0.7 pCi/g. The total plutonium in the top 5 cm at the plant perimeter averaged 0.016 pCi/g and at 100-mi distance, 0.017 pCi/g; the respective concentrations of ^{90}Sr averaged 0.10 pCi/g and 0.18 pCi/g. Deposits of cesium, plutonium, and strontium measured in soils for the past 5 years are summarized in table 11. Deposition of the three radionuclides in all samples are within the range normally found in global fallout. ^{238}Pu in plant perimeter and 100-mi-radius soil samples did not exceed the sensitivity of the analysis (0.001 pCi/g). Soil data are shown in table B-13.

Soil samples from noncultivated areas were first collected for radioanalysis in 1973 at four locations along the plant perimeter (representing each quadrant) and at three locations up to 100 mi from the plant. In each successive year, samples have been collected at the plant perimeter locations and at two of the 100-mi-radius locations. At each site, 10 soil cores, 5 cm deep, are taken in a straight line 30 cm apart for plutonium analysis. Ten 15-cm soil cores were taken at each site for ^{137}Cs analysis prior to 1976. The soil cores were composited by location for radioanalysis.

TABLE 11
RADIOACTIVITY IN SURFACE SOIL, mCi/km²

Year	Plant Perimeter				100-Mile Radius			
	^{239}Pu	^{238}Pu	^{137}Cs	^{90}Sr	^{239}Pu	^{238}Pu	^{137}Cs	^{90}Sr
1973[a]	1.78	<0.08	78	79	1.69	<0.12	105	120
1974	1.19	< .11	73	-	1.26	< .13	59	-
1975	1.13	< .07	88	-	0.68	< .02	72	-
1976	1.30	< .07	63	6	1.09	< .06	74	25
1977	1.18	<0.07	52	8	1.22	<0.04	54	14

[a] 15-cm deep cores in 1973.

RADIATION DOSE COMMITMENT – INDIVIDUAL AND POPULATION

As used in this report, "radiation dose" means "radiation dose equivalent" as defined by the International Commission on Radiological Protection [12]. Radiation dose commitment is the amount of radiation dose received from major pathways of exposure, internal and external, throughout the lifetime of an individual from direct first-pass exposure. (A brief description of dose calculational techniques is given in appendix C.) Population dose commitment is the sum of radiation dose commitment of individuals and is expressed in units of man-rem. (For example, if 1000 people each received a dose of 1 rem, their population dose would be 1000 man-rems.) The segments of the population that receive the highest radiation dose commitments from SRP releases of radioactive materials to the environment are described in the following sections.

Persons Living in the Area Surrounding the Savannah River Plant and Exposed to Radioactive Materials via Atmospheric Pathways

Radioactive materials released from exhaust stacks are diluted by the atmosphere and the concentration in air decreases with distance from point of release because of mixing by turbulent movements of the atmosphere. As a result of this dispersion, the average radiation dose commitment from SRP releases to individuals 50 mi from the center of the plant is only about 30% of that received by people living near the plant perimeter. The radiation dose received by people from atmospheric releases of radioactive materials from SRP is too low to permit direct measurement of all pathways of exposure; therefore, radiation dose commitments are calculated with mathematical models using known dispersive characteristics of the atmosphere and the known major pathways of exposure to man.

During 1977, the average dose commitment to an individual from atmospheric releases of radioactive materials from SRP was calculated to be 0.8 mrem at the plant perimeter (table 12). The major contributors to this dose were tritium (^{3}H), 78%; ^{41}Ar, 15%; and ^{14}C, 5%. The remaining 2% was from krypton and xenon isotopes (chemically inert noble gases), $^{129,131}I$, and miscellaneous

radioactive particles. The calculated population dose commitment from release of radioactive materials from SRP to the atmosphere in 1977 to people living within 80 km (50 mi) of the center of SRP (population: 465,000) is 114 man-rems. Table 12 shows the amount of each radionuclide released to the atmosphere from normal SRP operations and calculated whole-body radiation dose commitment.

Tritium (T), the major contributor to population dose from normal SRP releases in 1977, is a radioactive isotope of hydrogen with a radiological half-life of 12.33 years. The maximum energy of the beta particle emitted during decay is 0.0186 MeV; the average energy is about 0.006 MeV. At SRP, some tritium unavoidably released during normal operations both as an elemental gas (T_2, HT, DT) and in combination with oxygen (T_2O, HTO, DTO). Both forms are readily dispersed in air and will enter into the same chemical and biological reactions as hydrogen or water vapor.

TABLE 12
ATMOSPHERIC TRANSPORT AND DOSE – 1977

Nuclide	Curies Released At Emission Source	Calculated Average Conc. At Plant Perimeter, $\mu Ci/cm^3$	Calculated Whole Body Dose to Individual at Plant Perimiter, mrem		Calculated Population Dose Commitment, man-rem	
			Average	Maximum	80Km	100Km
Gases and Vapors						
^{3}H	3.9×10^{5}	1.1×10^{-10}	0.63	0.85	97.8	122.4
^{14}C	6.3×10^{1}	1.7×10^{-14}	.044	.060	6.9	8.6
^{41}Ar	6.5×10^{4}	8.6×10^{-12}	.12	.18	8.3	9.2
^{85m}Kr	8.4×10^{2}	1.6×10^{-13}	.00033	.00049	.032	.036
^{85}Kr	4.4×10^{5}	1.2×10^{-10}	.0016	.0022	.27	.35
^{87}Kr	6.0×10^{2}	6.3×10^{-14}	.0011	.0017	.064	.067
^{88}Kr	6.7×10^{2}	1.1×10^{-13}	.0028	.0043	.24	.26
^{131m}Xe	1.2×10^{1}	3.2×10^{-15}	<0.00001	<0.00001	.0008	.0010
^{133}Xe	2.3×10^{3}	6.5×10^{-13}	.00060	.00086	.082	.099
^{135}Xe	1.5×10^{3}	3.3×10^{-13}	.0010	.0015	.11	.13
^{129}I	1.4×10^{-1}	3.8×10^{-17}	.00090	.0013	.10	.12
^{131}I	6.1×10^{-2}	1.1×10^{-17}	.00001	.00001	.0012	.0014
Particulates						
^{60}Co	3.8×10^{-4}	2.2×10^{-20}	<0.00001	<0.00001	<0.0001	<0.0001
$^{89,90}Sr$	4.1×10^{-3}	2.4×10^{-19}	<0.00001	<0.00001	<0.0001	<0.0001
^{95}Zr	1.4×10^{-2}	8.1×10^{-19}	<0.00001	<0.00001	<0.0001	<0.0001
^{95}Nb	3.7×10^{-2}	2.1×10^{-18}	<0.00001	<0.00001	<0.0001	<0.0001
^{103}Ru	2.5×10^{-2}	1.4×10^{-18}	<0.00001	<0.00001	<0.0001	<0.0001
^{106}Ru	1.4×10^{-1}	8.1×10^{-18}	<0.00001	<0.00001	<0.0001	<0.0001
^{134}Cs	4.3×10^{-4}	2.5×10^{-20}	<0.00001	<0.00001	<0.0001	<0.0001
^{137}Cs	1.9×10^{-3}	1.1×10^{-19}	<0.00001	<0.00001	<0.0001	<0.0001
^{141}Ce	3.5×10^{-4}	2.0×10^{-20}	<0.00001	<0.00001	<0.0001	<0.0001
^{144}Ce	1.5×10^{-2}	8.7×10^{-19}	<0.00001	<0.00001	<0.0001	<0.0001
U	1.6×10^{-3}	9.2×10^{-20}	<0.00001	<0.00001	0.0001	0.0001
^{238}Pu	5.0×10^{-3}	2.9×10^{-19}	.00040	.00053	.036	.041
^{239}Pu	1.0×10^{-4}	5.8×10^{-21}	.00001	.00001	.0008	.0009
^{241}Am	3.4×10^{-4}	2.0×10^{-20}	.00001	.00001	.0008	.0009
^{244}Cm	3.4×10^{-4}	2.0×10^{-20}	.00001	.00001	.0008	.0009
			Totals →	.802	1.103	113.9	141.3

The low energy beta particle emitted by tritium during decay will penetrate human tissue only 0.013 cm. As an elemental gas, tritium constitutes little hazard because the weak beta is completely attenuated (absorbed) in the inert external skin layer (epidermis). Only 0.004% of the gas inspired is converted to the oxide and retained in the body. Almost all tritium oxide (water vapor) inhaled is absorbed in the lungs and enters the body water pool. In addition, almost as much tritium oxide is absorbed through the skin as is absorbed during inhalation. Because of the great difference between the biological assimilation of tritium gas and tritium oxide, the concentration guide [1] for tritium oxide is several hundred times more restrictive than for elemental gas. The environmental radiation dosimetry program used at SRP makes the conservative assumption that all normal SRP releases are in the oxide form and thus, there is an overestimation of individual and population dose commitment from tritium.

Persons Living Downstream from SRP and Consuming Savannah River Water Containing Low Concentrations of Radioactive Materials

Radioactive materials released to plant streams on the SRP site flow to the Savannah River. The description of SRP hydrology is given in "The Savannah River Plant Site" [DP-1323] [9]. There is no known use of river water for irrigation downstream from SRP. Fish from the river are not an important source of food for any large segment of the population. The most important pathway of exposure of a population segment to radioactive materials in the river is from consumption of river water. Two water treatment plants downstream from SRP supply treated river water to customers in Beaufort and Jasper Counties in South Carolina and Port Wentworth, GA. Of the radioactive materials released to effluent streams on SRP during 1977 (table 13), only tritium is measurable by routine water monitoring techniques of the water from the treatment plants. Data shown for other nuclides are calculated, based on dilution by known river flow rates. Of the radioactive materials in water, tritium is the source of 99% of the whole-body dose commitment to consumers. People who consume this water at a rate of 1.2 liters per day would receive a dose commitment from tritium as shown below; these dose rates are within the National Interim Primary Drinking Water Regulation of 4 mrem/yr.

Beaufort-Jasper	0.26 mrem
Port Wentworth	0.33 mrem

The population dose commitment from tritium to these two groups from 1977 SRP tritium releases are 12.9 man-rems to consumers of Beaufort-Jasper water (population: 50,000) and 6.6 man-rems to consumers of Port Wentworth water (estimated consumer population: 20,000 – most of Port Wentworth water is used for industrial purposes), a total of 19.5 man-rems to river water consumers. Radionuclides other than tritium contribute an additional 0.1 man-rem population dose commitment as shown in table 13.

TABLE 13
RIVER TRANSPORT AND DOSE – 1977

Nuclide	Curies Released at Emission Source[e]	Average Conc. in River, µCi/mℓ	Calculated Individual Dose Commitment, mrem					Calculated Population Dose Commitment, man-rem
			Whole Body	Bone	Lower Large Intestine	Thyroid	Testis	
^{3}H	4.4×10^{4}	2.9×10^{-6}[a]	.26					12.9
		3.7×10^{-6}[b]	.33					6.6
^{32}P	6.4×10^{-3}	6.1×10^{-13}	<0.00001	.00005				.0001
^{35}S	6.2×10^{-1}	5.9×10^{-11}	.00007				.00027	.0045
^{51}Cr	6.6×10^{-1}	6.3×10^{-11}	<0.00001		.00003			<0.0001
$^{58,60}Co$	1.0×10^{-1}	9.9×10^{-12}	.00002		.00024			.0014
^{89}Sr	2.3×10^{-1}	2.2×10^{-11}	<0.00001	.0002				.0004
^{90}Sr	6.9×10^{-1}	7.3×10^{-11}	.00012	.048				.0082
$^{89,90}Sr$	1.1×10^{-2}	1.1×10^{-12}	<0.00001	.00072				.0001
^{91}Y	8.1×10^{-2}	7.8×10^{-12}	<0.00001		.00025			<0.0001
^{95}Zr-^{95}Nb	9.4×10^{-2}	8.9×10^{-12}	<0.00001		.00012			<0.0001
$^{103,106}Ru$	1.0×10^{-3}	9.7×10^{-14}	<0.00001		.00001			<0.0001
^{131}I	1.2×10^{-2}	1.2×10^{-12}	<0.00001			.00099		.0001
^{134}Cs	4.7×10^{-2}	4.5×10^{-12}	.0002					.014
^{137}Cs	4.9×10^{-1}	4.6×10^{-11}	.00044					.031
$^{134,137}Cs$	1.8×10^{-2}	1.7×10^{-12}	.00008					.0053
$^{141,144}Ce$	1.4×10^{-1}	1.4×10^{-11}	<0.00001		.00097			<0.0001
^{147}Pu	2.9×10^{-2}	2.8×10^{-12}	<0.00001		.00001			<0.0001
U	8.4×10^{-2}	8.0×10^{-12}	<0.00001		.00021			.0001
^{239}Pu	8.3×10^{-3}	7.9×10^{-13}	.00001	.00037				.0006
			Total → .26[c] / 33[d]	.049	.0018	.00099	.00027	19.6

[a] Beaufort-Jasper concentrations are measured values.
[b] Port Wentworth concentrations are measured values.
[c] Summation for Beaufort-Jasper.
[d] Summation for Port Wentworth.
[e] Includes direct releases to streams and groundwater migration from earthen basins used for retention of low level radioactivity.

Comparison of Calculated Dose Commitment from Plant Releases with that from Other Sources

Population dose commitment (man-rem) can be used for comparison with radiation exposure from other sources, such as natural radioactivity and medical radiation exposure. The 1977 population dose commitment from SRP releases (114 man-rems from atmospheric releases to people within 80 km of the center of the plant and 20 man-rems from liquid releases to people consuming Beaufort-Jasper and Port Wentworth water) is compared with radiation dose from natural and medical sources in the following table.

Source of Exposure	Population Dose, man-rem
Natural	63,000
Artificial	
Medical diagnosis [13]	54,000
Weapons fallout [14]	2,700
SRP releases	134

Even though SRP contribution to population dose is very small (0.21% of that from natural sources), SRP has a continuing program to improve operating techniques and to develop new technology directed toward reducing releases of radioactive materials to the environment.

Tritium Quality Factor

Tritium doses were calculated using a quality factor of 1.7 for the low energy beta particle emission. The Concentration Guide (CG) for tritium published in the Code of Federal Regulations, Title 10, Part 20 (10CFR20) was derived with this same quality factor. In 1969 [15], the International Commission on Radiological Protection (ICRP), and in 1971, the National Council on Radiation Protection and Measurement (NCRP) recommended a quality factor of 1.0 as being appropriate within the degree of precision required for purposes of radiological protection. However, this recommendation has not yet been reflected in the federal regulations. A quality factor of 1.0 would have the effect of lowering the calculated population dose from tritium.

APPENDIX A
DATA ANALYSIS AND QUALITY CONTROL

Data Analysis

The sensitivity of laboratory analyses (shown in table on page 45) refers to the minimum amount of radioactivity that can be detected by the radiochemical analytical technique in use. It is based on statistical counting error (95% confidence level) and is influenced by sample size, counter and procedure efficiencies, length of count, counter background, and decay. Where samples are analyzed by gamma spectrometry, the lower level of detection of a given radionuclide varies with the background of each individual channel grouping, with the geometry and volume of sample analyzed, and with number of radionuclides present in the sample. For this reason average sensitivities are given for only milk and vegetation.

Many of the concentrations of radioactive materials in ambient environmental monitoring samples are at or near zero and should statistically show a distribution at or near zero. Because of this, when a chemical or instrument background is subtracted from an environmental measurement, it is possible, not only to obtain net values that are less than the minimum detection level (MDL), but to obtain zero and negative values (values less than zero). In this report negative values are used in reporting individual measurements and in determining averages. It is believed that the best estimate of the mean is obtained if the negative values are averaged with the extremely low and positive values. Additionally, this new approach, without any arbitrary cutoff of small or negative values, will allow all data to be reported and possibly permit better statistical evaluation to determine trends. Survey data (appendix B) show the arithmetic annual averages of individual measurements.

Average values are usually accompanied by a plus or minus (±) limit value. This value, designated 2 std dev, is the standard deviation (95% confidence level) of the average and is a measure of the range in the concentration encountered at that location. When the average is given for groups of locations, the std dev is the measure of the range in concentration found at all locations. In some tables the standard deviation is not calculated because of the small number of sample results. When a ± figure accompanies an individual result, such as the maximum (max) or minimum (min), it represents the statistical counting error at the 95% confidence level, which in many cases exceeds the net value of the sample. Max and min refer to the greatest and smallest concentration found in a single sample collected during the year.

No self-absorption corrections have been applied to gross alpha and gross nonvolatile beta results. If activity appears unusual, and specific analyses are not routinely scheduled, further analyses are performed for verification.

Quality Control

An internal quality control program is maintained by (1) monthly calibration of counting instruments; (2) daily source and background counts; (3) routine yield determinations of radiochemical procedures; (4) duplicate analyses to check precision; (5) reagent blank analyses to check purity of all chemicals. Accuracy of radioactivity measurements is established by use of standards obtained from the National Bureau of Standards or their equivalent.

In 1976, participation in a DOE (formally ERDA) wide program of quality assurance was initiated. Environmental samples are sent from the Environmental Measurements Laboratory (EML) to various laboratories on a quarterly basis for analysis of a number of nuclides in various media. EML was previously known as the Health and Safety Laboratory (HASL).

Samples received for September 1976, January 1977, April 1977, and July 1977 include soil, vegetation, animal bone (tissue), water, and air filters. The sample aliquots are already prepared for radioassay; the soil pulverized and blended, the vegetation ashed and sieved, the bone ashed, ground, sieved, and blended, and the water acidified. The air filter samples consist of two glass fiber filters; each has been moistened with solution, evenly distributed, and dried. Suggested radionuclide determinations for each sample are listed. The results are submitted to EML prior to a reporting deadline and an intercomparison of data obtained by other participating laboratories (on split samples of the same media) are returned to each laboratory.

The results of the sample analyses are summarized in table 14. The EML values which all laboratory results are compared to are not necessarily the true value, but are used as the reference value throughout this Quality Assurance program. The EML value is the mean of replicate determinations by EML for each nuclide. The SRP Environmental Monitoring goal is to obtain ratios of SRP/EML values in the range of 0.8 to 1.20 (100% ± 20%). This range is considered acceptable because of variations in radiochemical and radiometric techniques.

The quality control program in the water quality laboratory is designed to constantly evaluate results of the analyses. An intralaboratory quality control program is maintained by (1) routine calibration of instruments, (2) routine yield determinations of procedures and analysis of standards furnished by the Environmental Protection Agency (EPA), (3) routine standardization of titrating solutions used in procedures, and (4) duplicate analyses.

Because spikes are not run for biochemical oxygen demand, pH, alkalinity, and chloride analyses, the quality of these results is dependent on the standardization of standards and instrument calibration. Evaluations of the stability of reagents are determined. Some standards must be standardized daily; however, other standards are stable for varying but known amounts of time. Stability has been improved by storing in dark bottles or away from light. Standardization is done before significant changes occur.

Samples sometimes require digestion in order to break down organic compounds which may contain the element of interest in their chemical structure. Unless the organic molecule is fragmented by digestion, this element may not exhibit the chemical properties which indicate its presence. The efficiency of the digestion process for samples is evaluated by digesting prepared standard organic compounds.

TABLE 14
SUMMARY OF EML — QA SAMPLES
SEPTEMBER 1976 — OCTOBER 1977

Sample	Analysis	Number Analyzed	Average[a] SRP to EML Ratios (×100)
Water	^{3}H	5	100 ± 23
	^{7}Be	1	106
	^{22}Na	1	83
	^{54}Mn	3	100 ± 1
	^{57}Co	2	88 ± 12
	^{58}Co	1	95
	^{59}Fe	3	104 ± 8
	^{60}Co	4	94 ± 4
	^{65}Zn	1	95
	^{134}Cs	2	97 ± 3
	^{137}Cs	4	99 ± 1
	^{141}Ce	1	89
	^{144}Ce	2	90 ± 2
	^{90}Sr	4	98 ± 18
	^{238}Pu	4	45 ± 24
	^{239}Pu	5	57 ± 40
Soil	^{40}K	4	64 ± 34
	^{58}Co	1	91
	^{60}Co	3	78 ± 14
	^{137}Cs	4	88 ± 4
	^{90}Sr	4	143 ± 62
	^{238}Pu	5	73 ± 19
	^{239}Pu	5	73 ± 8
Vegetation	^{40}K	2	91 ± 0
	^{60}Co	1	112
	^{137}Cs	3	112 ± 16
	^{90}Sr	1	76
Air	^{7}Be	3	94 ± 5
	^{22}Na	1	94
	^{24}Na	1	83
	^{54}Mn	3	95 ± 6
	^{57}Co	3	85 ± 9
	^{58}Co	1	90
	^{59}Fe	2	92 ± 8
	^{60}Co	4	93 ± 3
	^{65}Zn	1	102
	^{95}Zr	2	92 ± 5
	^{95}Nb	1	96
	^{103}Ru	2	105 ± 0
	^{106}Ru	1	91
	^{125}Sb	2	83 ± 14
	^{134}Cs	4	116 ± 29
	^{137}Cs	5	104 ± 9
	^{141}Ce	1	95
	^{144}Ce	1	89
	^{90}Sr	3	125 ± 14
	^{238}Pu	3	163 ± 78
	^{239}Pu	5	92 ± 59
Tissue	^{40}K	4	223 ± 161
	^{137}Cs	2	194 ± 91
	^{90}Sr	5	99 ± 30

[a] Standard deviation of average

TABLE A-1
SENSITIVITY AND STANDARD DEVIATIONS OF LABORATORY ANALYSES

Analysis	Sample Type	Length of Count, Minutes	Standard Aliquot	Sensitivity and Precision (95% Confidence Level)	Units
		Zinc Sulfide Alpha Counters			
Gross alpha	Water	20	1 ℓ	0.25 ± 0.13	pCi/l
	Vegetation	20	2 g	.12 ± .06	pCi/g
	Rain (collection pan)	20	0.37 m^2	.0007 ± .0004	nCi/m^2
	Air	20	∿800 m^3	.03 ± .02	pCi/m^3($\times10^{-2}$) (0.0003 ± 0.0002 pCi/m^3)
U or Pu (alpha)	Food	20	100 g	0.002 ± 0.001	pCi/g
		Gas Flow Proportional Beta Counters			
Gross beta	Water	10	1 ℓ	7.05 ± 0.39	pCi/l
	Air	10	∿800 m^3	0.88 ± .05	pCi/m^3($\times10^{-2}$) (0.0088 ± 0.0005 pCi/m^3)
Strontium-89,90	Bone	10	2 g	4.5 ± .25	pCi/g
	Rain	10	0.37 m^2	0.02 ± .001	nCi/m^2
	Air composites				
	Plant perimeter	10	∿19,500 m^3	0.10 ± 0.001	pCi/m^3($\times10^{-2}$) (0.0010 ± 0.00001 pCi/m^3)
	25-mile radius	10	∿18,000 m^3	.11 ± .001	pCi/m^3($\times10^{-2}$) (0.0011 ± 0.00001 pCi/m^3)
	100-mile radius	10	∿6,000 m^3	0.33 ± 0.02	pCi/m^3($\times10^{-2}$) (0.0033 ± 0.0002 pCi/m^3)
		Low Background Beta Counter			
Strontium-90	River water	50	20 ℓ	0.02 ± 0.002	pCi/l
	Milk	50	0.5 ℓ	1.10 ± .12	pCi/l
	Food	50	20 g	0.02 ± .002	pCi/g
	Rain	50	0.37 m^2	0.004 ± 0.0004	nCi/m^2
		Liquid Scintillation Counters			
Tritium	Drinking water	300	4 ml	300 ± 10	pCi/l (0.30 ± 0.01 pCi/ml)
	River water	300	4 ml	300 ± 10	pCi/l (0.30 ± 0.01 pCi/ml)
	Rainwater	300	4 ml	300 ± 10	pCi/l (0.30 ± 0.01 pCi/ml)
	Milk	300	4 ml	300 ± 10	pCi/l (0.30 ± 0.01 pCi/ml)
	Air (atmospheric moisture)	300	4 ml (water)	300 ± 10	pCi/l (0.30 ± 0.01 pCi/ml) (× avg abs humidity = ∿4 pCi/m^3 of air)
	Food	20	3 ml	1 ± 0.05	pCi/ml (free water)
	Vegetation	20	3 ml	1 ± 0.05	pCi/ml (free water)
		Solid-State Alpha Spectrometer			
Plutonium-238	Air composites				
	Plant perimeter	72[a]	∿19,500 m^3	0.36	aCi/m^3
	25-mile radius	72[a]	∿18,000 m^3	0.39	aCi/m^3
	100-mile radius	72[a]	∿6,000 m^3	1.18	aCi/m^3
	Rain composites				
	Plant perimeter	72[a]	4.81 m^2	0.0020	pCi/m^2
	25-mile radius	72[a]	4.44 m^2	.0022	pCi/m^2
	Soil	24[a]	50 g	0.0002	pCi/g
Plutonium-239	Air composites				
	Plant perimeter	72[a]	∿19,500 m^3	0.35	aCi/m^3
	25-mile radius	72[a]	∿18,000 m^3	0.38	aCi/m^3
	100-mile radius	72[a]	∿6,000 m^3	1.12	aCi/m^3
	Rain composites				
	Plant perimeter	72[a]	4.81 m^2	0.0019	pCi/m^2
	25-mile radius	72[a]	4.44 m^2	.0021	pCi/m^2
	Soil	24[a]	50 g	0.0002	pCi/g
		Na(I) Detector (9 in. × 9 in.)			
Iodine-131	Milk	200	3.8 ℓ	1.0 ± 0.5	pCi/l
	Vegetation	10	50 g	0.2 ± 0.01	pCi/g
Cesium-137	Milk	200	1.8 ℓ	3 ± 2	pCi/l

[a] Hours

TABLE B-1
RADIOACTIVITY IN AIR

ALPHA, PCI/CU M E-2

LOCATION	NO. OF SAMPLES	MAXIMUM	CT ERR 95% CL	MINIMUM	CT ERR 95% CL	ARITHMETIC MEAN	2 SID DEV
PLANT PERIMETER							
ALLENDALE GATE	51	0.18	±0.09	0.01	±0.05	0.08	±0.08
A-14	50	0.22	±0.10	0.00	±0.06	0.07	±0.08
BARNWELL GATE	50	0.21	±0.11	0.00	±0.04	0.07	±0.08
D AREA	51	0.15	±0.09	-0.01	±0.05	0.07	±0.08
DARK HORSE	52	0.15	±0.08	0.00	±0.03	0.07	±0.08
EAST TALATHA	52	0.25	±0.12	0.01	±0.05	0.09	±0.10
GREEN POND	52	0.16	±0.08	0.00	±0.04	0.07	±0.08
HIGHWAY 21/167	52	0.21	±0.10	0.00	±0.04	0.07	±0.08
JACKSON	51	0.22	±0.10	0.00	±0.05	0.09	±0.08
PATTERSONS MILL	52	0.32	±0.17	0.01	±0.04	0.09	±0.10
TALATHA GATE	51	0.17	±0.10	0.00	±0.05	0.07	±0.08
WEST JACKSON	45	0.17	±0.10	-0.03	±0.03	0.06	±0.08
WINDSOR ROAD	51	0.22	±0.27	0.01	±0.04	0.08	±0.10
AVERAGE						0.07	±0.09
25 MILE RADIUS							
AIKEN AIRPORT	52	0.19	±0.09	0.01	±0.05	0.08	±0.08
AIKEN STATE PARK	52	0.16	±0.08	0.00	±0.03	0.06	±0.08
ALLENDALE	51	0.25	±0.13	0.00	±0.04	0.07	±0.10
AUGUSTA	50	0.26	±0.11	-0.02	±0.05	0.13	±0.10
HIGHWAY 301	52	0.24	±0.11	0.00	±0.05	0.08	±0.10
LANGLEY	52	0.23	±0.11	0.02	±0.05	0.09	±0.10
LEES	47	0.24	±0.11	0.01	±0.03	0.11	±0.10
OLAR	52	0.20	±0.11	-0.01	±0.03	0.09	±0.10
PERKINS	47	0.23	±0.09	-0.01	±0.05	0.07	±0.10
SOUTH RICHMOND	52	0.27	±0.11	-0.01	±0.05	0.09	±0.10
SPRINGFIELD	50	0.22	±0.09	0.00	±0.08	0.09	±0.10
WAYNESBORO	51	0.20	±0.11	0.00	±0.05	0.07	±0.08
AVERAGE						0.08	±0.10
100 MILE RADIUS							
COLUMBIA	52	0.27	±0.11	-0.01	±0.06	0.11	±0.12
GREENVILLE	48	0.32	±0.15	-0.02	±0.05	0.09	±0.12
MACON	38	0.21	±0.12	0.00	±0.05	0.08	±0.08
SAVANNAH	49	0.44	±0.26	-0.01	±0.05	0.09	±0.14
AVERAGE						0.09	±0.12

BETA, PCI/CU M E-2

LOCATION	NO. OF SAMPLES	MAXIMUM	CT ERR 95% CL	MINIMUM	CT ERR 95% CL	ARITHMETIC MEAN	2 SID DEV
PLANT PERIMETER							
ALLENDALE GATE	51	120	±2.8	1.9	±0.8	15	±35
A-14	50	190	±5.0	2.1	±0.8	18	±56
BARNWELL GATE	50	180	±4.0	2.3	±0.9	17	±51
D AREA	51	110	±2.6	2.4	±1.1	15	±32
DARK HORSE	52	120	±3.1	2.1	±1.1	16	±36
EAST TALATHA	52	130	±3.2	1.9	±1.0	15	±37
GREENPOND	52	130	±2.9	1.9	±0.9	15	±37
HIGHWAY 21/167	52	120	±2.9	1.4	±0.9	16	±36
JACKSON	51	120	±2.9	2.5	±1.1	15	±34
PATTERSONS MILL	52	120	±2.8	2.4	±1.0	15	±35
TALATHA GATE	51	150	±3.3	2.5	±0.9	15	±41
WEST JACKSON	45	31	±1.7	-0.4	±0.7	10	±16
WINDSOR ROAD	51	120	±2.8	1.3	±0.8	15	±35
AVERAGE						15	±38
25 MILE RADIUS							
AIKEN AIRPORT	52	130	±2.7	2.6	±0.9	14	±36
AIKEN STATE PARK	52	130	±2.6	2.4	±0.9	15	±36
ALLENDALE	51	130	±2.7	0.0	±0.7	14	±38
AUGUSTA	50	94	±2.4	1.3	±1.8	13	±28
HIGHWAY 301	52	130	±2.8	2.2	±0.9	15	±37
LANGLEY	52	130	±2.7	1.1	±0.8	15	±37
LEES	47	120	±2.8	2.3	±1.0	15	±36
OLAR	52	120	±2.6	1.4	±0.8	16	±36
PERKINS	47	120	±2.6	1.1	±0.7	14	±36
SOUTH RICHMOND	52	140	±3.0	2.6	±0.9	16	±40
SPRINGFIELD	50	74	±2.0	2.6	±0.7	13	±24
WAYNESBORO	51	130	±2.6	2.1	±1.0	15	±38
AVERAGE						15	±35
100 MILE RADIUS							
COLUMBIA	52	180	±4.5	1.7	±1.2	16	±51
GREENVILLE	48	52	±3.1	0.6	±0.6	13	±21
MACON	38	50	±1.4	1.7	±0.6	11	±20
SAVANNAH	49	120	±2.8	0.0	±1.5	15	±35
AVERAGE						14	±35

TABLE B-1, CONTD
RADIOACTIVITY IN AIR

TRITIUM IN AIR

LOCATION	NO. OF SAMPLES	MAXIMUM	CT ERR 95% CL	MINIMUM	CT ERR 95% CL	ARITHMETIC MEAN	2 STD DEV
			H-3, PCI/CU M				
PLANT PERIMETER							
ALLENDALE GATE	24	57	±2.4	2.0	±5.4	22	±27
A-14	26	110	±2.4	2.6	±2.8	53	±55
BARNWELL GATE	24	160	±4.2	16	±5.4	55	±64
D-AREA	24	330	±5.4	38	±1.6	130	±180
DARKHORSE	25	210	±4.3	4.8	±1.2	61	±94
EAST TALATHA	26	260	±5.5	0.2	±1.2	60	±120
GREENPOND	25	210	±5.5	10	±1.2	63	±98
HIGHWAY 21/167	24	330	±4.2	11	±1.2	69	±150
JACKSON	26	310	±4.6	8.1	±1.6	67	±130
PATTERSON'S MILL	24	220	±0.9	5.1	±5.5	44	±88
TALATHA GATE	24	420	±5.5	9.3	±1.2	83	±180
WEST JACKSON	21	230	±5.4	13	±1.6	78	±120
WINDSOR ROAD	23	170	±4.2	3.4	±1.2	58	±92
AVERAGE						65	±120
25 MILE RADIUS							
AIKEN AIRPORT	26	84	±5.5	0.6	±1.2	20	±37
AIKEN STATE PARK	26	140	±4.2	0.4	±1.2	23	±54
ALLENDALE	25	87	±2.4	0.0	±5.1	16	±35
AUGUSTA	24	55	±5.4	1.2	±5.1	18	±29
HIGHWAY 301	26	48	±2.4	0.0	±5.1	12	±20
LANGLEY	26	52	±2.4	2.9	±1.2	18	±27
LEES	24	96	±4.6	0.0	±5.1	27	±47
OLAR	25	36	±3.4	0.0	±4.3	16	±20
PERKINS	23	25	±2.4	0.0	±1.2	8.8	±15
SOUTH RICHMOND	25	100	±5.4	3.1	±5.2	23	±45
SPRINGFIELD	26	71	±4.3	0.0	±4.6	18	±29
WAYNESBORO	23	48	±3.4	1.4	±3.3	19	±32
AVERAGE						18	±35
100 MILE RADIUS							
COLUMBIA	2	2.4	±3.1	0.0	±0.3	1.2	-
GREENVILLE	4	9.3	±5.4	4.8	±4.2	7.3	-
MACON	1	13	±2.4	13	±2.4	13	-
SAVANNAH	3	13	±5.5	2.3	±1.9	7.4	-
AVERAGE						7.1	±8.8

SPECIFIC RADIONUCLIDES IN AIR

RADIONUCLIDE / PLANT PERIMETER	NO. OF SAMPLES[a]	MAXIMUM	CT ERR 95% CL	MINIMUM	CT ERR 95% CL	AVERAGE	2 STD DEV
			GAMMA EMITTERS, PCI/M^3 ($\times 10^{-2}$)				
BE-7	11	50	±2	0.1	±1.0	25	±28
SR-89,90	11	0.15	±0.03	0	±0.03	0.07	±0.08
ZR-95, NB-95	11	13.7	±0.4	0.01	±0.06	6.7	±10.8
RU-103,106	11	6.6	±1.2	0.2	±0.6	3.2	±4.9
CS-137	11	1.0	±0.2	0.1	±0.2	0.4	±0.6
CE-141[b]	11	19.3	±0.8	4.6	±0.4	-	-
CE-144	11	5.2	±0.8	0.4	±0.4	2.5	±3.9
25-MILE RADIUS							
BE-7	11	44	±2	0	±1	23	±23
SR-89,90	12	0.19	±0.04	0.02	±0.04	0.09	±0.12
ZR-95, NB-95	11	13.5	±0.4	0.03	±0.08	6.3	±10.1
RU-103,106	11	6.0	±1.2	0.1	±0.6	2.9	±4.6
CS-137	11	1.0	±0.2	0.1	±0.2	0.4	±0.6
CE-141[b]	11	16.4	±0.8	3.8	±0.4	-	-
CE-144		4.9	±0.6	0.3	±0.4	2.3	±3.5
100-MILE RADIUS							
BE-7	10	49	±6	15	±4	26	±21
SR-89,90	12	0.68	±0.18	0.01	±0.03	0.25	±0.50
ZR-95, NB-95	10	15.7	±0.6	0	±0.2	7.0	±10.6
RU-103,106	10	6.9	±2.8	0.1	±2.4	3.6	±4.2
CS-137	10	0.8	±0.4	0.1	±0.2	0.4	±0.9
CE-141[b]	10	14.5	±1.8	3.8	±1.2	-	-
CE-144		5.4	±1.6	0.4	±1.2	2.7	±3.8
			ALPHA EMITTERS, aCI/M^3				
PLANT PERIMETER							
PU-238	11	14.7	±1.4	1.0	±0.3	4.3	±9.5
PU-239	11	36	±2	3.6	±0.9	20.0	±20.6
25-MILE RADIUS							
PU-238	12	13.6	±1.9	0.4	±0.2	2.5	±7.3
PU-239	12	38	±4.1	3.4	±1.0	18.3	±18.2
100-MILE RADIUS							
PU-238	12	6.3	±3.1	<0.5	±0.5	2.3	±3.5
PU-239	12	41.0	±7	5.0	±1.8	21.3	±15.8

- INSUFFICIENT DATA TO CALCULATE.
a MONTHLY COMPOSITE OF WEEKLY SAMPLES.
b DETECTED ONLY IN OCTOBER AND NOVEMBER.

TABLE B-2
RADIOACTIVITY IN RAINWATER

Total Fallout Deposited, nCi/m²

Location	No. of Samples	Alpha	^{7}Be	^{89}Sr	^{90}Sr	^{95}Zr, ^{95}Nb	^{103}Ru	^{131}I	^{137}Cs	^{140}Ba, ^{140}La	^{141}Ce	^{144}Ce	239
Plant Perimeter													
Allendale Gate	13	0.019	34	<0.09	0.57	3.9	1.3	1.1	0.2	4	1.7	0.6	2
Road A-14	13	<0.004	34	<0.09	.48	4.1	0.7	1.1	0.3	11	0.9	<0.3	2
Barnwell Gate	13	0.021	51	1.32	.27	2.8	5.1	2.4	<0.1	23	2.8	<0.3	1
D Area	13	<0.004	30	0.53	.25	9.0	2.6	3.2	0.2	17	2.4	<0.3	2
Dark Horse	13	0.008	59	.91	.43	6.8	5.8	4.9	.1	30	3.8	0.4	4
East Talatha	13	.020	52	0.35	.45	8.2	3.6	2.9	.2	22	3.3	0.7	3
Green Pond	13	.019	41	<0.09	.55	5.3	3.7	2.3	.1	15	0.7	<0.3	2
Highway 21/167	13	.025	78	0.91	.80	8.5	6.5	3.6	.2	24	3.3	1.3	2
Jackson	13	.015	39	.82	.40	4.0	3.2	2.7	.1	22	2.5	<0.3	2
Pattersons Mill	13	.008	32	.44	.40	2.2	2.1	1.1	.2	11	1.8	0.4	1
Talatha Gate	13	.016	45	0.32	.43	3.8	3.2	2.2	.2	22	2.6	.4	7
West Jackson	13	.011	16	<0.09	.24	4.3	<0.6	0.7	.2	7	1.7	.4	2
Windsor Road	13	.004	59	0.57	.50	8.6	4.6	3.9	.3	31	2.4	.6	3
Avg →		0.013	44	0.50	0.44	5.0	3.3	2.5	0.2	18	2.3	0.4	3
2 Std Dev →		±0.013	±32	±0.78	±0.30	±4.1	±3.7	±2.5	±0.1	±16	±1.8	±0.3	±3
25-Mile Radius													
Aiken Airport	13	0.039	44	2.11	0.55	5.7	1.7	1.0	0.4	14	1.8	0.6	3
Aiken State Park	13	.005	10	0.32	.28	2.4	<0.6	0.6	.2	6	1.0	<0.3	2
Allendale	13	.011	42	.18	.32	7.2	2.2	1.2	.2	8	1.1	0.8	2
Augusta	13	0.057	24	.69	.39	2.9	1.6	1.1	.2	12	1.1	0.5	3
Highway 301	13	<0.004	30	.50	.37	3.5	1.7	1.1	.2	9	1.5	<0.3	2
Langley	13	0.016	50	0.33	.49	8.5	2.4	2.2	.4	14	2.2	0.9	4
Lees	13	.068	28	1.75	.22	3.1	0.6	0.9	.2	9	1.5	<0.3	2
Olar	13	.066	51	2.72	.55	7.6	1.9	0.8	.4	12	1.3	1.1	2
Perkins	13	.026	22	2.15	.25	3.3	0.8	0.6	.2	6	1.4	<0.3	3
South Richmond	13	.005	45	0.89	.34	5.2	4.6	3.8	.2	26	3.6	0.4	5
Springfield	13	.005	60	0.79	.32	6.7	3.5	2.7	.3	27	2.8	1.2	3
Waynesboro	13	.031	35	<0.36	.36	6.6	0.8	0.8	.5	8	2.0	0.8	3
Avg →		0.028	37	1.07	0.37	5.2	1.9	1.4	0.3	13	1.8	6.3	3
2 Std Dev →		±0.049	±29	±1.75	±0.22	±4.2	±2.4	±2.0	±0.2	±14	±1.6	±6.6	±1

Value shown with < symbol is the minimum detectable value for a monthly sample.

Plutonium Fallout Deposited, pCi/m²

Location	No. of Samples	^{238}Pu	^{239}Pu
Plant Perimeter	11	0.3	1.1
25-Mile Radius	13	0.7	1.2

LOCATION	NO. OF SAMPLES	MAXIMUM	CT ERR 95% CL	MINIMUM	CT ERR 95% CL	ARITHMETIC MEAN	2 SID DEV
		H-3, PCI/ML					
PLANT PERIMETER							
ALLENDALE GATE	21	1.9	±0.30	0.00	±0.30	0.77	±1.2
A-14	22	5.9	±0.30	0.00	±0.30	2.6	±3.8
BARNWELL GATE	22	9.4	±0.30	0.00	±0.30	2.9	±5.3
D AREA	22	20	±0.30	0.51	±0.30	5.8	±11
DARK HORSE	24	7.1	±0.30	0.33	±0.30	2.3	±4.1
EAST TALATHA	21	5.5	±0.30	0.00	±0.30	1.5	±2.8
GREENPOND	17	5.3	±0.30	0.00	±0.30	1.8	±2.9
HIGHWAY 21/167	25	3.8	±0.30	0.06	±0.30	1.4	±2.0
JACKSON	22	12	±0.30	0.14	±0.30	2.9	±6.6
PATTERSONS MILL	17	5.0	±0.30	0.00	±0.30	1.3	±2.9
TALATHA GATE	24	22	±0.30	0.04	±0.30	2.6	±8.6
WEST JACKSON	24	13	±0.30	0.00	±0.30	3.1	±5.8
WINDSOR ROAD	23	7.9	±0.30	0.02	±0.30	2.1	±4.0
AVERAGE						2.4	±5.9
25 MILE RADIUS							
AIKEN AIRPORT	22	1.9	±0.30	0.00	±0.30	0.58	±1.1
AIKEN STATE PARK	22	3.0	±0.30	0.00	±0.30	0.98	±1.5
ALLENDALE	20	1.8	±0.30	0.00	±0.30	0.49	±1.1
AUGUSTA	19	1.7	±0.30	0.00	±0.30	0.61	±0.98
HIGHWAY 301	22	2.4	±0.30	0.00	±0.30	0.42	±1.1
LANGLEY	23	4.4	±0.30	0.00	±0.30	0.72	±2.0
LEES	17	3.9	±0.30	0.00	±0.30	1.1	±2.0
OLAR	22	1.9	±0.30	0.00	±0.30	0.60	±1.?
PERKINS	20	3.4	±0.30	0.00	±0.30	0.65	±1.9
SOUTH RICHMOND	25	1.9	±0.30	0.00	±0.30	0.50	±1.1
SPRINGFIELD	22	3.1	±0.30	0.00	±0.30	0.71	±1.7
WAYNESBORO	22	6.6	±0.30	−0.02	±0.30	0.74	±2.8
AVERAGE						0.67	±1.6

TABLE B-3
ENVIRONMENTAL GAMMA RADIATION

	TLD, MR/24 HRS							
LOCATION	NO. OF SAMPLES	MAXIMUM	CT ERR 95% CL	MINIMUM	CT ERR 95% CL	ARITHMETIC MEAN	2 SID DEV	MR/YEAR
PLANT PERIMETER								
ALLENDALE GATE	4	0.14	±0.01	0.12	±0.01	0.13	-	47
A-14	4	0.18	±0.02	0.16	±0.02	0.17	-	62
BARNWELL GATE	4	0.18	±0.02	0.16	±0.02	0.18	-	66
D-AREA	4	0.19	±0.02	0.17	±0.02	0.18	-	66
DARK HORSE	4	0.16	±0.02	0.14	±0.01	0.16	-	58
EAST TALATHA	4	0.17	±0.02	0.15	±0.02	0.16	-	58
GREEN POND	4	0.17	±0.02	0.15	±0.02	0.16	-	58
HIGHWAY 21/167	4	0.16	±0.02	0.15	±0.02	0.16	-	58
JACKSON	4	0.19	±0.02	0.18	±0.02	0.18	-	66
PATTERSONS MILL	4	0.17	±0.02	0.16	±0.02	0.16	-	58
TALATHA GATE	4	0.22	±0.02	0.19	±0.02	0.20	-	73
WEST JACKSON	4	0.25	±0.02	0.21	±0.02	0.23	-	84
WINDSOR ROAD	4	0.17	±0.02	0.16	±0.02	0.17	-	62
AVERAGE						0.17	±0.05	62
25 MILE RADIUS								
AIKEN AIRPORT	4	0.21	±0.02	0.15	±0.02	0.18	-	66
AIKEN STATE PARK	4	0.18	±0.02	0.14	±0.01	0.16	-	58
ALLENDALE	4	0.21	±0.02	0.16	±0.02	0.18	-	66
AUGUSTA	4	0.20	±0.02	0.16	±0.02	0.18	-	66
HIGHWAY 301	4	0.28	±0.03	0.17	±0.02	0.22	-	80
LANGLEY	4	0.20	±0.02	0.18	±0.02	0.19	-	69
LEES	4	0.23	±0.02	0.18	±0.02	0.20	-	73
OLAR	4	0.21	±0.02	0.15	±0.02	0.17	-	62
PERKINS	3	0.21	±0.02	0.16	±0.02	0.18	-	66
SOUTH RICHMOND	4	0.21	±0.02	0.16	±0.02	0.18	-	66
SPRINGFIELD	4	0.21	±0.02	0.17	±0.02	0.20	-	73
WAYNESBORO	3	0.19	±0.02	0.14	±0.01	0.16	-	58
AVERAGE						0.18	±0.05	66
100 MILE RADIUS								
COLUMBIA	4	0.27	±0.02	0.15	±0.02	0.21	-	77
GREENVILLE	4	0.35	±0.03	0.31	±0.03	0.33	-	120
MACON	4	0.25	±0.02	0.23	±0.02	0.24	-	88
SAVANNAH	3	0.17	±0.02	0.12	±0.01	0.15	-	55
AVERAGE						0.23	±0.14	84

INSUFFICIENT DATA

TABLE B-4, CONTD
RADIOACTIVITY IN VEGETATION

H-3, PCI/ML (FREE WATER)

LOCATION	NO. OF SAMPLES	MAXIMUM	CT ERR 95% CL	MINIMUM	CT ERR 95% CL	ARITHMETIC MEAN	2 STD DEV
PLANT PERIMETER							
PLANT PERIMETER 2	11	23	±3.0	-4.8	±1.9	2.9	±16
PLANT PERIMETER 3	11	35	±3.0	-4.3	±1.9	4.9	±21
PLANT PERIMETER 6	12	6.5	±3.0	-5.1	±1.9	0.83	±5.9
PLANT PERIMETER 8	11	9.6	±1.9	-5.2	±1.9	1.0	±8.5
PLANT PERIMETER 10	12	37	±3.0	-4.7	±1.9	4.8	±23
PLANT PERIMETER 12	12	9.7	±2.0	-5.3	±1.9	2.0	±8.1
PLANT PERIMETER 14	11	34	±2.5	-6.2	±1.9	3.8	±21
AVERAGE						2.9	±16
25 MILE RADIUS							
25 MILE RADIUS 2	9	0.84	±3.0	-4.5	±1.9	1.60	±3.7
25 MILE RADIUS 3	11	5.1	±1.9	-6.1	±1.9	0.12	±5.8
25 MILE RADIUS 5	11	4.9	±1.9	-2.5	±1.7	0.59	±4.1
25 MILE RADIUS 8	9	3.7	±3.0	-4.1	±1.7	0.01	±4.8
25 MILE RADIUS 10	10	14	±3.0	-4.6	±1.7	2.1	±11
25 MILE RADIUS 12	10	14	±0.3	-4.1	±1.7	1.0	±9.9
25 MILE RADIUS 14	9	17	±0.3	-3.1	±15	2.2	±13
AVERAGE						0.64	±8.1
100 MILE RADIUS							
COLUMBIA	2	0.14	±3.0	-0.53	±1.7	0.20	-
GREENVILLE	2	0.43	±1.6	0.0	±1.8	0.22	-
MACON	2	6.7	±0.3	0.0	±3.0	3.4	-
SAVANNAH	2	3.3	±2.0	1.4	±1.6	2.3	-
AVERAGE						1.4	±4.9

INSUFFICIENT DATA

SPECIFIC RADIONUCLIDES IN VEGETATION

pCi/g (DRY WEIGHT)

LOCATION	NO. OF SAMPLES	MAX	CT ERR 95% CL	MIN	CT ERR 95% CL	MEAN	2 STD DEV
			BE-7				
PLANT PERIMETER[a]	11	21.0	±4.8	1.3	±1.2	11.0	±13.8
25-MILE RADIUS[a]	12	31.0	±5.3	0.1	±6.8	12.0	±19.7
100-MILE RADIUS[b]	15	16.2	±3.7	0.8	±2.9	12.7	±13.1
			ZR-95,NB-95				
PLANT PERIMETER[a]	11	5.8	±0.4	0.0	±0.6	3.1	±4.0
25-MILE RADIUS[a]	12	9.5	±1.0	.0	±0.5	3.8	±5.8
100-MILE RADIUS[b]	15	10.1	±0.5	0.0	±0.6	3.8	±5.9
			RU-103,106				
PLANT PERIMETER[a]	11	21.0	±23.9	0.0	±1.9	3.0	±12.3
25-MILE RADIUS[a]	12	13.8	±17.9	.0	±2.0	2.2	±7.5
100-MILE RADIUS[b]	15	6.0	±3.5	0.0	±2.2	1.2	±3.7
			CS-137				
PLANT PERIMETER[a]	11	1.9	±0.4	0.0	±0.3	0.6	±1.2
25-MILE RADIUS[a]	12	1.5	±0.3	.0	±0.5	.5	±0.9
100-MILE RADIUS[b]	15	3.2	±0.3	0.0	±0.3	0.5	±1.7
			CE-141,144				
PLANT PERIMETER[a]	11	25.6	±4.7	0.0	±1.6	5.7	±14.9
25-MILE RADIUS[a]	12	27.2	±3.8	.0	±2.5	6.7	±15.9
100-MILE RADIUS[b]	15	13.4	±2.0	0.0	±1.7	6.5	±9.2

[a] COMPOSITE ANALYSIS OF 7 LOCATIONS.
[b] INDIVIDUAL ANALYSIS OF 4 LOCATIONS.

TABLE B-4
RADIOACTIVITY IN VEGETATION

ALPHA, PCI/G

LOCATION	NO. OF SAMPLES	MAXIMUM	CT ERR 95% CL	MINIMUM	CT ERR 95% CL	ARITHMETIC MEAN	2 STD DEV
PLANT PERIMETER							
PLANT PERIMETER 2	12	0.92	±0.41	0.00	±0.13	0.31	±0.62
PLANT PERIMETER 3	12	0.74	±0.31	-0.07	±0.09	0.20	±0.44
PLANT PERIMETER 6	12	0.97	±0.36	0.07	±0.19	0.45	±0.52
PLANT PERIMETER 8	12	0.90	±0.41	-0.07	±0.14	0.28	±0.58
PLANT PERIMETER 10	12	1.1	±0.44	-0.04	±0.19	0.31	±0.80
PLANT PERIMETER 12	12	1.2	±0.40	-0.03	±0.12	0.34	±0.72
PLANT PERIMETER 14	12	0.94	±0.35	-0.03	±0.15	0.35	±0.58
AVERAGE						0.32	±0.61
25 MILE RADIUS							
25 MILE RADIUS 2	12	0.87	±0.40	0.04	±0.20	0.26	±0.42
25 MILE RADIUS 3	12	0.80	±0.39	0.03	±0.12	0.34	±0.56
25 MILE RADIUS 5	12	0.74	±0.31	0.00	±0.13	0.25	±0.44
25 MILE RADIUS 8	12	0.84	±0.33	-0.03	±0.15	0.26	±0.54
25 MILE RADIUS 10	12	0.71	±0.38	0.00	±0.17	0.29	±0.56
25 MILE RADIUS 12	12	0.64	±0.36	0.00	±0.17	0.23	±0.42
25 MILE RADIUS 14	11	1.5	±0.49	0.07	±0.21	0.46	±0.86
AVERAGE						0.29	±0.55
100 MILE RADIUS							
COLUMBIA	4	0.57	±0.32	-0.07	±0.15	0.27	-
GREENVILLE	3	0.67	±0.37	0.20	±0.24	0.36	-
MACON	4	0.60	±0.35	0.04	±0.20	0.35	-
SAVANNAH	4	0.54	±0.34	0.00	±0.14	0.18	-
AVERAGE						0.29	±0.49

- INSUFFICIENT DATA

BETA, PCI/G

LOCATION	NO. OF SAMPLES	MAXIMUM	CT ERR 95% CL	MINIMUM	CT ERR 95% CL	ARITHMETIC MEAN	2 STD DEV
PLANT PERIMETER							
PLANT PERIMETER 2	12	66	±5.0	13	±3.6	31	±36
PLANT PERIMETER 3	12	51	±4.4	13	±3.3	29	±28
PLANT PERIMETER 6	12	110	±6.0	14	±3.8	38	±54
PLANT PERIMETER 8	12	61	±4.7	10	±3.5	30	±31
PLANT PERIMETER 10	12	79	±5.1	8.0	±3.5	27	±38
PLANT PERIMETER 12	12	56	±4.6	8.1	±3.4	27	±26
PLANT PERIMETER 14	12	47	±4.4	8.6	±3.5	27	±23
AVERAGE						30	±35
25 MILE RADIUS							
25 MILE RADIUS 2	12	53	±4.5	12	±3.3	28	±26
25 MILE RADIUS 3	12	62	±5.3	13	±3.1	33	±32
25 MILE RADIUS 5	12	50	±4.4	13	±3.7	27	±26
25 MILE RADIUS 8	12	42	±4.8	11	±3.5	25	±19
25 MILE RADIUS 10	12	49	±4.4	12	±3.0	26	±25
25 MILE RADIUS 12	12	81	±5.2	7.7	±2.9	30	±40
25 MILE RADIUS 14	11	55	±4.6	5.3	±3.3	30	±30
AVERAGE						28	±28
100 MILE RADIUS							
COLUMBIA	4	45	±4.8	21	±4.1	32	-
GREENVILLE	3	32	±4.0	26	±3.8	28	-
MACON	4	44	±6.8	20	±3.8	33	-
SAVANNAH	4	33	±4.0	19	±3.3	24	-
AVERAGE						29	±17

- INSUFFICIENT DATA

TABLE B-5
RADIOACTIVITY IN MILK, pCi/ℓ

Local Dairies	No. of Samples	Tritium CG: 3,000,000 Max	Min	Avg	2 Std Dev	Strontium-90 CG: 300 Max	Min	Avg	2 Std Dev	Iodine-131 CG: 300 Max	Min	Avg	Cesium-137 CG: 20,000 Max	Min	Avg	2 Std Dev
Denmark, SC	7	1500	<300	410	±1040	29	3	12	±23	2	<1	<1	24	14	19	±10
Waynesboro, GA	25	1800	<300	1000	±920	25	6	13	±13	8	<1	<1	36	<1	18	±21
Major distributor[a]	21	1000	<300	350	±620	12	2	4	±8	8	<1	<1	34	7	15	±16
	25	760	<300	<240	±440	17	1	7	±13	8	<1	<1	21	9	16	±10

[a] Milk produced in local dairies but sold by major distributor.

TABLE B-6
RADIOACTIVITY IN FOOD, pCi/g
(wet weight)

	No. of Samples	Sr-90 Max	Min	Avg	2 Std Dev	Zr-95, Nb-95 Max	Min	Avg	2 Std Dev	Ru-106 Max	Min	Avg	2 Std Dev	I-131 Max	Min	Avg	2 Std Dev
Collards	14	1.43	0.24	0.76	0.64	0.12	<0.02	0.04	±0.07	<0.18	<0.18	<0.18	-	<0.9	<0.9	<0.9	-
Plums	14	0.14	<0.01	0.02	±0.08	0.02	<0.02	<0.02	-	<0.17	<0.17	<0.17	-	<0.4	<0.4	<0.4	-
Oats, rye, & wheat	14	0.42	<0.08	0.13	±0.23	0.04	<0.02	<0.02	-	<0.18	<0.18	<0.18	-	<0.8	<0.8	<0.8	-
Corn	14	<0.03	<0.03	<0.03	-	<0.02	<0.02	<0.02	-	<0.18	<0.18	<0.18	-	<0.5	<0.5	<0.5	-
Chicken	4	0.05	<0.03	<0.03	-	<0.02	<0.02	<0.02	-	0.30	<0.17	<0.30	-	<0.5	<0.5	<0.5	-
Beef	4	<0.06	<0.06	<0.06	-	<0.02	<0.02	<0.02	-	<0.16	<0.16	<0.16	-	<0.03	<0.03	<0.03	-

	No. of Samples	Cs-137 Max	Min	Avg	2 Std Dev	Ce-141, 144 Max	Min	Avg	2 Std Dev	Tritium, pCi/ml, Free Water Max	Min	Avg	2 Std Dev
Collards	14	0.03	<0.01	0.01	±0.02	0.29	<0.07	0.15	±0.13	11	<1	6	±10
Plums	14	.01	<0.01	<0.01	-	<0.07	<0.07	<0.07	-	6	<1	2	±4
Oats, rye, & wheat	14	.03	<0.01	0.02	±0.02	<0.08	<0.08	<0.08	-	3	<1	<1	-
Corn	14	.08	<0.01	.02	±0.04	<0.07	<0.07	<0.07	-	4	<1	<1	-
Chicken	4	.02	0.01	.02	±0.01	<0.07	<0.07	<0.07	-	2	<1	1	-
Beef	4	0.02	0.01	0.01	±0.01	0.08	<0.07	<0.07	-	a	a	a	-

[a] No analysis.
- Insufficient data to calculate.

TABLE B-7
RADIOACTIVITY AND MERCURY IN SAVANNAH RIVER FISH
pCi/g (Wet Weight)

Location	No. of Fish Assayed Bass	Bream	Catfish	^{137}Cs (Whole Fish) Bass Max	Min	Avg	Bream[a] Max	Min	Avg	Catfish[b] Max	Min	Avg	^{89,90}Sr Bone[c] Max	Min	Avg
Above SRP boundary	0	9	11	-	-	-	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	6.6	0.1	2.3
Adjacent to SRP	1	1	5	<0.1	-	-	<0.2	<0.2	<0.2	0.2	<0.1	<0.1	5.4	.1	3.3
Below SRP at highway 301	1	2	7	<0.1	-	-	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	6.6	0.1	3.2

Location	No. of Fish Assayed Bass	Bream	Catfish	Tritium, pCi/ml (Free Water) Bass Max	Min	Avg	Bream[a] Max	Min	Avg	Catfish[b] Max	Min	Avg
Above SRP boundary	0	5	7	-	-	-	26	3	9	15	<1	6
Adjacent to SRP	1	1	3	12	-	-	12	-	-	24	<1	11
Below SRP at highway 301	0	2	6	-	-	-	2	<1	1	20	2	13

Location	Mercury No. of Fish Assayed Bass	Bream	Catfish	µg/g (Wet Weight) Bass	Bream	Catfish	Max all Species
Above SRP boundary	0	4	3	-	0.8	1.3	1.9
Adjacent to SRP	1	1	1	<0.3	0.4	<0.3	
Below SRP at highway 301	0	0	4	-	-	0.7	1.8

- No analysis.
[a] Shell cracker, bluegill, and redbreast (Leopomis).
[b] Predominantly yellow cat (Ictalurus).
[c] Bass, bream, and catfish composited monthly.

TABLE B-8
RADIOACTIVITY IN DEER AND HOGS

pCi/g (Wet Weight)

No. of Animals	Species	Flesh ^{137}Cs Average	Flesh ^{137}Cs Range	Bone[a] $^{89,90}Sr$ Average	Bone[a] $^{89,90}Sr$ Range	Thyroid[a] ^{131}I Average	Thyroid[a] ^{131}I Range
1271	Deer	10	<1-42	<5	<5	65	<3-410
57	Hogs	8	<1-24	-	-		

[a] 13 deer bone samples; 73 deer thyroid samples.
- No analysis.

TABLE B-9
RADIOACTIVITY IN SAVANNAH RIVER WATER

ALPHA, PCI/L

LOCATION	NO. OF SAMPLES	MAXIMUM	CT ERR 95% CL	MINIMUM	CT ERR 95% CL	ARITHMETIC MEAN	2 SID DEV
SAVANNAH RIVER							
R-2 DISSOLVED	51	1.0	±0.63	-0.22	±0.34	0.14	±0.44
R-2 SUSPENDED	50	1.5	±0.67	-0.15	±0.37	0.19	±0.64
R-4 ABOVE 4 MILE CK	51	0.70	±0.50	-0.14	±0.27	0.17	±0.38
R-8 BELOW STEEL CK	52	0.69	±0.52	-0.22	±0.26	0.16	±0.34
R-9 BELOW L3R CREEK	52	0.77	±0.61	-0.30	±0.30	0.20	±0.42
R-10 DISSOLVED	51	0.48	±0.45	-0.22	±0.26	0.13	±0.28
R-10 SUSPENDED	51	1.3	±0.65	-0.14	±0.19	0.16	±0.50
TREATMENT PLANTS							
SAVANNAH RAW	12	0.74	±0.52	0.00	±0.19	0.33	±0.48
SAVANNAH TREATED	12	0.82	±0.51	-0.13	±0.19	0.16	±0.48
BEAUFORT TREATED	12	0.54	±0.43	-0.14	±0.27	0.13	±0.44
CONTROL							
EDISTO RIVER	51	3.5	±1.2	0.14	±0.44	0.81	±1.1

BETA, PCI/L

LOCATION	NO. OF SAMPLES	MAXIMUM	CT ERR 95% CL	MINIMUM	CT ERR 95% CL	ARITHMETIC MEAN	2 SID DEV
SAVANNAH RIVER							
R-2 DISSOLVED	51	9.6	±6.1	-3.0	±6.6	2.9	±5.3
R-2 SUSPENDED	51	3.4	±5.8	-3.7	±5.6	0.3	±3.3
R-4 ABOVE 4 MILE CK	51	6.5	±6.5	-1.8	±5.6	2.1	±3.8
R-8 BELOW STEEL CK	52	9.3	±6.5	-2.6	±6.6	2.3	±4.8
R-9 BELOW L3R CREEK	52	9.8	±6.6	-2.2	±5.7	2.1	±4.4
R-10 DISSOLVED	51	8.9	±6.0	-4.0	±5.1	2.0	±4.8
R-10 SUSPENDED	51	6.0	±5.5	-5.7	±6.5	0.1	±4.3
TREATMENT PLANTS							
SAVANNAH RAW	12	13	±5.8	0.0	±5.7	4.3	±6.6
SAVANNAH TREATED	12	13	±6.6	6.3	±6.9	11	±4.3
BEAUFORT	12	7.9	±7.0	-2.1	±5.2	2.1	±5.9
CONTROL							
EDISTO RIVER	51	15	±6.8	-4.3	±6.1	3.4	±6.2

H-3, PCI/ML

LOCATION	NO. OF SAMPLES	MAXIMUM	CT ERR 95% CL	MINIMUM	CT ERR 95% CL	ARITHMETIC MEAN	2 SID DEV
SAVANNAH RIVER							
R-2 ABOVE PLANT	52	2.5	±0.3	0.0	±0.30	0.5	±1.1
R-4 ABOVE 4 MILE CK	51	15	±0.3	0.0	±0.30	2.2	±4.9
R-10 HIGHWAY 301	52	11	±0.3	0.7	±0.30	4.8	±4.5
TREATMENT PLANTS							
SAVANNAH RAW	12	7.6	±0.3	1.3	±0.3	3.6	±4.0
SAVANNAH TREATED	12	8.9	±0.3	1.3	±0.3	3.7	±4.0
BEAUFORT TREATED	12	7.1	±0.3	0.0	±0.3	2.9	±4.9
CONTROL							
EDISTO RIVER	49	0.9	±0.3	0.0	±0.3	0.4	±0.4

TABLE B-10
RADIONUCLIDES IN SAVANNAH RIVER WATER

RADIONUCLIDE	MINIMUM LEVEL OF DETECTION	CONCENTRATION, pCi/ℓ 1 MILE UPSTREAM FROM UPPER THREE RUNS CREEK R-2 (CONTROL) MAX	MIN	AVG	8 MILES DOWNSTREAM FROM LOWER THREE RUNS CREEK AT HIGHWAY 301 R-10 MAX	MIN	AVG	% OF CG AT HIGHWAY 301
H-3	300	2500	<300	500	11,000	700	4,800	0.16
S-35	5.0	ND			ND			<0.01
CR-51	4.3	ND			ND			<0.001
MN-54	0.4	ND			ND			<0.0004
CO-60	1.4	ND			ND			<0.005
ZN-65	1.1	ND			ND			<0.001
SR-89	0.3	ND			ND			<0.001
SR-90	.02	2.0	<0.1	0.35	1.2	<0.1	0.3	0.10
ZR-95,NB-95	0.5	ND			ND			<0.001
RU-103,106	3.2	ND			ND			<0.03
I-131	0.2	ND			ND			<0.07
CS-137	<0.01	ND			0.022	0.008	0.015	<0.001
BA-140,LA-140	1.6	ND			ND			<0.01
CE-141,144	2.5	ND			ND			<0.02
NP-239	2.2	ND			ND			<0.002

ND = LESS THAN MINIMUM LEVEL OF DETECTION.

TABLE B-11
SAVANNAH RIVER WATER QUALITY

PARAMETER	UNITS	NO. OF ANALYSES	MAXIMUM	MINIMUM	ARTHIMETIC MEAN	2 SID DEV
RIVER 2 ABOVE PLANT						
WATER VOLUME	LITERS		1.36 E+13(TOTAL)			
TEMPERATURE	DEG C	12	25.600	6.000	17.417	±13.930
PH	PH	11	7.000	6.100		
DISSOLVED O	MG/L	12	12.400	6.320	9.831	±2.943
ALKALINITY	MG/L	12	17.500	7.700	13.575	±5.721
HARDNESS	MG/L	12	24.000	9.100	13.783	±8.406
CONDUCTIVITY	UMHOS	12	88.000	4.900	55.325	±42.864
SUSP SOLIDS	MG/L	12	29.000	5.000	15.875	±12.462
VOLTL SOLIDS	MG/L	12	29.000	7.000	20.000	±10.954
T DIS SOLIDS	MG/L	12	52.000	29.000	43.792	±14.681
FIXD RESIDUE	MG/L	12	44.000	14.000	23.792	±15.240
BOD	MG/L	12	2.000	1.000	1.375	±0.965
LIGNIN	MG/L	12	1.500	<1	.642	±1.360
CHLORIDE CL	MG/L	12	8.100	.500	4.725	±4.604
NITRITE N	MG/L	12	.090	<0.02	.022	±0.062
NITRATE N	MG/L	12	.600	.020	.299	±0.342
SULFATE SO-4	MG/L	12	5.600	2.900	4.033	±1.368
SULFIDE S	MG/L	12	.400	<1	.054	±0.239
TOTL PHOSP P	MG/L	12	.700	<0.02	.262	±0.473
ALUMINUM AL	MG/L	12	<0.5	<0.5	<0.5	
AMMONIA NH-4	MG/L	12	.200	<0.1	.042	±0.140
CALCIUM CA	MG/L	12	2.300	1.300	1.792	±0.562
SODIUM NA	MG/L	12	8.400	4.300	6.779	±2.589
TOTL IRON FE	MG/L	12	1.200	<0.1	.283	±0.631
RIVER 10 BELOW PLNT						
WATER VOLUME	LITERS		1.63 E+13(TOTAL)			
TEMPERATURE	DEG C	12	26.600	5.600	17.862	±15.161
PH	PH	12	6.800	6.300		
DISSOLVED O	MG/L	12	12.600	6.200	9.713	±3.285
ALKALINITY	MG/L	12	19.500	7.800	14.333	±5.975
HARDNESS	MG/L	12	17.000	9.100	13.504	±4.917
CONDUCTIVITY	UMHOS	12	86.000	41.000	59.750	±26.712
SUSP SOLIDS	MG/L	12	21.000	4.000	14.000	±10.162
VOLTL SOLIDS	MG/L	12	27.000	6.000	20.417	±13.058
T DIS SOLIDS	MG/L	12	76.000	33.000	46.708	±22.387
FIXD RESIDUE	MG/L	12	51.000	12.000	26.292	±22.265
BOD	MG/L	12	3.000	<1	1.083	±1.801
LIGNIN	MG/L	12	1.300	<1	.750	±1.133
CHLORIDE CL	MG/L	12	7.500	.500	4.621	±3.793
NITRITE N	MG/L	12	.030	<0.02	.005	±0.018
NITRATE N	MG/L	12	2.000	<0.02	.417	±1.085
SULFATE SO-4	MG/L	12	5.600	2.000	3.921	±1.980
SULFIDE S	MG/L	12	.700	<1	.058	±0.404
T PHOSP PO-4	MG/L	12	.400	<0.02	.167	±0.355
ALUMINUM AL	MG/L	12	<0.5	<0.5	<0.5	
AMMONIA NH-4	MG/L	12	.200	<0.1	.017	±0.115
CALCIUM CA	MG/L	12	2.600	1.400	1.971	±0.592
SODIUM NA	MG/L	12	7.600	4.900	6.375	±1.939
TOTL IRON FE	MG/L	12	1.200	<0.1	.312	±0.690

TABLE B-12
RADIOACTIVITY IN DRINKING WATER

ALPHA, PCI/L

LOCATION	NO. OF SAMPLES	MAXIMUM	CT ERR 95% CL	MINIMUM	CT ERR 95% CL	ARITHMETIC MEAN	2 STD DEV
TOWN							
AIKEN	2	1.2	±0.65	1.0	±0.60	1.1	-
ALLENDALE	2	0.54	±0.51	0.43	±0.49	0.49	-
AUGUSTA	2	0.50	±0.51	0.00	±0.33	0.25	-
BARNWELL	1	0.62	±0.50	0.62	±0.50	0.62	-
BATH	2	0.43	±0.49	0.34	±0.45	0.39	-
BLACKVILLE	2	0.48	±0.49	0.07	±0.31	0.28	-
CLEARWATER	2	0.34	±0.41	0.34	±0.41	0.34	-
JACKSON	2	2.0	±0.82	1.2	±0.68	1.6	-
LANGLEY	2	0.41	±0.44	0.27	±0.43	0.34	-
NEW ELLENTON	2	0.76	±0.53	0.61	±0.49	0.69	-
NORTH AUGUSTA	2	0.76	±0.53	0.41	±0.47	0.59	-
SARDIS	2	0.14	±0.34	0.00	±0.33	0.07	-
WAYNESBORO	2	0.21	±0.37	0.14	±0.38	0.18	-
WILLISTON	2	1.8	±0.79	1.1	±0.64	1.4	-
AVERAGE						0.60	±1.0

BETA, PCI/L

LOCATION	NO. OF SAMPLES	MAXIMUM	CT ERR 95% CL	MINIMUM	CT ERR 95% CL	ARITHMETIC MEAN	2 STD DEV
TOWN							
AIKEN	2	4.5	±5.8	-1.5	±6.1	1.5	-
ALLENDALE	2	4.5	±6.9	1.1	±6.2	2.8	-
AUGUSTA	2	0.41	±6.7	-2.1	±6.1	0.8	-
BARNWELL	1	0.0	±5.8	0.0	±5.6	0.0	-
BATH	2	4.5	±5.8	2.6	±6.3	3.5	-
BLACKVILLE	2	4.0	±5.8	-1.6	±6.1	1.2	-
CLEARWATER	2	2.8	±6.3	1.8	±5.7	2.3	-
JACKSON	2	2.6	±6.3	0.81	±6.7	1.7	-
LANGLEY	2	2.4	±5.8	-3.5	±6.1	0.5	-
NEW ELLENTON	2	4.5	±5.4	1.8	±5.7	3.2	-
NORTH AUGUSTA	2	2.5	±5.8	2.1	±6.3	2.3	-
SARDIS	2	3.4	±6.6	-0.49	±6.2	1.5	-
WAYNESBORO	2	3.0	±5.8	0.24	±6.2	1.6	-
WILLISTON	2	6.5	±6.4	1.5	±6.3	4.0	-
AVERAGE						1.7	±4.7

H-3, PCI/ML

LOCATION	NO. OF SAMPLES	MAXIMUM	CT ERR 95% CL	MINIMUM	CT ERR 95% CL	ARITHMETIC MEAN	2 STD DEV
TOWN SOURCE							
AIKEN STREAM & WELL	2	0.47	±0.30	0.41	±0.30	0.44	-
ALLENDALE WELL	2	0.27	±0.30	0.00	±0.30	0.14	-
AUGUSTA RIVER	2	0.48	±0.30	0.31	±0.30	0.40	-
BARNWELL WELL	1	0.18	±0.30	0.18	±0.30	0.18	-
BATH WELL	2	0.44	±0.30	0.00	±0.30	0.22	-
BLACKVILLE WELL	2	0.11	±0.30	0.00	±0.30	0.06	-
CLEARWATER LAKE	2	0.37	±0.30	0.34	±0.30	0.36	-
JACKSON WELL	2	0.66	±0.30	0.19	±0.30	0.43	-
LANGLEY WELL	2	0.39	±0.30	0.11	±0.30	0.25	-
NEW ELLENTON WELL	2	0.13	±0.30	0.08	±0.30	0.11	-
NORTH AUGUSTA RIVER	2	0.52	±0.30	0.23	±0.30	0.38	-
SARDIS WELL	2	0.29	±0.30	0.09	±0.30	0.19	-
WAYNESBORO STREAM	2	0.45	±0.30	0.00	±0.30	0.23	-
WILLISTON WELL	2	0.19	±0.30	0.00	±0.30	0.10	-
AVERAGE						0.24	±0.38

- INSUFFICIENT DATA

TABLE B-13
RADIOACTIVITY IN SOIL (0-5 cm DEPTH)

	Concentration pCi/g				Deposition mCi/km^2			
	^{238}Pu	^{239}Pu	^{137}Cs	^{90}Sr	^{238}Pu	^{239}Pu	^{137}Cs	^{90}Sr
Plant Perimeter								
Northeast	< 0.001 ±0.002	0.024 ±0.006	0.8 ±0.03	0.20 ±0.02	0.01 ±0.14	1.86 ±0.48	58 ±2	14.9 ±1.1
Northwest	.001 ± .001	.010 ± .003	0.4 ± .03	.04 ± .01	.07 ± .07	0.80 ± .22	29 ±2	2.7 ±0.5
Southeast	.001 ± .001	.016 ± .003	0.9 ± .03	.12 ± .01	.10 ± .07	1.21 ± .20	65 ±2	9.4 ±1.0
Southwest	.001 ± .001	.011 ± .001	.7 ± .03	.04 ± .01	.10 ± .09	0.87 ± .22	54 ±2	3.2 ±0.4
100 Mile Radius								
Clinton, SC	< 0.001 ±0.001	0.021 ±0.002	0.7 ±0.04	0.11 ±0.01	0.04 ±0.03	1.60 ±0.16	53 ±3	8.6 ±0.8
Savannah, GA	< 0.001 ±0.001	0.011 ± .001	0.7 ± .06	0.25 ±0.02	0.03 ±0.02	0.85 ±0.10	55 ±5	18.8 ±1.9

TABLE B-14
SAVANNAH RIVER SWAMP - STEEL CREEK TO LITTLE HELL LANDING
RADIATION MEASUREMENTS (TLD, 1 METER ABOVE GROUND)

Location			mR/Day					
River Mile	Trail Number	Distance From River Meters	1972	(Aug) 1974	(June July) 1975	(Oct[a] Nov) 1975	(Aug. Sept.) 1976	(June July) 1977
141.5	1	0	0.27	0.30	0.23	0.21	0.26	0.30 ±0.03
		178	0.35	0.35	0.29	0.17	.36	.36 ± .04
		358	0.58	0.51	0.44	0.31	.60	.54 ± .05
		550	-	-	-	0.76	-	1.23 ± .09
		656	1.47	1.60	1.56	0.94	1.85	1.51 ± .11
		805	0.17	0.18	0.15	0.20	0.20	0.19 ± .02
140.8	2	0	0.19	0.22	0.20	0.22	.28	------
		207	0.21	0.26	0.20	0.24	.28	.27 ± .03
		406	0.19	0.24	0.22	0.22	.27	.28 ± .03
		598	0.23	0.28	0.22	0.24	.26	------
		798	0.29	0.37	0.28	0.27	.35	------
		945	-	0.59	0.63	0.54	.58	.62 ± .06
		975	0.14	0.19	0.20	0.15	.20	.20 ± .02
139.5	3	0		0.22		0.19	.23	0.23 ± .02
To		281		0.23		0.17	-	.32 ± .03
140.8		627		0.23		0.23	.23	.25 ± .03
139	4	0		0.30		0.27	.31	0.30 ± .03
		293		0.31		0.25	.33	------
		380		0.49		0.32	.46	------
		515		0.45		0.26	.40	0.46 ± .04
		580		0.99		0.79	.91	.83 ± .07
		729		0.22		0.20	.25	.25 ± .03
138.5	5	0		0.19		0.20	.22	0.24 ± .02
		534		0.36		0.30	.35	.34 ± .03
		573		0.61		0.55	.62	.58 ± .05
		640		1.09		1.03	1.22	1.00 ± .08
		773		0.24		0.21	0.24	0.26 ± .03
137	6	0		0.22		0.18	.30	0.25 ± .03
		549		0.30		0.29	.33	.38 ± .04
		701		0.84		0.43	.65	.74 ± .06
		772		0.85		0.62	.77	.94 ± .08
		817		0.26		0.21	.29	.28 ± .03
136.3	7	0		0.20		0.19	.21	0.25 ± .03
		579		0.19		0.16	.21	.24 ± .02
		793		0.90		0.91	.96	1.08 ± .08
		823		0.24		0.24	.23	0.27 ± .03
135.7	8	0	0.20	0.22	0.19	0.19	.20	0.27 ± .03
		168	0.21	0.25	0.22	0.21	.26	.29 ± .03
		279	0.23	0.24	0.20	0.15	.23	.28 ± .03
		445	0.21	0.24	0.22	0.22	.28	.26 ± .03
		612	0.23	0.24	0.22	0.20	.24	.28 ± .03
		814	0.34	0.36	0.35	0.28	.39	.44 ± .04
		884	-	0.64	0.63	0.57	.62	.64 ± .06
		915	0.22	0.22	0.23	0.22	.23	.27 ± .03
135.5	9	0		0.22		0.20	.23	.28 ± .03
		512		0.46		0.36	.44	.50 ± .04
		621		0.54		0.29	.57	.63 ± .06
		671		-		0.47	.75	.72 ± .06
		769		0.18		0.18	.20	.24 ± .02
134.4	10	0		-		0.18	-	------
		30		-		0.28	-	.26 ± .03
		73		0.20		0.18	-	.45 ± .04
Green Pond, near 700 Area (Control)				0.16		0.18	0.17	.16 ±.02

- No measurement.

[a] Lower results are attributed to shielding from higher water levels observed in swamp.

± Error associated with the precision observed from known exposures of the same magnitude under similar conditions.

TABLE B-15
SAVANNAH RIVER SWAMP - STEEL CREEK TO LITTLE HELL LANDING
RADIOACTIVITY IN SOIL

Location			pCi/g (dry weight)				
			^{137}Cs				^{90}Sr[a]
River Mile	Trail Number	Distance From River Meters	1974 0-6 cm	1975 0-8 cm	1976 0-8 cm	1977 0-8 cm	1977 0-8 cm
141.5	1	0	31	41			
		178	23	14	21	18	0.7
		358	126	46			
		550	345	261	174	100	0.6
		656	194	75			
		805	3	1	1	1	0.1
140.8	2	0	1	1			
		207	2	3	2	3	
		406	4	3			
		598	9	4			
		798	47	18			
		945	122	73	5	38	
		975	3	1	1	9	
139.5	3	0	<1	2	<1	1	
to		281	5	2	2	2	
140.8		627	4	1	1	1	
139	4	0	1	2			
		293	13	19	18	19	
		380	86	61			
		515	72	55			
		580	187	98		171	
		729	2	2	44	2	
138.5	5	0	1	1			
		534	34	13	<1	27	
		573	140	86			
		640	260	141	<1	99	
		773	1	2	<1	1	
137	6	0	1	2			
		549	50	29	27	23	
		701	160	124			
		772	300	123	93	196	
		817	4	1	3	3	
136.3	7	0	2	1			
		579	6	3	3	6	
		793	527	26	159	173	
		823	3	2	2	3	
135.7	8	0	12	1			
		168	4	1	2	2	
		279	1	2			
		445	5	2			
		612	6	2			
		814	63	37	32	35	
		884	114	5			
		915	5	2	4	3	
135.5	9	0	2	1			
		512	120	57			
		621	134	111	74	92	
		671	1	92	117	105	
		762		1	2	2	
134.4	10	0		24	28	30	
		30	51	36	34	27	
		73	5	2	4	4	
Control (100 mi. from plant)			0.8	0.3	1	1	0.3

Blank data space indicates no analysis

[a] Analyzed for trail 1 only.

TABLE B-16
SAVANNAH RIVER SWAMP - STEEL CREEK TO LITTLE HELL LANDING PLUTONIUM IN SOIL
pCi/g (DRY WEIGHT)

Location		Distance	^{238}Pu			^{239}Pu		
River Mile	Trail Number	From River Meters	1975 0-8 cm	1976 0-8 cm	1977 0-8 cm	1975 0-8 cm	1976 0-8 cm	1977 0-8 cm
141.5	1	178			0.001 ± 0.006			0.024 ± 0.011
		550		0.054 ± 0.006	0.024 ± 0.004		0.123 ± 0.010	0.067 ± 0.007
		656	0.052 ± 0.016			0.096 ± 0.028		
		805			0.001 ± 0.002			0.017 ± 0.006
140.8	2	945			0.010 ± 0.006			0.056 ± 0.014
		975	0.012 ± 0.001	<0.001		0.036 ± 0.003	0.025 ± 0.006	
139.5 to 140.8	3	281	0.003 ± 0.006			0.022 ± 0.001		
		627		<0.001	<0.001		0.005 ± 0.002	<0.002
139	4	580	0.026 ± 0.012	0.001 ± 0.002	0.031 ± 0.008	0.067 ± 0.015	0.003 ± 0.003	0.096 ± 0.013
138.5	5	640	0.026 ± 0.014	<0.001	0.022 ± 0.006	0.090 ± 0.047	0.004 ± 0.003	0.083 ± 0.012
137	6	772	0.027 ± 0.010			0.088 ± 0.41		
		817		0.002 ± 0.002	0.002 ± 0.002		0.032 ± 0.005	0.036 ± 0.006
136.3	7	793	0.005 ± 0.004	0.026 ± 0.005	0.032 ± 0.005	0.036 ± 0.008	0.081 ± 0.008	0.085 ± 0.007
135.7	8	814			0.008 ± 0.004			0.033 ± 0.006
		884	0.010 ± 0.006			0.033 ± 0.003		
		915		0.001 ± 0.004			0.040 ± 0.009	
135.5	9	671	0.019 ± 0.005	0.024 ± 0.006	0.026 ± 0.006	0.044 ± 0.004	0.073 ± 0.011	0.077 ± 0.009
134.4	10	73	0.010 ± 0.003	0.002 ± 0.002	0.002 ± 0.002	0.089 ± 0.007	0.036 ± 0.006	0.038 ± 0.007
Control (100 mi. from plant)			0.003 ± 0.003	0.001 ± 0.001	<0.001	0.009 ± 0.001	0.010 ± 0.002	0.016 ± 0.002

Blank data spaces indicate no sample or anlaysis

TABLE B-17
SAVANNAH RIVER SWAMP — STEEL CREEK TO LITTLE HELL LANDING
RADIOACTIVITY IN VEGETATION

Location River Mile	Location Trail Number	Distance From River, Meters	Vegetation, pCi/g (Dry Wt) ^{137}Cs 1974	^{137}Cs 1975	^{137}Cs 1976	^{137}Cs 1977	Alpha 1976	Alpha 1977	pCi/ml (Free Water) Tritium
141.5	1	0	2	<1					
		178	20	13	52	2	0.3	0.0 ± 0.2	9 ± 3
		358	3	2					
		550	122	103	100	132	0.4	0.2 ± 0.3	32 ± 5
		656	22	189					
		805	2	<1	<1	2	<0.1	0.2 ± 0.2	3 ± 2
140.8	2	0	<1	<1		<1		0.1 ± 0.2	
		207	3	<1	<1		<0.1		
		406	1	<1					
		598	<1	<1					
		798	2	<1					
		945	144	54	3	10	<0.2	0.1 ± 0.2	
		975	1	<1	<1	<1	<0.1	0.3 ± 0.3	
139.5 to 140.8	3	0	<1	<1	<1	3	<0.2	0.4 ± 0.3	
		281	<1		<1	<1	0.2	0.3 + 0.3	
		627	<1	<1	<1	<1	<0.2	<0.1 ± 0.2	
139	4	0	2	<1					
		293	2	<1	7	2	<0.2	0.5 ± 0.3	
		380	15	2					
		515	19	30					
		580	98	15	<1	29	<0.1	0.2 ± 0.3	
		729	1	<1	1	<1	0.3	0.5 ± 0.3	
138.5	5	0	1	<1					
		534	1	<1	<1	2	0.2	0.3 ± 0.3	
		573	15	3					
		640	36	6	<1	12	<0.1	0.8 ± 0.4	
		773	<1	<1	<1	2	0.3	0.1 ± 0.2	
137	6	0	1	<1					
		549	47	15	9	4	0.3	0.2 ± 0.3	
		701	18	26					
		772	235	2	119	13	0.4	0.1 ± 0.2	
		817	1	<1	1	<1	0.2	0.2 ± 0.2	
136.3	7	0	1	2					
		579	1	<1	1	7	0.3	<0.1 ± 0.2	
		793	79	24	35	8	0.3	0.2 ± 0.3	
		823	<1	<1	<1	<1	0.3	0.2 ± 0.3	
135.7	8	0	4	1					
		168	1	<1	<1		<0.2	0.8 ± 0.4	
		279	<1	<1					
		445	1	2					
		612	1	<1	<1	6			
		814	11	6	8	2	<0.1	0.6 ± 0.3	
		884	43	19					
		915	1	3	<1	<1	<0.1	0.1 ± 0.2	
135.5	9	0	<1	<1		<1			
		512	3	1					
		621	1	1		<1	<0.1	0.1 ± 0.2	
		671	1	6	2	1	<0.1	0.3 ± 0.3	
		769		1	<1		<0.1	0.3 ± 0.3	
134.4	10	0		3	11	9	0.2	0.3 ± 0.3	
		30	1	2	<1	2	0.2	0.1 ± 0.2	
		73	<1	<1	1	<1	0.3	0.3 ± 0.3	
Plant perimeter and 100 mile radius vegetation (Control)			1	1	<1	<1	0.1	0.1 ± 0.2	1-37[a]

[a] Blank data space indicates no analysis
Range, plant perimeter

TABLE B-18
FALLOUT IN AIR, pCi/m³

1977	^{95}Zr	^{95}Nb	^{99}Mo	^{103}Ru	^{131}I	^{132}Te	^{140}Ba	^{140}La	^{141}Ce	^{239}Np	Total Gamma Activity
9/25 - 9/26	0.02	0.02	0.05	0.04	0.07	0.04	0.07	0.14	0.04	0.22	0.71
9/26 - 9/27	-	-	.06	.06	.11	.08	.10	.16	.06	.27	.90
9/27 - 9/28	-	-	.06	.07	.10	.07	.14	.20	.08	.30	1.02
9/28 - 9/29	.09	.05	.10	.13	.15	.11	.17	.30	.13	.35	1.58
9/29 - 9/30	-	.02	.02	-	.09	.02	.05	.06	.04	.12	0.38
9/30 - 10/1	.09	.05	.07	.15	.08	.07	.22	.65	.18	.56	2.12
10/1 - 10/2	.36	.12	.24	.49	.50	.24	.80	2.07	.67	.95	6.44
10/2 - 10/3	-	-	.01	.03	.03	-	-	.06	-	.11	0.24
10/3 - 10/4	-	.03	.01	.05	.07	.02	.06	.08	.06	.15	0.53
10/4 - 10/5	-	-	-	.03	.04	-	-	.03	.04	.15	0.29
10/5 - 10/6	-	-	.01	.02	.04	.03	-	.05	.03	.33	0.51
10/6 - 10/7	-	-	-	.04	.03	-	.05	.07	.04	.21	0.44
10/7 - 10/8	.03	.03	-	.03	.02	-	.04	.12	.04	-	0.31
10/8 - 10/10	.02	.02	-	.02	.01	-	.01	.03	.02	-	0.13
10/10 - 10/11	-	-	-	-	.01	-	-	-	-	-	0.01
10/11 - 10/14	.01	.02	-	.01	-	-	-	.04	.02	.02	0.12
10/14 - 10/17	.01	.01	-	.02	-	-	-	.02	.01	.03	0.10
10/17 - 10/19	.02	.02	-	.01	-	-	-	.02	.01	-	0.08
Minimum Detection Level	<0.02	<0.01	<0.01	<.01	<.01	<.01	<0.03	<.02	<0.01	<0.02	

- Less than minimum detection level.

TABLE B-19
FALLOUT DEPOSITION IN RAIN
(AS DETERMINED BY DEPOSITION PAN AND RAIN ANALYSES)

Period	Nonvolatile Beta, nCi/m²	Rainfall, inch
9/21 - 9/28/77	7.5	1.26
9/29	9.2	0.23
10/3	4.2	1.40
10/10	0.6	0.63
10/12	0.1	0.04

FALLOUT RADIONUCLIDES IN RAIN[a]
(DURING 24-HOUR PERIOD ENDING 9/29 AT 9:00 A.M.)

Radionuclide	nCi/m²
^{99}Mo	0.2
^{103}Ru	0.7
^{131}I	1.2
^{140}Ba	1.2
^{140}La	1.1
^{141}Ce	0.2
^{239}Np	4.2
^{132}Te-I	0.4

[a] Delay in the gamma analysis of other rain samples prevented the detection of several of the above short-lived radionuclides.

TABLE B-20
^{131}I IN MILK AND VEGETATION[a]

Date	Concentration in Farm Cow Milk, pCi/l			Concentration in Dairy Milk, pCi/l		
	Elko	Windsor	Williston	Williston	N. Augusta	Waynesboro
9/29/77	140	77	39	<1	<1	8
9/30	150	160	100			
10/1	120		66			
10/2	160		39			
10/3			62			
10/4				6	3	
10/6			51	5	7	14
10/13					7	3
10/28					2	3
[a] Vegetation, pCi/g						
9/29	7	5	7		4	
9/30	9	6	8			

APPENDIX C. METHODS FOR CALCULATING ENVIRONMENTAL RADIATION DOSE

Releases to the Atmosphere

Savannah River Plant operations are conducted in a manner that confines radioactivity as completely as practical rather than releasing it to the environment. Radiation dose to man in the vicinity of SRP is calculated for the radioactive gases and particulates that are released to the atmosphere. Although SRP has an extensive environmental monitoring system, a mathematical model is needed to estimate potential radiation dose commitment from the atmospheric releases. The mathematical model is needed because the majority of releases lead to very low concentrations not detectable (exception: tritium oxide) by current monitoring techniques.

The model is based on measured and calculated releases and on dispersion by measured meteorology. The meterorological data were obtained over a two-year period (1966-1968) from instrumentation installed at eleven elevations on a 1200-foot television transmitting tower 30 kilometers (18.8 miles) northwest of the geometric center of SRP. Data collected at three-minute intervals over the two-year period provided information on wind speed, wind direction, wind variability, and thermal stability. Sufficient data were collected to include meteorological variations typical of the SRP site. Adequacy of this meteorological data base and calculational model is verified annually with measured dispersion of tritium released during normal operations to the atmosphere at SRP.

Annual averaged concentration factors in air and external gamma dose rate factors from a plume were calculated for each radionuclide individually by processing the meteorological data assuming a 1-curie release for each data period (15-minute averages). Ground level concentrations and external gamma dose were accumulated for each azimuth (16 sectors) and radial distance from the point of release for each meteorological data period according to a polar grid overlay of SRP and environs (see figure 17). After all meteorological data for the two-year period had been processed, the accumulated concentrations and gamma doses were divided by the total number of data periods represented. The result was a quantity representing a yearly integrated concentration (curie-seconds per cubic meter) and gamma dose associated with each grid point for a curie release over the year. These quantities were corrected for decay according to radionuclide and measured meteorology for each data period. For each of the 320 grid points, the integrated air concentration and gamma dose factor for a curie release is multiplied by the number of curies of each radionuclide released in a year to obtain integrated air concentrations and gamma cloud dose for subsequent calculations of dose commitment to individuals (and to the population).

The grid overlay was divided into sixteen 22.5° sectors and twenty 5-kilometer radial increments. Population distribution for each sector and radial increment was determined from the 1970 census and is shown in figure 17. Integrated air concentration and gamma plume dose is calculated at the center of each areal increment and is assumed to be representative of average conditions for the increment. The integrated air concentration and gamma dose are used for calculating radiation dose commitment to all persons within the areal increment.

Major pathways of radiation exposure from radioactive materials released to the atmosphere are:

- o External dose from radioactive materials in the atmosphere
- o External dose from radioactive materials deposited on earth's surface
- o Internal dose from inhalation of radioactive materials in the air
- o Internal dose from ingestion of food and water containing radioactive materials deposited from the atmosphere.

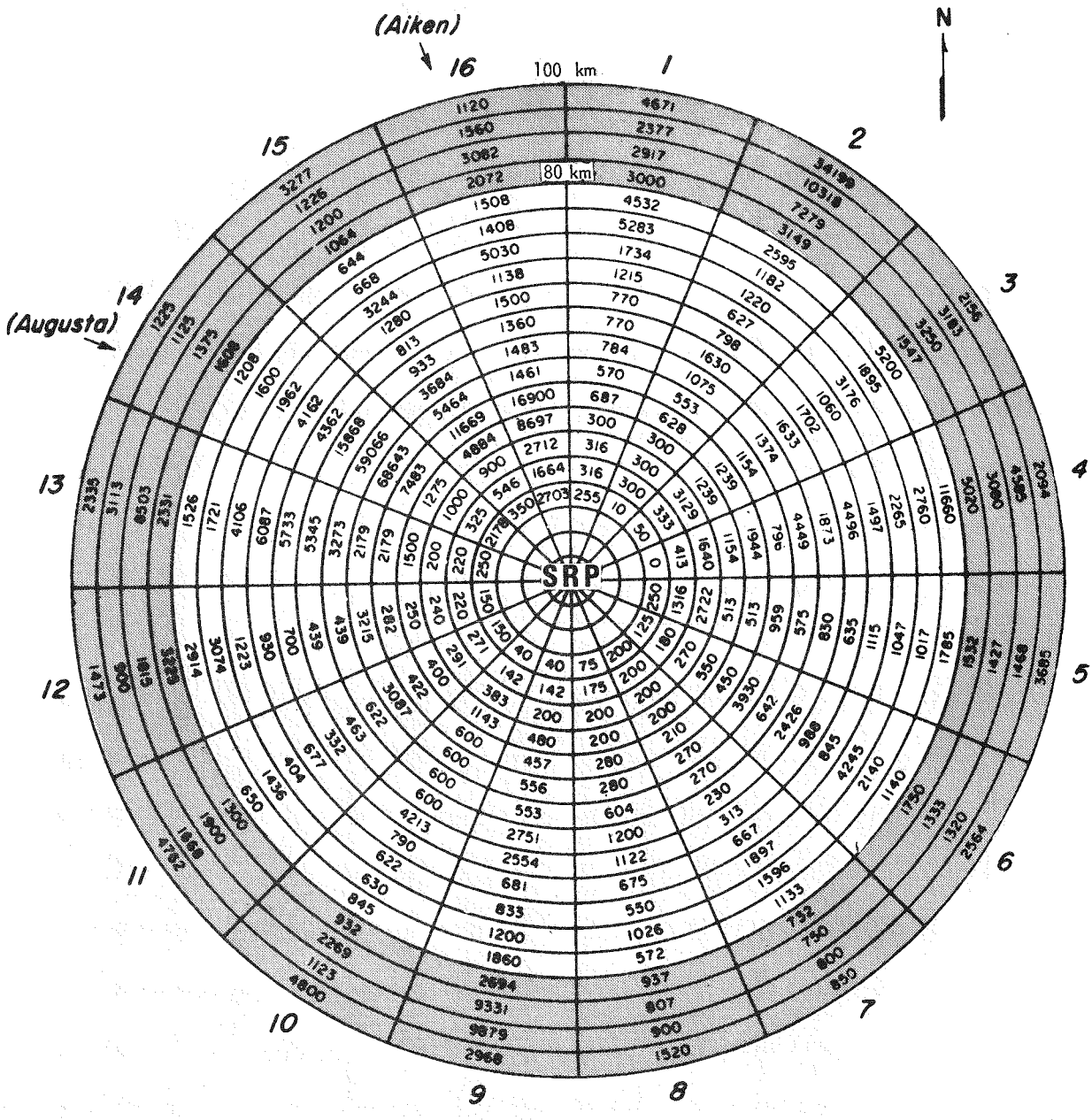

FIGURE 17. DISTRIBUTION OF POPULATION IN REGION SURROUNDING SRP
(Radial Increments = 5 km, 22.5° Sector)
1970 Census

Factors were calculated for converting integrated air concentrations of each radionuclide to a 70-year lifetime dose commitment via each exposure pathway [19]. Techniques for calculating dose were patterned after methods used by the ICRP [2,12,16]. Standard man data were used for deriving dose factors for the general population; factors are also provided for calculating dose to infants when they are critical members of the population for specific pathways of exposure (example: iodine-131 in air → pasture grass → cow → milk → infant thyroid gland). Body dose, as calculated with dose factors, is summarized with gamma plume dose to obtain whole body dose.

Recycling of noble gases, carbon-14, and tritium oxide in the global invironment is not included in the mathematical dose model. If noble gases and carbon-14 are assumed to be diluted by the world's atmosphere and tritium oxide is diluted by the world hydrological cycle, subsequent 70-year dose commitment to the population groups considered in this report will be a small fraction of 1% of the first pass dose from release of all radionuclides.

The external dose from gamma-emitting radionuclides deposited on the earth's surface are calculated assuming the nuclides are on the surface of soil and on surfaces of vegetation during the first year following release, and in succeeding years are distributed exponentially with depth in the soil as a result of washoff and infiltration into the soil with rainwater. Lifetime dose from these deposited nuclides is calculated with the assumption that each person is exposed throughout life only at the location of his residence. No corrections are made for surface runoff, surface roughness factors, or shielding by buildings.

Releases to the Savannah River

Radionuclides in liquid effluents from SRP are analyzed at the point of release, in surface streams on the SRP site before entry into the Savannah River swamp, and in the Savannah River upstream and downstream from SRP. Many radionuclides that are measurable at the point of release are below the analytical limit of sensitivity after being diluted with river water; only tritium oxide and trace amounts of cesium-137 and strontium-90 are routinely measurable in the river, and only tritium oxide at the two downstream water treatment plants. Dose commitments to downstream consumers of river water are based on the release inventory and the following assumptions.

- All radionuclides, as measured at the point of release, move down the Savannah River during the year of release.
- No depletion in the quantity of radionuclides occurs except for natural radioactive decay. Approximately five days elapse between time of release of radionuclides and entry into the two water treatment plants approximately 100 miles downstream. For the radionuclides released in 1977, no decay corrections were made.
- The flow rate of the river at the water treatment plants in 1977 averaged about 14,300 cubic feet per second (annual flow = 1.05×10^{16} ml).
- No allowance is made for removal of radionuclides in the water treatment plants.
- Dose commitment from tritium is based on measured concentrations at the water treatment plants.
- Individuals served by the water treatment plants consume an average of 1200 ml of water per day (standard man).

Dose factors were calculated for converting concentration of each radionuclide in water to a 70-year lifetime dose commitment. Techniques for calculating dose were patterned after methods used by the ICRP [2,12,16].

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