Chapter 4

Environmental Restoration and Waste Management

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ENVIRONMENTAL restoration and waste management programs at Savannah River Site (SRS) continued to make significant progress on environmental cleanup in 1996. This chapter presents a brief overview of the programs, describes some of their major milestones during the year, and summarizes their shift from initial concept and formulation to the achievement of results in the field in an open, responsive, and accountable manner.

The U.S. Department of Energy (DOE) uses the term "environmental restoration" to mean the assessment and cleanup of inactive waste units and groundwater (remediation). "Cleanup" means actions taken to deal with the release or potential release of hazardous substances. This may refer to complete removal of a substance, or it may mean stabilizing, containing, or otherwise treating the substance so it does not affect human health or the environment [DOE EM, 1991]. Determining the most environmentally sound methods of cleaning up waste units is a major component of the environmental restoration program at SRS.

In 1996, for example, environmental restoration accomplishments included

- placement of a composite geosynthetic closure cap—the first approved by the South Carolina Department of Health and Environmental Control (SCDHEC) for a hazardous waste closure—over the Nonradioactive Waste Disposal Facility
- completion of a geosynthetic closure cap over two sections, totaling five acres, of the Low Level Radioactive Waste Disposal Facility
- removal of more than 350,000 pounds of waste organic solvents from over 2.3 billion gallons of groundwater by the continuous operation of the M–1 Air Stripper
- installation of a 60-foot-tall A–2 air stripper in A-Area/M-Area (in the northeast part of the site) that has more than five times the capacity of the former A–1 stripper—to accelerate cleanup of groundwater contaminated by volatile organic compounds (VOCs)
- continuous operation of vacuum extraction vadose zone units that increased the removal rate of VOCs by 500 percent, and installation of automated control systems that allow remote operations to increase efficiency and reduce operating costs
- removal of more than 50 drums of contaminants at the D-Area oil seepage basin, which reduced the immediate health and environmental contact potential of the contaminant source.
- initial operation of four recovery wells and a low-profile air stripping unit at the TNX Area to provide the capacity to treat groundwater from the downgradient edge of the contaminant plume at a rate of 80 gallons per minute
- completion of removal of 260,000 pounds of radioactive vegetation from 4.5 acres at the H-Area retention basin, Warner's Pond, and the HP–52 outfall and placement of erosion controls to protect the basins until remediation is complete
- completion of (1) a time-critical removal action consisting of soil and asphalt covers designed to contain and reduce the spread of contamination and (2) maintenance of the R-Reactor seepage basins

DOE uses the term "waste management" to refer to the safe, effective management of various kinds of nonhazardous, hazardous, and radioactive waste generated on site. Identifying the need for appropriate

waste management facilities and ensuring their availability have been major components of the SRS waste management program.

Waste management highlights during 1996 included

- the pollution prevention/waste minimization programs, which earned national awards for their activities for the second straight year
- the transuranic waste management program's successful management of legacy waste from a weapons production mission by safely venting sealed drums containing potentially explosive gases
- the safe removal and transfer of 40,000 pounds of highly radioactive solvent from old single-walled tanks in the Burial Ground complex to new double-walled tanks near the Consolidated Incineration Facility
- continuation of preparations for a pretrial burn (conducted in December) at the Consolidated Incineration Facility

Regulatory Compliance

Two major federal statutes govern the site's environmental restoration and waste management activities, which were begun in 1981: the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). RCRA addresses the management of regulated hazardous waste and requires that permits be obtained for DOE facilities that treat, store, or dispose of hazardous or mixed waste. It also requires that DOE facilities perform appropriate corrective action. CERCLA (also known as Superfund) addresses releases of hazardous substances and the cleanup of inactive waste disposal sites. This act establishes a National Priority List of sites targeted for assessment and, if necessary, for remediation. SRS was placed on the list December 21, 1989 [Fact Sheet, 1995]. Complete information on SRS compliance activities can be found in chapter 2, "Environmental Compliance."

Environmental Restoration

SRS began its remediation program in 1981, before many of the regulations requiring environmental restoration were written. However, the site's current Environmental Restoration program was not officially established and developed until 1990. Since then, 467 inactive waste and contaminated groundwater sites have been identified (figure 4–1). The program achieved its goals during 1996 through

- groundwater remediation
- the use of preventive measures and removal actions to reduce contamination risks
- the deployment of innovative technologies

In 1996, all regulatory commitments were met by the program, and Environmental Restoration placed an additional 160 acres of waste sites into remediation—an increase of 178 percent over 1995. In addition, within A-Area and M-Area area during 1996, more than 80,000 pounds of organic solvents were removed from the soil and groundwater (a 74-percent increase over 1995) through vacuum extraction—a technology 500 percent more efficient than pump and treat. Vacuum extraction pulls toxins from the vadose zone—the layer of soil above the groundwater table.

Treatment of contaminated groundwater in F-Area and H-Area accelerated during 1996 with the installation of 30 extraction wells and 20 injection wells. The entire treatment system, which will be in full operation in 1997, employs water treatment units that use reverse osmosis technology. Through this system, contaminated groundwater is treated at a combined rate (for both F-Area and H-Area) of 350 gallons per minute. Solid-waste contaminants are extracted and stored in vaults above ground, and the treated water is sent to underground injection wells for storage. The wells have been designed to control tritium seepage into the wetlands from the groundwater.

Effective remediation of contaminated groundwater sites cannot be achieved without an effective groundwater monitoring system. Successful onsite field testing was conducted in the summer of 1996, and approval—by SCDHEC and the U.S. Environmental Protection Agency (EPA), for use at SRS—of a new system for retrieving protocol samples on clean wells and handling the reinjection of purge water is expected in 1997. Technical support has concluded that the well sampling methodology used by the new purge water management system will

- reduce purge water handling
- eliminate the need for treatment of contaminated water

The use of the purge water management system at wells where purge water contains radioactive waste, mixed waste, or listed waste is expected to reduce worker risks significantly.

Also in 1996, engineers began protective capping at a 76-acre tract known as the Old Radioactive Waste Burial Ground. This is part of the largest and highest priority waste area at SRS; low-level radioactive waste was buried there from 1952 until 1972. The area is being covered with special soil as an interim

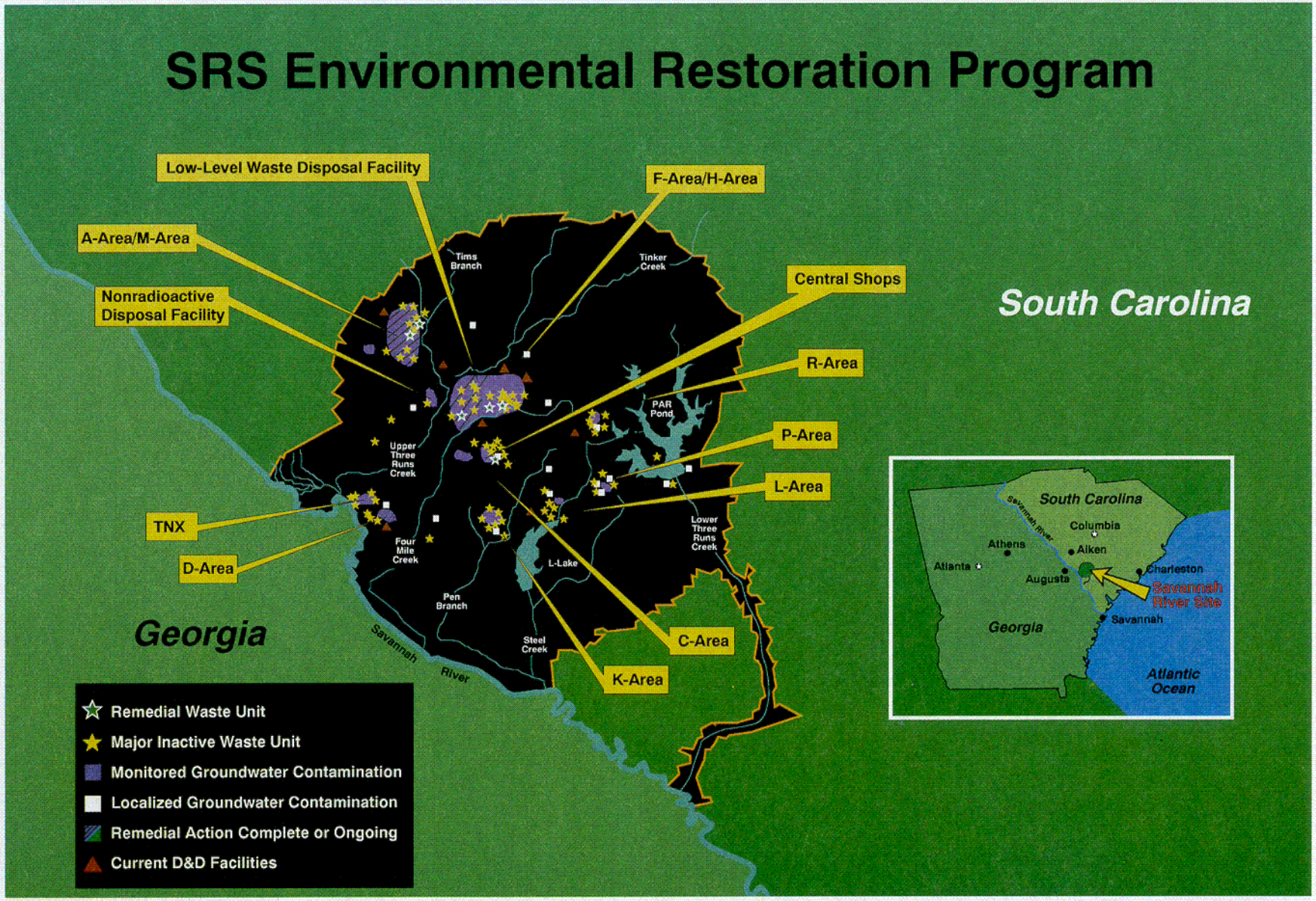

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Figure 4–1 Environmental Program Map

The SRS environmental restoration program map identifies the site's major waste units, monitored and localized groundwater contamination, completed and ongoing remedial action, and some SRS facilities designated for decommissioning.

action to help stop the infiltration of rainwater, which can flush contamination into the groundwater. This prevention measure provides groundwater protection until a final remediation design is developed.

Another action that will prevent rainwater infiltration at waste sites is the deployment of geosynthetic cap closure technology. The SRS Environmental Restoration program used geosynthetic caps to cover 60 acres of waste sites in 1996. These were the first closure plans that used geosynthetic capping approved for hazardous waste sites by the state of South Carolina. Both the Nonradioactive Waste Disposal Facility and the Low-Level Radioactive Waste Disposal Facility were chosen for a geosynthetic cap versus the traditional kaolin clay cap design because of geosynthetic capping's many advantages, including

- added flexibility
- reduction in cap height by 4 feet
- ease of installation
- less construction time

Unlike traditional kaolin clay caps, geosynthetic caps do not crack and, therefore, do not allow rainwater to seep into waste sites. Thus, they provide greater protection for groundwater than traditional kaolin clay caps.

An important part of restoring the environment at SRS involves removing contaminated vegetation. Vegetation removal at the H-Area retention basin was completed during 1996, and contaminated trees were reduced in size for disposal to a vendor for treatment. All H-Area retention basin vegetation and most Warner's Pond vegetation has been transported off site for incineration; the total is approximately 260,000 pounds.

In D-Area, 58 contaminated drums were removed during April and May 1996 following expedited site sampling and characterization. The area then was backfilled with soil and covered by vegetation to minimize rainwater infiltration and erosion. The drum removal action eliminated the source of contamination at the D-Area oil seepage basin, thus reducing the immediate health and environmental contact potential with the contaminant source.

SRS continues to use new environmental remediation technologies. BaroBall™—a passive remediation device—was designed by Savannah River Technology Center researchers and deployed in August 1996 under the environmental restoration program to remove solvent vapors underground through wells. Using natural atmospheric pressure fluctuations, BaroBall™ can remove volatile organic compounds from the vadose zone. During low-pressure weather patterns, the BaroBall™ device releases vapor in low but safe concentrations. This technology was deployed in A-Area and M-Area; however, it may be applied to any site where volatile substances have contaminated the vadose zone.

Solid Waste Management

In 1996, SRS's solid waste program faced the challenge of reducing the volume of waste generated sitewide and of safely treating, storing, and disposing of the waste in the most cost-effective manner possible.

The program's major focus involved shifting from a production phase to cleanup activities by managing large volumes of backlog wastes at various site facilities. Proper handling of the waste requires first that the waste be categorized as sanitary, low-level, transuranic, hazardous, mixed, or high-level (high-level waste discussion begins on page 56).

Sanitary Waste

Sanitary waste includes office waste, food, garbage, refuse, and other solid wastes that can be disposed of in landfills. SRS has privatized the collection, hauling, and disposal of its sanitary waste, which consists primarily of food and office wastes. In 1996, 6,700 tons of the site's sanitary waste were disposed of at a permitted offsite commercial facility, according to Solid Waste Certification and Minimization Records.

Low-Level Waste

Low-level waste is any radioactive waste not classified as high-level waste or transuranic waste. Examples of SRS low-level wastes include protective clothing, job control waste, equipment, tools, filters, rags, and papers. All certified low-level wastes are stored or disposed of in the E-Area Vaults. During 1996, the Solid Waste Management Department accepted 252,908 cubic feet of low-level waste for storage or disposal in these vaults, according to the site's Computerized Radioactive Waste Burial Records Analysis System and Waste Information Tracking System. The department also began shipping low-level waste to an offsite vendor to reduce volume, prolong the life of the vaults, and reduce costs.

Transuranic Waste

Transuranic waste is radioactive waste contaminated with certain isotopes that have decay rates and activities exceeding defined levels. It contains

manmade elements that are heavier than uranium and that decay slowly, thus requiring thousands of years of isolation. At SRS, transuranic wastes can include contaminated equipment, protective clothing, and tools. In 1996, 5,815 cubic feet of solid transuranic waste were accepted for storage on transuranic waste pads, according to the site's Computerized Radioactive Waste Burial Records Analysis System.

Hazardous Waste

According to RCRA, hazardous waste is any toxic, corrosive, reactive, or ignitable material that could damage the environment or negatively affect human health. Examples of SRS hazardous wastes include oils, solvents, acids, metals, and pesticides. In 1996, the Solid Waste Management Department accepted 3,519 cubic feet of hazardous waste for storage at the site's hazardous waste storage facilities, according to Solid Waste Certification and Minimization records.

Mixed Waste

Mixed waste is both radioactive and hazardous and is subject to regulations governing both waste types. In 1996, the Solid Waste Management Department accepted 801 cubic feet of mixed waste for storage at SRS's mixed waste storage buildings, according to Solid Waste Certification and Minimization records.

Addressing the Legacy

Management strategy for each type of waste often depends on consent orders and agreements-in-principle that DOE enters into with host states and EPA—largely according to RCRA requirements. For example, DOE is complying with Federal Facility Compliance Act (FFCAct) requirements for mixed waste—including high-level waste, most transuranic waste, and low-level waste with hazardous constituents. This act requires that DOE develop and submit site treatment plans to EPA or state regulators for approval.

Through established SRS protocol, the solid waste program provides opportunities for its representatives to listen to stakeholders and discuss and share information with them. This is designed to ensure strong public participation in decision-making processes.

Near-term program emphasis has been placed on the establishment of new facilities for

- solidification of high-level waste
- treatment of stored transuranic waste in preparation for future permanent storage at a federal repository
- incineration of low-level, hazardous, and mixed wastes

Each type of waste requires a different management strategy, as each has specific requirements for treatment, storage, and disposal.

These ongoing waste management programs are supplemented by a waste certification program through which SRS waste generators must demonstrate compliance with the waste acceptance criteria of the site's various waste management facilities. Other 1996 solid waste program activities involved continued hazardous waste shipments, the site treatment plan for mixed wastes, and the RCRA Part B permit renewal.

Accomplishments

Solid waste program activities for 1996 included accomplishments in the following areas:

- pollution prevention/waste minimization
- transuranic waste management
- solvent storage tank closures
- vendor partnerships
- the Waste Management Environmental Impact Statement
- Consolidated Incineration Facility startup preparations

Noteworthy results are described in the paragraphs that follow.

Pollution Prevention/Waste Minimization

Comprehensive, integrated sitewide pollution prevention/waste minimization programs achieved substantial reductions in waste during 1996 and earned recognition for sitewide recycling efforts. Senior management support and source reduction actions—part of a long-term effort that includes controlled-area rollbacks, decontamination, the use of reusable anticontamination materials, and other pollution control programs—contributed to a waste generation reduction in 1996 of about 180,000 cubic feet of low-level waste and more than 3,600 cubic feet of hazardous, mixed, and transuranic wastes, according to *Pollution Prevention—Everybody's Business*, a booklet produced for SRS's Solid Waste Division [SWD, 1997].

Projects such as beneficial reuse and office and industrial products recycling contributed to SRS's already exceeding Secretary of Energy 1999 goals for recycling and radioactive waste reduction. In 1996, the beneficial reuse program established and began implementing a method to convert the site's

contaminated stainless steel scrap into metals that could be used at SRS and other DOE facilities. Also, the site recycled more than 3,200 tons of material through its salvage yard and more than 74,000 pounds of chemicals and chemical products through the excess operations function of the SRS Chemical Commodity Management Center, according to *Pollution Prevention—Everybody's Business.*

The pollution prevention and waste minimization programs earned four DOE awards in 1996 (to be presented in 1997) for

- incorporating pollution prevention/waste minimization initiatives into environmental restoration activities
- solid waste recycling
- reduction in the size of contamination areas
- development and use of prefabricated radiological containment huts

Transuranic Waste Management

In 1996, SRS managed more than 10,000 cubic meters of transuranic and mixed transuranic waste, generated by the site's former weapons production mission. An automated vent and purge system safely released combustible gas from stored drums, and portable equipment was used to assay transuranic waste. SRS reduced risk by dewatering, retrieving, inspecting, and repacking transuranic drums and moving them to covered storage pads. The solid waste program is developing strategies to stabilize transuranic waste for disposal at the Waste Isolation Pilot Plant in Carlsbad, New Mexico.

Solvent Storage Tank Closures

On October 25, 1996, a week ahead of schedule, approximately 40,000 pounds of solvent were removed from two tanks at SRS's old burial ground complex and transferred by cask to new double-lined tanks at the Consolidated Incineration Facility.

To further reduce risk at the complex, a closure plan submitted to SCDHEC in 1996 authorized a complete cleanup of the solvent tank storage site, and the process of filling the two tanks with grout began. Final plans call for turning the site over to the Environmental Restoration Division for capping. The site then will become a part of the Low Level Radioactive Waste Disposal Facility, which is expected to be closed in 1999.

Vendor Partnerships

In 1996, SRS continued to implement various waste stream treatments developed from the 1994 Supplier Environmental and Waste Management Information Exchange with commercial vendors. The ongoing shredding of filter paper take-up rolls prepared mixed waste for incineration at the Consolidated Incineration Facility. The shredding process further reduces the volume of mixed waste, enabling it to fit inside the facility's incineration boxes. The shredding technology was expanded to treat five additional SRS waste streams in 1996. Other demonstrations successfully decontaminated cadmium-coated filter frames and radioactive lead for recycling.

Waste Management Environmental Impact Statement

The Final Waste Management Environmental Impact Statement (EIS) was issued to the public July 28, 1995, and the first of two National Environmental Protection Act (NEPA) Records of Decision was approved September 22, 1995. The second NEPA Record of Decision, originally expected to be issued in 1996, now is targeted for issue in 1997. The EIS

- forecasts the next 30 years of SRS waste management activities
- provides waste generation estimates for various waste streams
- describes treatment, storage, and disposal options available for managing wastes

Consolidated Incineration Facility

Construction of the Consolidated Incineration Facility—completed in 1995—was followed by preparations for a pretrial burn, which was conducted in December 1996. A self assessment was conducted in late 1995 in preparation for an expected readiness verification in 1997. Pending another pretrial burn, the facility is scheduled for startup in 1997; it will incinerate solid and liquid forms of radioactive, hazardous, and mixed wastes and is expected to reduce waste volume at an average ratio of 20 to 1. Ash formed in the rotary kiln will be loaded into drums and solidified with concrete into a waste form called "ashcrete," which will be disposed of in onsite waste disposal facilities.

High-Level Waste Management

"High-level waste" is highly radioactive waste material that results primarily from the reprocessing of spent nuclear fuel. It contains liquid waste produced directly in reprocessing, any solid waste derived from that liquid, and both transuranic waste and fission products in concentrations requiring permanent isolation from the environment.

High-level waste from the F-Area and H-Area canyons is segregated according to radionuclide and

heat content. High-heat waste, generated primarily during the first extraction cycle in SRS's Separations canyons, contains a major portion of the radioactivity. Low-heat waste is generated primarily from the second and subsequent canyon extraction cycles.

The major waste streams into the F-Area and H-Area tank farms include transfers from the canyons, receipts from the Receiving Basin for Offsite Fuels (RBOF), and a recycle stream from the Defense Waste Processing Facility (DWPF).

SRS continues to manage approximately 34 million gallons of high-level liquid radioactive waste (about 496 million curies); this waste is stored in 51 massive storage tanks grouped into two "tank farms." Twenty-nine tanks are located in the H-Area Tank Farm, 22 in the F-Area Tank Farm. All SRS tanks are built of carbon steel inside reinforced concrete containment vaults.

High-Level Waste Facilities

Each tank farm has one operating evaporator system used to concentrate high-level waste received from the canyons. These evaporators reduce the waste to about 25 percent of its original volume. SRS has successfully conducted this dewatering operation in the tank farms since the early 1960s. Since the first evaporator facilities began operation in 1960, approximately 105 million gallons of space have been reclaimed.

Without these evaporator systems, SRS would have required 70 additional waste storage tanks—at $50 million apiece—to store waste produced over the site's lifetime. A new evaporator, the replacement high level waste evaporator, is under construction to enable the tank farms to process future waste loads. This new evaporator will have twice the processing capacity of the existing two evaporators.

The In-Tank Precipitation Facility (ITP) is a volume reduction/pretreatment operation for DWPF. It will process the majority (about 90 percent) of the "liquid salt" waste in tanks, splitting that waste into two distinct streams. The highly radioactive portion, called "precipitate," will go to DWPF for vitrification, while the remainder, called "filtrate" (about 90 percent of the salt waste), will be low-level waste that will be grouted into a solid form at the Saltstone Facility.

Accomplishments

In 1996, SRS continued to effectively manage its high-level waste facilities in support of the integrated high-level waste removal program. DWPF began radioactive operations and had produced 64 canisters of immobilized radioactive waste by the end of the fiscal year. Also, SRS gained regulatory approval of its general closure plan for high-level waste tanks—the first such plan developed and approved in the DOE complex.

Tank Farms

The tank farm evaporators recovered more than 2 million gallons of tank space in 1996 through evaporation of the watery "supernate" that floats atop the sludge in the tanks. The 2–H evaporator system, which recovered more than 1.5 million gallons, set a single-month tank space gain record for SRS in July, creating 338,000 gallons of storage space with an availability of 97 percent during the month. This was accomplished through improved planning and predictive maintenance techniques and by performing routine maintenance during scheduled outages to minimize unplanned outages. An outage of the 2–F evaporator during the summer of 1996 enabled personnel to focus on problem areas and incorporate improvements demonstrated on the 2–H evaporator.

Processing strategies were developed to extend evaporator operations and improve DWPF wastewater processing flexibility. The strategies provide a 9-month contingency for unexpected evaporator outages without impacting DWPF operations by

- selectively choosing the waste streams fed to the 2-H evaporator
- modifying operating parameters for the 2-H evaporator based on tank chemistry and DWPF receipt rates

Actions were completed during the summer of 1996 to activate the interarea line between H-Area and F-Area tank farms. This line will transfer feed to the ITP and provide feed to the 2-F evaporator as part of the integrated waste removal program. Approximately 15,000 gallons of high-level waste material were transferred from F-Area to H-Area during 1996 as part of the project; this culminated several years of preparation of the line for operation.

Waste Tank Closure

SCDHEC and EPA approved SRS's general closure plan for high-level waste tanks—the first in the DOE complex—in July 1996, after public hearings. The plan represents a cooperative effort between Westinghouse Savannah River Company, DOE, and the regulators. All aspects of the SRS program to place high-level waste in an environmentally acceptable form through DWPF, the ITP, and the Saltstone Facility now have been demonstrated.

A plan to close empty waste tanks also was developed in 1996. The tanks are being filled with

grout and a low-release reduction material to ensure that the remaining radioactivity in them cannot contaminate the environment. This program eliminates the need for extensive, high-cost decontamination and/or disassembly of the tanks.

In-Tank Precipitation

Progress was made in 1996 toward understanding and resolving a benzene generation rate problem identified during startup of the ITP in 1995. Excess benzene was successfully removed from the facility, and generation rates were stabilized at lower levels.

A process verification testing safety evaluation developed by the Regulatory Programs group of High-Level Waste Engineering to demonstrate resolution of all safety issues was approved by DOE in October 1996.

DWPF

DWPF personnel began processing radioactive sludge in March 1996 and had poured 64 canisters through the end of the fiscal year, surpassing their goal of 60 canisters. Filling the canisters with sludge culminated a lengthy testing process involving "waste qualification runs" that were completed in November 1995. These runs included the filling of 71 canisters with a high-quality glass form that met all projected quality and environmental requirements to contain SRS's waste. Nonradioactive chemicals were used to simulate the properties of the waste throughout the testing process.

In early 1996, DWPF began its final review before requesting approval to begin radioactive operations: a thorough operational readiness review by a DOE-Headquarters team. This process is similar to Nuclear Regulatory Commission review and licensing at a commercial nuclear facility. The operational readiness review process is an indepth critique of the facility and its processes, along with face-to-face interviews of personnel.

Saltstone Facility

A component of DWPF, the Saltstone Facility plays a vital role in treating and disposing of low-level radioactive salt solutions that are the byproduct of the high-level waste treatment process at SRS.

After the salt solutions are received at the facility, they are mixed with cement, fly ash, and furnace slag to form a grout. The grout then is pumped into a large concrete vault divided into sections, or cells. Here, it cures into a stable form called "saltstone." After it is filled, the vault will be capped with clean grout to isolate it from rain and weathering. Final closure of the vault disposal area will include covering each vault with a clay cap and backfilling it with earth.

Radioactive operations began at the Saltstone Facility in June 1990; through the end of 1996, the facility had processed approximately 2.1 million gallons of salt solutions, creating about 3.4 million gallons of "saltstone."

Public Involvement

One of the hallmarks of all environmental management programs, including DOE's, following the end of the Cold War is the involvement of various stakeholders in environmental management decisions and resulting activities.

Stakeholder involvement in the development of environmental management decisions and subsequent actions is required by law and encouraged by DOE and SRS beyond the bare legal requirements. The SRS credibility-and-trust target initiative encompasses stakeholder involvement in environmental restoration and facilitates the decision-making process while responding to needs, ideas, and concerns of communities and entities impacted by the site.

During 1996, SRS's public involvement program continued to support the SRS Citizens Advisory Board (CAB), an independent group whose members provide recommendations to DOE, EPA, and SCDHEC. Among major issues addressed by the 14 CAB recommendations from 1996 were

- establishment of criteria to close the tank farms by the end of 1996 and the drafting of a closure plan to meet tank farm criteria
- simplification of the waste management programmatic environmental impact statement and elaboration on worker risks for treatment alternatives
- provision of the highest budget priority recommendations on the FY 1998 budget to address the health and safety of workers and the public and to protect the environment
- implementation of a Blue Ribbon Panel Report recommendation for an urgent budget request to treat SRS transuranic waste
- establishment of a preferred alternative, placement of a soil cover over the old Burial Ground, as an interim action
- focus by SRS on the safe and secure interim storage of surplus plutonium
- support of SRS plans to remediate the old F-Area seepage basin for the cleanup of contaminated groundwater

- evaluation of the environmental restoration program for remediation of the highest risks first, and exploration of ways to shorten the remediation—particularly the design phase
- provision of input to the SRS Ten Year Plan in an effort to accelerate elimination of the most urgent site risks
- establishment of an alternative disposal method at the Saltstone Facility
- a January 1997 startup of the Consolidated Incineration Facility
- chemical processing alternatives for spent nuclear fuel
- revisions to enhance the Management Action Plan

The three agencies substantially concurred with all the 1996 recommendations [CAB, 1994–1995].

Attendance at meetings and feedback from stakeholders increased during 1996, and stakeholders provided DOE with more specific recommendations on various SRS activities. The CAB provided information to the public on nuclear material-related issues through educational forums, and meetings were held in a variety of geographic locations to involve stakeholders who had not participated in the past. Other initiatives were implemented to increase public knowledge, including editorials and presentations to civic and governmental organizations.

Chapter 5

Radiological Effluent Monitoring

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THIS chapter describes the Savannah River Site (SRS) radiological effluent monitoring program and summarizes the 1996 effluent monitoring data results. Objectives and rationale for the SRS radiological effluent monitoring program are discussed in chapter 3, "Environmental Program Information."

Radiological effluent monitoring results are a major component in determining compliance with applicable dose standards, which can be found in chapter 7, "Potential Radiation Doses," and in appendix A, "Applicable Guidelines, Standards, and Regulations." Also, SRS management philosophy is that potential exposures to members of the public be kept as far below regulatory standards as is reasonably achievable. This philosophy is known as the "as low as reasonably achievable" (ALARA) concept.

SRS airborne and liquid effluents that potentially contain radionuclides are monitored at their points of discharge by a combination of direct measurement and/or sample extraction and analysis. Radiological Control Operations (RCO) and the Environmental Protection Department's Environmental Monitoring Section (EMS) share most of the radiological effluent monitoring responsibilities. RCO personnel collect and screen air and liquid samples from regulated (radiologically controlled) areas and maintain monitoring equipment on stacks and at some liquid effluent discharge points. EMS personnel collect and analyze most liquid effluent samples. Results of these analyses are compiled and reported in monthly radioactive releases reports.

Of the more than 4,400 radiological effluent samples collected and analyzed during 1996, 17 (0.4 percent) were not collected and/or analyzed because of sampling equipment failure or inadvertent loss of, or damage to, the sample media. The radioactive releases attributed to these samples were accounted for in the annual release totals by using either historical process knowledge or less sensitive on-line monitoring results.

A complete description of the EMS sampling and analytical procedures used for radiological effluent monitoring can be found in sections 1102 and 1103 of the *Savannah River Site Environmental Monitoring Section Plans and Procedures*, WSRC–3Q1–2, Volume 1 (SRS EM Program), which was issued in June 1995. A summary of data results is presented in this chapter; however, more detailed data can be found in *SRS Environmental Data for 1996* (WSRC–TR–97–0077).

Airborne Emissions

Process area discharge stacks that release or have the potential to release radioactive materials are monitored continuously by applicable on-line monitoring (for tritium and noble gases) and/or sampling systems [SRS EM Program, 1995]. Filter paper samples, used to collect radioactive particles, generally are gathered daily and screened initially for radioactivity by RCO personnel. Charcoal canisters, used to collect radioiodines, are gathered weekly. RCO personnel routinely transfer the charcoal canisters and filter paper samples on a weekly basis to EMS sampling personnel for transport to, and analysis in, the EMS laboratories.

Depending on the processes involved, discharge stacks also may be monitored with "real-time" instrumentation by area operations and/or RCO personnel to determine instantaneous and cumulative atmospheric releases to the environment. Tritium is one of the radionuclides monitored with continuous real-time instrumentation.

Description of Monitoring Program

Sample Collection Systems

Sample collection systems vary from facility to facility, depending on the nature of the radionuclides being discharged. Generally, RCO personnel are responsible for ensuring that the sampling systems are maintained and for collecting the filter papers and charcoal filter samples.

The following effluent sampling and monitoring changes were made during 1996:

- Reporting of "forced activity concentrations" was implemented for gamma spectroscopy data processed after January 5. Forced activity concentration values are now quantified for potassium-40, cobalt-60, and cesium-137, whether the values are significant or not, i.e., above or below minimum detectable concentrations. These three radionuclides were selected because of their importance in dose calculations and analytical trending. Also, availability of these data allows for trending of activities below method detection limits. Less-than-detectable data will produce numerical measurements with values below the detection limit and sometimes negative values. All actual values, including negative ones, are included in the statistical analyses. Practices such as assigning a zero, the detection limit value, or some in-between value to the below-detectable data point, or discarding those data points, severely biases the resulting parameter estimates.
- Sampling at several locations that are no longer radiological release points was discontinued. These locations include: 717–C Hot Shop Stack, 230–H Lag Stack, 230–H Process Stack, 299–H Building Stack, 299–H HP Exhaust Hood, and Low Point Drain Tank Stack.
- M-Area Vendor Treatment Facility (in Building 341–8M) was identified as a potential source of radiological air emissions in late 1995; the first sample result from this location was reported in June 1996. Due to sample collection and delivery complications, not all data are available for this location. However, omitted data will be included in the *SRS Environmental Report for 1997.*
- Modification of the C-Area Decontamination Facility air monitoring system began in mid-1996. The release point, "C-Area Decon Facility Stack," was retired in August and will be replaced by three new release points in 1997.
- Effective February 26, and with U.S. Environmental Protection Agency (EPA) approval, use of the 321–M machine room isokinetic sampler, which had been in service since 1994, was discontinued. By May 26, the simpler E.P. 927 sampler (the former 321–M machine room system) was placed back into service.
- Early in 1996, sampling with charcoal canisters used to collect radioiodines was discontinued for reactor air effluent streams because use of this method is not required during reactor shutdown.

Continuous Monitoring Systems

SRS reactor and tritium facilities use real-time instrumentation to determine instantaneous and cumulative atmospheric releases of tritium and noble gas radioisotopes. All other monitored radionuclides are sampled using filter papers, charcoal filters, or other air effluent sampling media.

Laboratory Analysis

EMS provides most of the necessary radioanalytical laboratory services required to conduct the site airborne effluent monitoring program. However, the Savannah River Technology Center (SRTC) environmental laboratory performs iodine-129 and carbon-14 analyses on certain air effluent samples because they have the sensitive instrumentation capable of detecting low levels of these radionuclides.

Effluent Flow Rates

Stack effluent flows generally are determined with hot-wire anemometers, Pitot tubes, or fan capacity calculations. Sample line flow rates usually are determined with in-line rotameters or hot-wire anemometers. Flow rates are used to determine the total quantity of radioactive materials released.

Diffuse and Fugitive Sources

An estimate of radionuclide releases from unmonitored diffuse and fugitive sources also is included in the SRS radioactive release totals. These unmonitored sources include ponds, contaminated land areas, and structures without ventilation—or with ventilation but without well-defined release points. The sources were included in the overall SRS source terms for the first time in 1991, as required by the U.S. Department of Energy (DOE).

Monitoring Results

The total amount of radioactive material released to the environment is quantified by using data obtained from continuously monitored airborne effluent releases points and estimates of diffuse and fugitive sources in conjunction with calculated release estimates of unmonitored radionuclides from the separations areas. These unmonitored radionuclides

are fission product tritium, carbon-14, and isotopes of krypton. These radionuclides cannot be measured in the effluent streams; therefore, the values are calculated on an annual basis. Total SRS atmospheric releases for 1996 are shown by source in table 5–1, page 71.

The data shown in table 5–1 are a major component in the determination of offsite dose estimations from SRS operations. The calculated individual and collective doses from atmospheric releases are presented in chapter 7, as is a comparison of these offsite doses to EPA and DOE dose standards.

For dose calculation purposes, values for unidentified beta- and alpha-emitting radionuclides in airborne releases are summed with the values reported for strontium-89,90 and plutonium-239, respectively. Accounting for the unidentified beta- and alpha-emitting radionuclides in this way, a conservative approach, generates an overestimated dose attributable to releases from SRS because

- strontium-89,90 and plutonium-239 have the highest dose factors among the common beta- and alpha-emitting radionuclides
- a part of the unidentified activity probably is from naturally occurring radionuclides, such as potassium-40 and radon-222 progeny, which have less dose consequence

In 1996, because this methodology was used, unidentified beta-emitting radionuclides accounted for 98 percent of the reported total strontium-89,90 and unidentified alpha-emitting radionuclides accounted for 43 percent of the reported total plutonium-239 (table 5–1).

Tritium in elemental and oxide forms accounts for more than 90 percent of the total radioactivity released to the atmosphere from SRS operations. About 10 percent of the total radioactivity released to the atmosphere is krypton-85 (based on calculated release estimates of unmonitored radionuclides) (table 5–1). As an isotope of hydrogen, tritium acts the same as hydrogen chemically and physically and thus is extremely difficult to remove from air effluent streams. During 1996, about 55,300 Ci (2.05E+15 Bq) of tritium was released from SRS, compared to about 96,700 Ci (3.6E+15 Bq) in 1995.

The amount of tritium (and other atmospheric radionuclides) released has been reduced throughout the history of SRS, with changes in the site's mission and improvements in facilities, processes, and operations. During the early years at SRS, large quantities of tritium were discharged to the atmosphere. The maximum yearly release of 2.4 million Ci (8.9E+16 Bq) of tritium occurred during 1958. From 1987 through 1992, the amount of tritium released from SRS decreased approximately 20 percent per year (figure 5–1). In 1993, an increase in tritium released was attributed to increased loading and unloading of reservoirs in the tritium facilities. The 43-percent decrease in the amount of tritium released in 1996—compared to 1995—is attributed to (1) reduced throughput in the tritium facilities, (2) reduced maintenance and layup activities in the reactor facilities, and (3) continued improvements in Replacement Tritium Facility (RTF) operation.

Comparison of Average Concentrations in Airborne Emissions to DOE Derived Concentration Guides

Average concentrations of radionuclides in airborne emissions are calculated by dividing the yearly release total of each radionuclide from each stack by the yearly stack flow quantities. These average concentrations then can be compared to the DOE derived concentration guides (DCGs), which are found in DOE Order 5400.5, "Radiation Protection of the Public and the Environment," for each radionuclide.

DCGs are used as reference concentrations for conducting environmental protection programs at all DOE sites. Based on a 100-mrem exposure, DCGs are applicable at the point of discharge (prior to dilution or dispersion) under conditions of continuous exposure (assumed to be an average inhalation rate of 8,400 cubic meters per year). This means that the DOE DCGs are based on the highly conservative assumption that a member of the public has direct access to—and continuously breathes, or is immersed in—the actual air effluent 24 hours a day, 365 days a year. However, because of the distance between most SRS operating facilities and the site boundary, and because the wind rose at SRS shows no strong prevalence (chapter 7), this scenario is improbable.

Average annual radionuclide concentrations in SRS air effluents can be referenced to DOE DCGs as a screening method to determine if existing effluent treatment systems are proper and effective.

Most of the SRS radiological stacks/facilities release small quantities of radionuclides at concentrations below the DOE DCGs [SRS Data, 1997]. However, certain radionuclides—such as (1) tritium (in the oxide form) from the heavy water rework facilities, the reactor facilities, and the tritium facilities, and (2) plutonium isotopes from the F-Area and H-Area separations facilities—were emitted at concentration levels above the DCGs. Because of the extreme difficulty involved in removing tritium and because

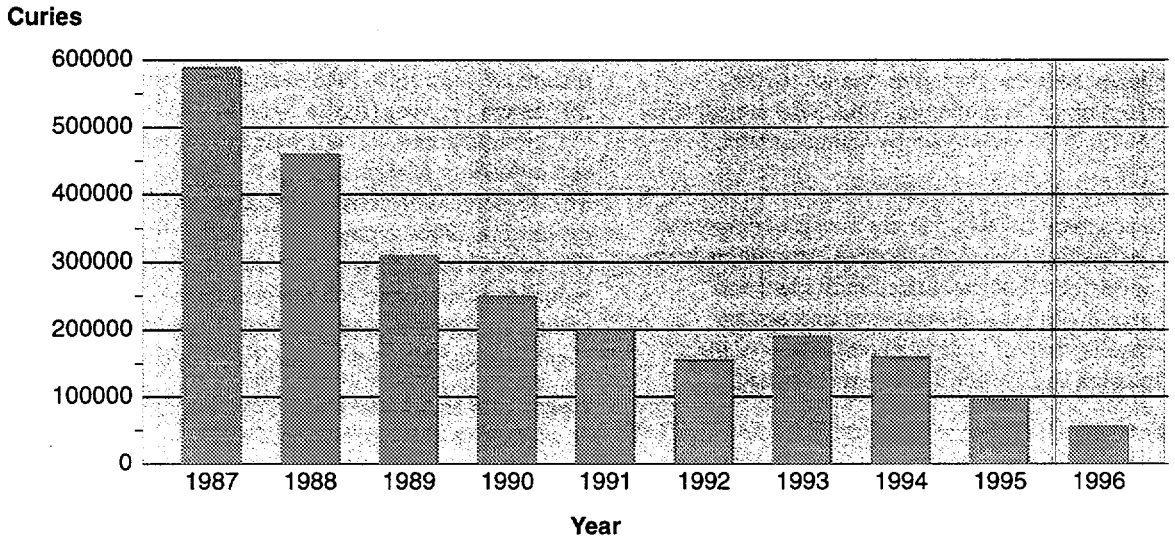


Figure 5–1 SRS Annual Atmospheric Tritium Releases, 1987–1996

of current facility designs, site missions, and operational considerations, this situation is unavoidable. However, the dose consequences from all SRS atmospheric releases during 1996 were 0.5 percent of the DOE and EPA annual atmospheric pathway dose standard of 10 mrem (0.1 mSv) (chapter 7).

Liquid Discharges

Each process area liquid effluent discharge point that releases or has potential to release radioactive materials is sampled routinely and analyzed for radioactivity [SRS EM Program, 1995]. The radiological liquid effluent sampling locations at SRS are shown, along with the surface water surveillance sampling locations, in chapter 6, "Radiological Environmental Surveillance" (page 81, figure 6–3).

Site streams also are sampled upstream and downstream of seepage basins to obtain data to calculate the amount of radioactivity migrating from the basins. These results are important in calculating the total amount of radioactivity released to the Savannah River as a result of SRS operations.

Description of Monitoring Program

Sample Collection Systems

Liquid effluents are sampled continuously at, or very near, their points of discharge to the receiving streams. Three primary systems are used—paddlewheel samplers, Brailsford motor pumps, and Isco samplers. EMS personnel normally collect the liquid effluent samples weekly and transport them to the EMS laboratory for analysis.

The following effluent sampling and monitoring changes were made during 1996:

- Sampling at the H–004 location (for the purpose of radiological effluent monitoring) began in January 1996 to obtain baseline data before startup of the Consolidated Incinerator Facility (CIF). This sampling location will be the official point–of–discharge for CIF liquid discharges when this facility becomes operational.
- Sampling at the K–008 outfall location, which is no longer a radiological release point, was discontinued.
- Liquid discharge sampling schedules were revised as a result of Rock Hill Initiative #2 (described in chapter 3, page 46), which involved a comprehensive evaluation of site environmental programs with the objectives of ceasing unnecessary monitoring and reducing programmatic costs. Samples will continue to be collected at effluent monitoring locations weekly, while samples will be collected at surveillance locations biweekly.

Continuous Monitoring Systems

Depending on the processes involved, liquid effluents also may be monitored by area operations and/or RCO personnel with real-time instrumentation to ensure that instantaneous releases stay within established limits. However, because of

instrumentation detection capabilities, on-line monitoring systems are not used to quantify liquid radioactive releases from SRS.

Laboratory Analysis

EMS provides most of the necessary radioanalytical laboratory services required to conduct the site liquid effluent monitoring program. However, specific low-level analyses for iodine-129 and technetium-99 are performed by SRTC environmental laboratory personnel.

Flow Rate Measurements

Liquid effluent flows generally are determined by one of four methods: U.S. Geological Survey (USGS) flow stations, stream velocity measurements, Isco sampler flow meters, or pump capacity calculations. Effluent flow rates are used to determine the total radioactivity released.

Monitoring Results

Data from continuously monitored liquid effluent discharge points are used in conjunction with site seepage basin and Solid Waste Disposal Facility (SWDF) migration release estimates to quantify the total radioactive material released to the Savannah River from SRS operations. SRS liquid radioactive releases for 1996 are shown by source in table 5–2, page 73.

The data shown in this table are a major component in the determination of offsite dose consequences from SRS operations. The calculated individual and collective doses from site liquid releases are presented in chapter 7, as is a comparison of these offsite doses to EPA and DOE dose standards.

For dose calculation purposes, values for unidentified beta- and alpha-emitting radionuclides in liquid discharges are summed with the values reported for strontium-89,90 and plutonium-239, respectively. Accounting for the unidentified beta- and alpha-emitting radionuclides in this way, a conservative approach, generates an overestimated dose attributable to releases from SRS because

- strontium-89,90 and plutonium-239 have the highest dose factors among the common beta- and alpha-emitting radionuclides
- a part of the unidentified activity probably is from naturally occurring radionuclides, such as potassium-40 and radon-222 progeny, which have less dose consequence

In 1996, because this methodology was used, unidentified beta-emitting radionuclides accounted for 60 percent of the reported total strontium-89,90 and unidentified alpha-emitting radionuclides accounted for 99 percent of the reported total plutonium-239 (table 5–2).

As with airborne releases, strontium-90 and plutonium-239 have the highest dose factors of the common beta- and alpha-emitting radionuclides found in liquid releases. Therefore, summing the unidentified beta and alpha emissions this way maintains conservatism of the highest dose being represented. In addition, some of the unidentified beta and alpha activity probably originates from naturally occurring radionuclides, such as potassium-40 and radon-222 progeny. This also adds a degree of conservatism to the dose calculations.

Tritium constitutes more than 99 percent of the radioactivity released to the Savannah River from site streams. Tritium reaches site streams as a result of direct discharges from facilities and from groundwater migration beneath seepage basins and SWDF. In 1996, about 7,560 Ci (2.80E+14 Bq) of tritium was released in liquid discharges from SRS, based on point-of-release concentrations and flow rates, compared to about 9,900 Ci (3.7E+14 Bq) in 1995 [SRS Data, 1997]. SRS tritium transport data for 1960–1996 are summarized in chapter 6 (page 86, figure 6–5). For conservatism, the slightly higher SRS river transport value of 8,950 Ci (3.31E+14 bq) was used for dose calculations and is discussed in chapter 7.

Direct Discharges of Liquid Effluents

As discussed previously, tritium is the major radionuclide released in SRS liquid effluents. The total amount of tritium released directly from process areas (i.e., reactor, separations, heavy water rework) to site streams during 1996 was 949 Ci (3.51E+13 Bq), which was 29 percent less than the 1995 total of 1,340 Ci (5.0E+13 Bq). The heavy water rework area (400–D) releases decreased 71 percent, from 628 Ci in 1995 to 183 Ci in 1996. In the reactor area (P-Area, L-Area, K-Area, and C-Area), releases decreased 19 percent (542 Ci in 1995; 437 Ci in 1996), while in the separations area, releases increased by about 96 percent (168 Ci in 1995; 329 Ci in 1996).

Direct releases of tritium to site streams for the years 1988–1996 are shown in figure 5–2.

Comparison of Average Concentrations in Liquid Releases to DOE Derived Concentration Guides

In addition to dose standards, DOE Order 5400.5 imposes other control considerations on liquid

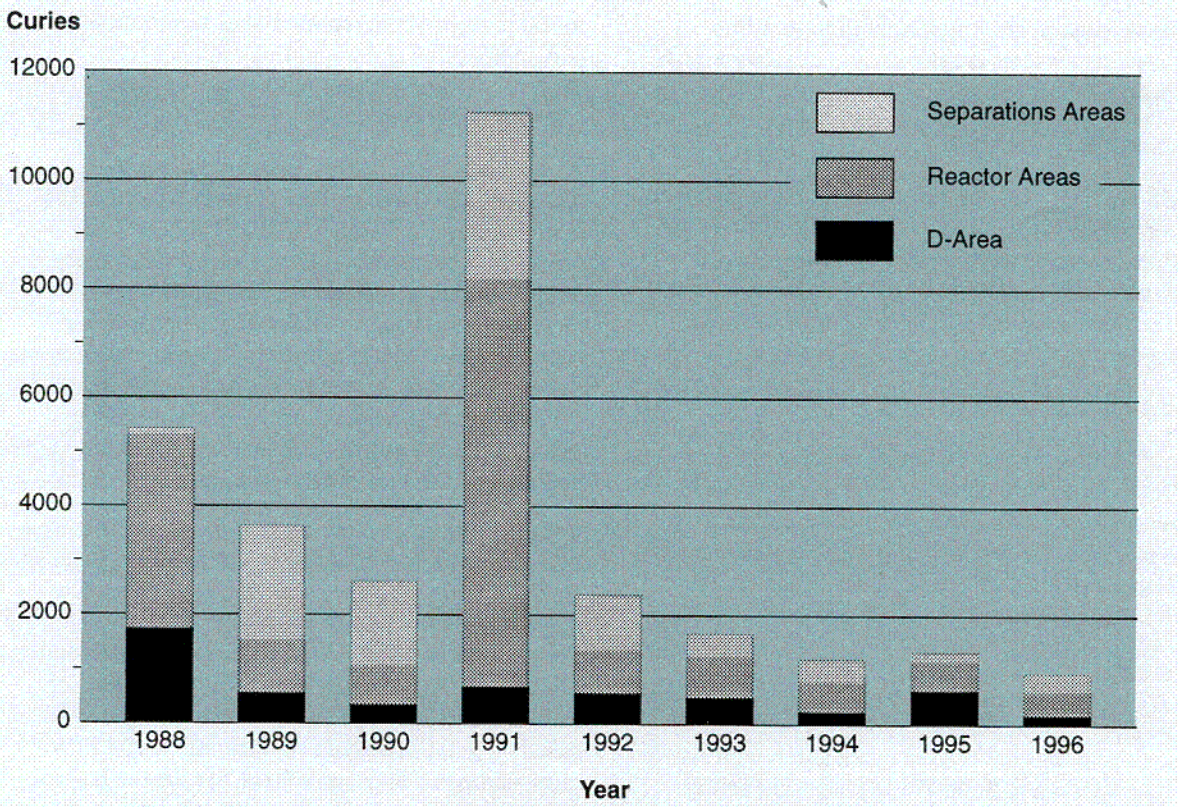


Figure 5–2 Direct Releases of Tritium to SRS Streams, 1988–1996
The 1991 total includes an accidental release in December of 5,700 Ci from K-Reactor.

releases. These considerations are applicable to direct discharges but not to seepage basin and SWDF migration discharges. The DOE order lists DCG values for most radionuclides. DCGs are used as reference concentrations for conducting environmental protection programs at all DOE sites. These DCG values are not release limits but screening values for "best available technology" investigations and for determining whether existing effluent treatment systems are proper and effective.

According to DOE Order 5400.5, exceedance of the DCGs at any discharge point may require an investigation of "best available technology" waste treatment for the liquid effluents. Tritium in liquid effluents is specifically excluded from "best available technology" requirements; however, it is not excluded from other ALARA considerations. DOE DCG compliance is demonstrated when the sum of the fractional DCG values for all radionuclides detectable in the effluent is less than 1.00, based on consecutive 12-month average concentrations.

DCGs, based on a 100-mrem exposure, are applicable at the point of discharge from the effluent conduit to the environment (prior to dilution or dispersion). They are based on the highly conservative assumption that a member of the public has continuous direct access to the actual liquid effluent and consumes 2 liters of the effluent every day, 365 days a year. However, because of security controls and the distance between most SRS operating facilities and the site boundary, this scenario is improbable.

For each site facility that releases radioactivity, EMS compares the monthly liquid effluent concentrations and 12-month average concentrations against the DOE DCGs. The 1996 liquid effluent 12-month average concentrations, their comparisons against the DOE DCGs, and the quantities of radionuclides released are provided, by discharge point, in *SRS Environmental Data for 1996*.

The data show that the U3R–2A ETF outfall at the Road C discharge point exceeded the DCG guide for 12-month average tritium concentrations during 1996. However, as noted previously, DOE Order 5400.5 specifically exempts tritium from "best available technology" waste treatment investigation requirements. This is because there is no practical

C02

technology available for removing tritium from dilute liquid waste streams. In 1992, in consideration of ALARA principles for tritium discharges and while reviewing, analyzing, and modifying the process for controlling liquid releases of radioactive effluents, SRS identified several options and alternatives to continuing with these discharges at the U3R–2A ETF outfall. None of these alternatives was considered viable on a cost/benefit basis. No other discharge points exceeded the DOE DCGs in 1996.

Seepage Basin and SWDF Migration Results

To incorporate the migration of radioactivity to site streams into total radioactive release quantities, EMS monitors and quantifies the migration of radioactivity from site seepage basins and the SWDF. During 1996, tritium, strontium-89,90, and iodine-129 were detected in migration releases [SRS Data, 1997].

Figure 5–3 is a graphical representation of releases of tritium via migration to site streams for the years 1988–1996. During 1996, the total quantity of tritium migrating from the seepage basins and SWDF was about 6,610 Ci (2.45E+14 Bq), compared to 8,560 Ci (3.2E+14 Bq) in 1995.

Figure 5–4 shows 1988–1996 total combined tritium releases from direct discharges and seepage basin and SWDF migration.

Migration of Radioactivity from the K-Area Drain Field and Seepage Basin Liquid purges from the K-Area disassembly basin were released to the K-Area seepage basin in 1959 and 1960. Since 1960, purges from the K-Area disassembly basin have been discharged to a percolation field below the K-Area retention basin. A total tritium migration of 1,290 Ci (4.77E+13 Bq) was calculated from weekly flow measurements and tritium concentrations measured in Indian Grave Branch (a tributary of Pen Branch) during 1996. The sample location used—beginning in 1995—to determine tritium migration from the K-Area seepage basin was changed to K–018 because stream flow is more easily measured there than at IGB–21, which has a lower flow rate. The 1996 migration total represents a 22-percent increase from the 1650 Ci (6.1E+13 Bq) recorded in 1995.

Migration of Radioactivity from F-Area and H-Area Seepage Basins Although seepage basins in F-Area and H-Area no longer are used, radioactivity previously deposited in them continues to migrate via

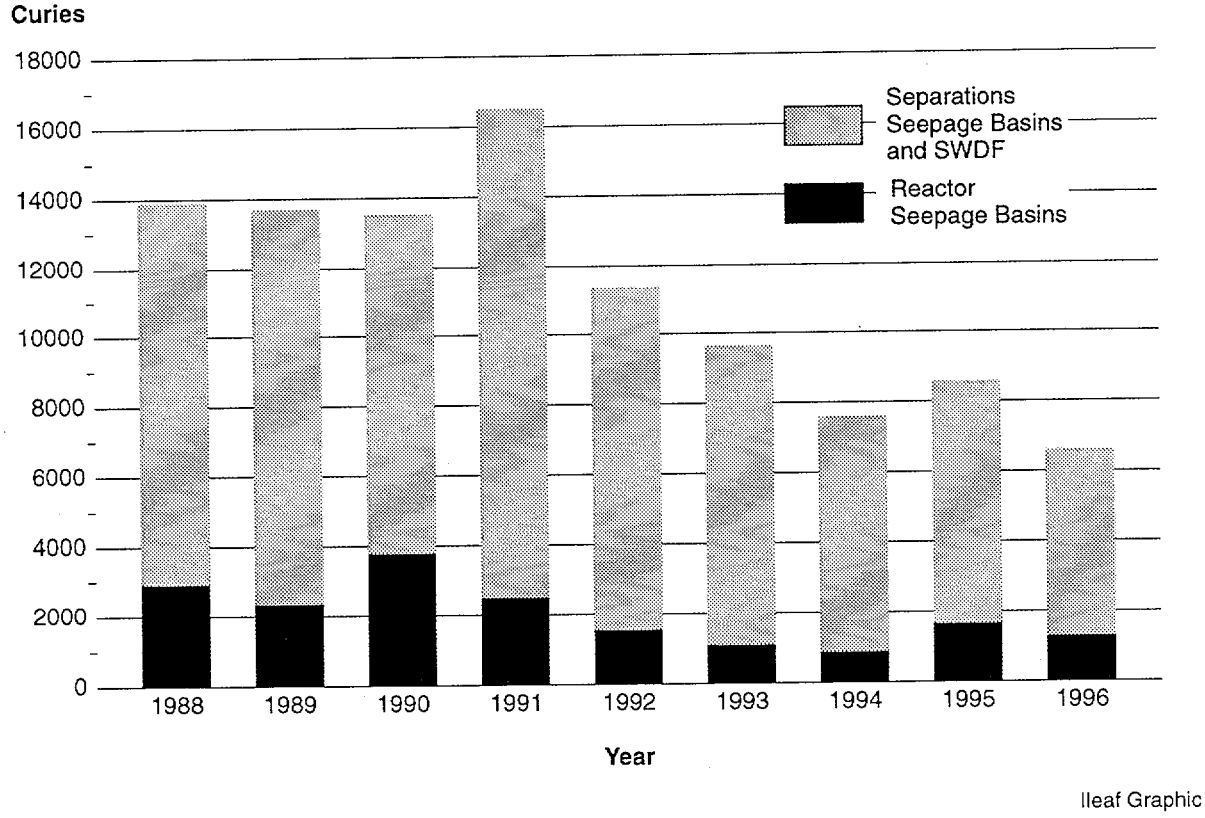
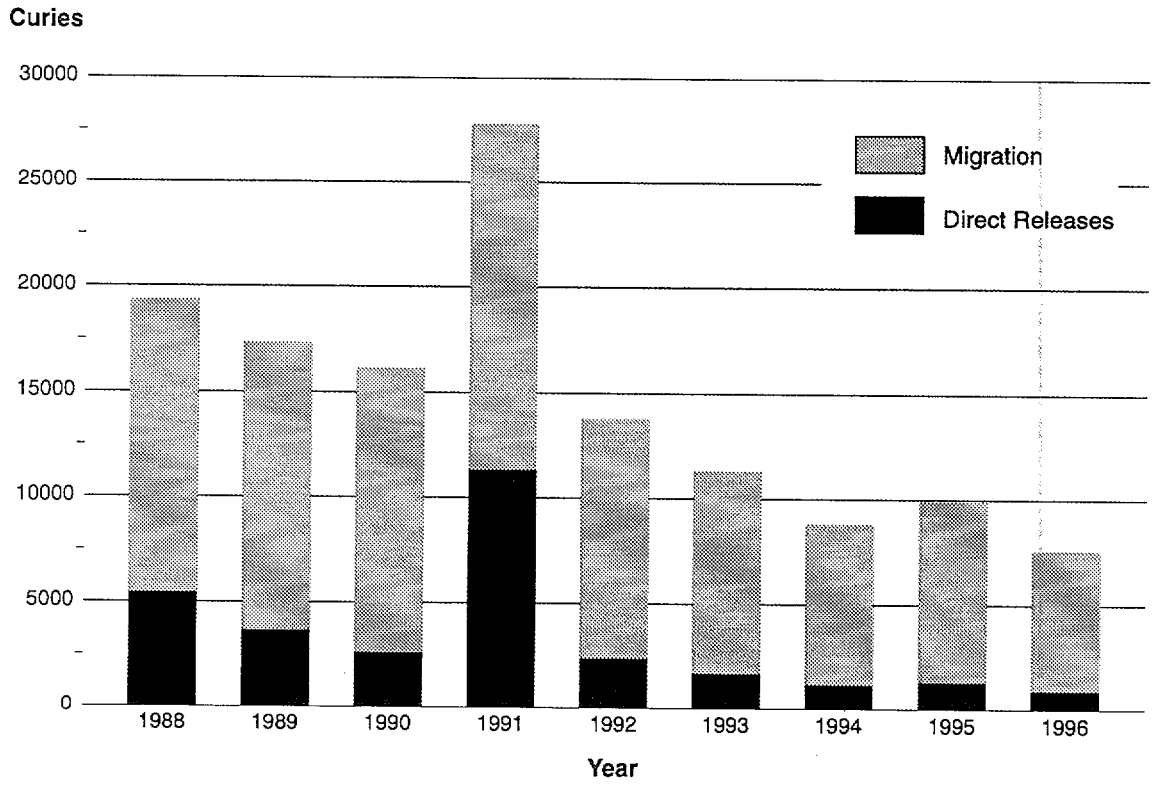


Figure 5–3 Tritium Migration from Seepage Basins and SWDF to SRS Streams, 1988–1996



Ileaf Graphic

Figure 5–4 Total Tritium Releases to SRS Streams (Direct Discharges and Migration), 1988–1996

the groundwater and to outcrop into Four Mile Creek. (also known as Fourmile Branch).

Migration of radioactivity from F-Area and H-Area seepage basins is measured with continuous samplers and flow recorders in Four Mile Creek. Groundwater from the F-Area seepage basins enters Four Mile Creek between sampling locations FM–3A, FM–2B, and FM–A7. Four Mile Creek sampling locations are shown in chapter 6, (page 81, figure 6–3).

Most of the outcropping from H-Area seepage basins 1, 2, and 3 occurs between FM–1C and FM–2B. Outcropping from H-Area seepage basin 4 and SWDF occurs between FM–3 and FM–3A. Radioactivity from H-Area seepage basin 4 and SWDF mixes during groundwater migration to Four Mile Creek. Therefore, radioactivity from the two sources cannot be distinguished at the outcrop point.

Measured migration of tritium from F-Area seepage basins was 1,620 Ci (5.99E+13 Bq) in 1996. This is nearly a 32 percent decrease from the 1995 total of 2,370 Ci (8.8E+13 Bq). The measured migration from H-Area seepage basin 4 and SWDF was 3,200 Ci (1.18E+14 Bq), a 20-percent decrease from the 1995 total of 4,010 Ci (1.5E+14 Bq). The measured migration from H-Area seepage basins 1, 2, and 3 was 505 Ci (1.87E+13 Bq), a 4-percent decrease from the 1995 total of 528 Ci (2.0E+13 Bq) [SRS Data, 1997].

Past, current, and computer model-projected tritium migration releases from F-Area and H-Area seepage basins and SWDF are shown in figure 5–5. Generally, and as the data show, tritium migration from the F-Area and H-Area seepage basins, which were closed in 1988, has been declining and is projected to continue to decline. However, tritium migration from SWDF has remained relatively stable during the past 10 years. Furthermore, based on the operational history of SWDF and the geology and hydrology of the site, it is anticipated that, with no corrective actions, SWDF tritium migration to Four Mile Creek is expected to remain at about 4,500 Ci (1.7E+14 Bq) per year for at least the next 10 to 20 years [Looney et al, 1993].

As required by the Resource Conservation and Recovery Act (RCRA) Part B Permit, SRS is developing SWDF groundwater corrective action plans for South Carolina Department of Health and Environmental Control (SCDHEC) approval. Portions of SWDF also are regulated under the

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). CERCLA characterization and assessment continued in 1996. Reduction of tritium migration releases is one of the factors being considered during the development of these RCRA/CERCLA groundwater corrective action plans. Low-permeability caps, waste form stabilization, groundwater barriers, groundwater pump-treat-reinjection, and other technologies are under consideration as relevant components of SWDF remediation.

The amount of strontium-89,90 entering Four Mile Creek during 1996 was estimated to be 68 mCi (2.52E+09 Bq) from the F-Area seepage basins. This was a 39-percent decrease from the 1995 level of 111 mCi (4.11E+09 Bq). In addition, 31 mCi (1.15E+09 Bq) of strontium-89,90 was estimated to have migrated from the H-Area seepage basins. This was a 22-percent decrease from the 1995 level of 40 mCi (1.5E+09 Bq) [SRS Data, 1997]. Like tritium migration, strontium migration is expected to continue to decline from these closed seepage basins.

In addition, a total of 78 mCi (2.89E+09 Bq) of iodine-129 and 47 mCi (1.74E+09 Bq) of cesium-137 migrated from the F-Area and H-Area seepage basins and from SWDF in 1996.

Because of the low dose consequence and radioanalytical difficulties associated with technetium-99, this radionuclide cannot be detected—using common radioanalytical methods—in dilute streams. Measurement for this radionuclide, which was begun in 1994, was discontinued in 1996.

Migration of Radioactivity from P-Area, C-Area, and L-Area Seepage Basins Liquid purges from the P-Area, L-Area, and C-Area disassembly basins have been released periodically to their respective seepage basins since 1978. Purge water is released to the seepage basins to allow a significant part of the tritium to decay before the water outcrops to surface streams and flows into the Savannah River. The delaying action of the basins reduces the dose that users of water from downriver water treatment plants receive from SRS tritium releases. The seepage basins were used for purging the disassembly basins from the 1950s until 1970, but disassembly basin purge water was released directly to SRS streams between 1970 and 1978. The earlier experience with

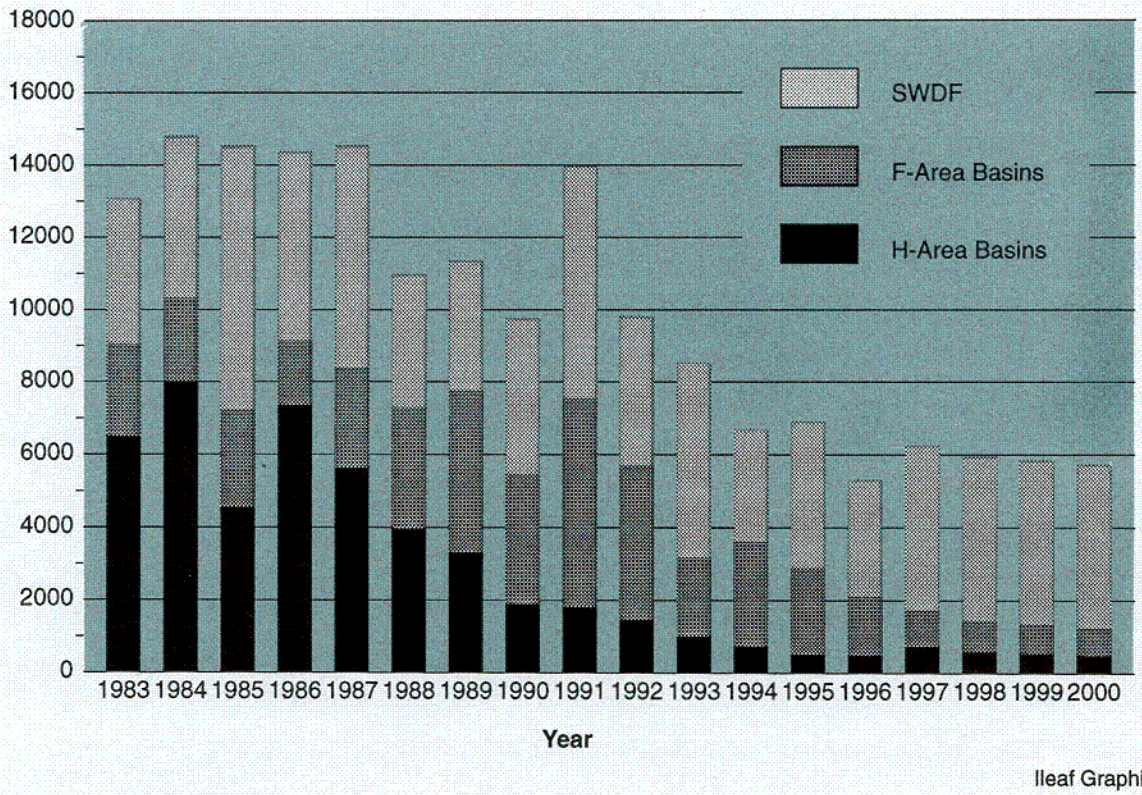


Figure 5–5 Past, Current, and Projected Tritium Migration Releases to Four Mile Creek from the F-Area and H-Area Seepage Basins and SWDF

C03

seepage basins indicated that the extent of radioactive decay during the holdup was sufficient to recommend that the basins be used again in P-Area, L-Area, and C-Area. However, no purges to the basins occurred during 1996.

No radionuclide migration was attributed to the C-Area seepage basin in 1996. The failure of the Twin Lakes Dam in 1991 made the determination of migration more difficult in this area. Results from a sampler installed on Steel Creek above L-Lake indicated that 320 Ci (1.18E+13 Bq) of tritium migrated from the P-Area seepage basin during 1996, slightly less than the 355 Ci (1.3E+13 Bq) of tritium in 1995 [SRS Data, 1997]. No migration of radionuclides from the L-Area seepage basin was detected in site streams.

Transport of Actinides in Streams

In 1996, a new and more sensitive actinide method was implemented for the analysis of uranium, plutonium, americium, and curium. As a result of the increased sensitivity, trace amounts of uranium and plutonium were detected at the stream transport locations FM–6, PB–3, L3R–2, and U3R–4. Consequently, these small amounts were incorporated into the source term used for the calculation of the annual dose.

Settleable Solids

In 1996, the settleable solids program was incorporated into the radiological environmental surveillance program for sediments. This was done to provide a more reliable and cost-effective method for determining the buildup of radioactivity in sediments. Eight additional sample sites were added to the sediment program to compensate for the loss of the settleable solids sampling program. Additional information on the sediment sampling program can be found in chapter 6.

Table 5–1
Radioactive Atmospheric Releases by Source

Radio-nuclide	Half-life	Curies[a]						
		Reactors	Separa-tions[b]	Reactor Materials	Heavy Water	SRTC[c]	Diffuse and Fugitive[d]	Total
Notes:	*Blank spaces indicate no quantifiable activity; h = hour, d = day, y = year*							
	GASES AND VAPORS							
H-3 (oxide)	12.3 y	1.10E+04	2.85E+04		3.29E+02		2.23E+02	4.01E+04
H-3 (elem)	12.3 y		1.51E+04					1.51E+04
H-3 Total	12.3 y	1.10E+04	4.37E+04		3.29E+02		2.23E+02	5.53E+04
C-14	5.73E3 y		8.11E+00				5.88E–09	8.11E+00
Kr-85	10.73 y		5.47E+03					5.47E+03
I-129	1.57E7 y		1.04E–02				3.83E–06	1.04E–02
I-131	8.040 d		5.74E–05			2.98E–05		8.72E–05
I-133	20.8 h					5.94E–04		5.94E–04
Xe-135	9.10 h					1.20E–03		1.20E–03
	PARTICULATES							
Co-57	271.8 d		5.76E–09					5.76E–09
Co-60	5.271 y		3.85E–07			8.55E–06	4.71E–07	9.41E–06
Ni-59	7.6E4 y						2.51E–08	2.51E–08
Zn-65	243.8 d						1.46E–16	1.46E–16
Se-79	6.5E4 y						2.47E–08	2.47E–08
Sr-90[e,f]	29.1 y	1.05E–03	1.46E–03	4.04E–05	9.48E–05	g	4.75E–04	3.12E–03
Zr-95	64.02 d						2.13E–05	2.13E–05
Nb-95	34.97 d						1.55E–15	1.55E–15
Tc-99	2.13E5 y						2.65E–08	2.65E–08
Ru-106	1.020 y		9.18E-07				7.00E–02	7.00E–02
Sn-126	1E5 y						6.79E–09	6.79E–09
Sb-125	2.758 y		2.61E–07				2.28E–04	2.28E–04
Cs-134	2.065 y		1.97E–07				2.49E–15	1.97E–07
Cs-137	30.17 y	1.76E–05	4.82E–04	3.94E–07	1.11E–06	1.22E–06	4.33E–03	4.83E–03
Ce-144	284.6 d		6.77E–07				7.36E–06	8.04E–06
Pm-147	2.623 y						6.75E–06	6.75E–06
Eu-154	8.59 y		1.87E–07				6.42E–06	6.61E–06

a One curie equals 3.7 E+10 Becquerels.
b Includes separations, waste management, and tritium facilities
c Savannah River Technology Center
d Estimated releases from minor unmonitored diffuse and fugitive sources
e Includes unidentified beta emissions
f Includes Sr-89
g No unidentified emissions

Table 5–1
Radioactive Atmospheric Releases by Source

Radio-nuclide	Half-life	Curies[a]						
		Reactors	Separa-tions[b]	Reactor Materials	Heavy Water	SRTC[c]	Diffuse and Fugitive[d]	Total
Eu-155	4.71 y		8.33E–07				1.66E–06	1.66E–06
Th-232	1.40E10 y						1.28E–08	1.28E–08
Pa-231	3.28E4 y						1.00E–09	1.00E–09
U-233	1.592E5 y						1.62E–08	1.62E–08
U–234	2.46E5 y		2.44E–04	6.81E–06			2.93E–07	2.51E–04
U–235	7.04E8 y		4.67E–05	1.06E–06			4.10E–05	8.88E–04
U–236	2.342E7 y						5.79E–08	5.79E–08
U–238	4.47E9 y		1.37E–03	1.09E–06			1.35E–06	1.37E–03
Np-237	2.14E6 y						4.66E–08	4.66E–08
Np-239	2.35 d						2.17E–07	2.17E–07
Pu-238	87.7 y		4.79E–04	2.23E–09			5.19E–06	4.84E–04
Pu-239[e]	2.410E4 y	6.74E–05	2.65E–04	2.78E–05	6.39E–06	6.67E–06	1.83E–04	5.57E–04
Pu-240	6.56E3 y						2.11E–07	2.11E–07
Pu-241	14.4 y						3.75E–06	3.75E–06
Am-241	432.7 y		1.27E–05	1.06E–08			4.20E–07	1.31E–05
Am-243	7.37E3 y						1.76E–05	1.76E–05
Cm-242	162.8 d						2.03E–16	2.03E–16
Cm-244	18.1 y		4.47E–06	2.43E–09			1.28E–04	1.32E–04

a One curie equals 3.7 E+10 Becquerels.
b Includes separations, waste management and tritium facilities
c Savannah River Technology Center
d Estimated releases from minor unmonitored diffuse and fugitive sources
e Includes unidentified alpha emissions

Table 5–2
Radioactive Liquid Releases by Source
(Including Direct and Seepage Basin Migration Releases)

Radio-nuclide	Half-life	Curies[a,b] Reactors	Separations[c]	Reactor Materials	Heavy Water/TNX	Savannah River Technology Center	Total
Notes:	*Blank spaces indicate no quantifiable activity; h = hour, d = day, y = year*						
H-3 (oxide)	12.3 y	2.73E+03	5.81E+03		1.83E+02	8.78E–01	8.95E+03[d]
Sr-90[e,f]	29.1 y	1.35E–01	1.21E–01	[g]	5.38E–03	9.31E–04	2.62E–01
I-129	1.6E7 y		7.82E–02				7.82E–02
Cs-137	30.2 y	2.30E–02	9.35E–02				1.17E–01[h]
Pm-147	2.6 y		4.80E–04				4.80E–04
U-234	2.46E5 y	1.19E–03	6.90E–03	3.55E–05	7.45E–07	5.06E–05	8.18E–03
U-235	7.04E8 y	1.81E–05	2.08E–04			1.43E–06	2.28E–04
U-238	4.47E9 y	8.21E–04	9.59E–03	5.83E–05	1.75E–06	5.00E–05	1.05E–02
Pu-238	87.7 y	1.36E–04	2.61E–03	4.01E–05	1.97E–06	6.71E–06	2.79E–03
Pu-239[i]	2.410E4 y	1.07E–02	1.52E–02	[g]	4.19E–04	3.41E–04	2.67E–02
Am-241	432.7 y		4.03E–06	6.72E–05			7.12E–05
Cm-244	18.1 y		6.23E–07	1.19E–05			1.25E–05

a One curie equals 3.7E+10 Becquerels.
b Blank spaces indicate no quantifiable activity.
c Includes separations, waste management, and tritium facilities
d For conservatism, the slightly higher river transport number (8.95E+03 Ci) was used for dose calculations.
e Includes unidentified beta
f Includes Sr-89
g No quantifiable unidentified releases
h For conservatism, the higher release number (1.55E–01 Ci), calculated from River Mile 120 fish concentrations, was used for dose calculations (chapter 7, "Potential Radiation Doses").
i Includes unidentified alpha

Chapter 6

Radiological Environmental Surveillance

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Environmental Protection Department

To Read About . . . **See Page . . .**

THE Savannah River Site (SRS) radiological environmental surveillance program is designed to survey and quantify any effects that routine and nonroutine operations might have on the site and on the surrounding area and population. The program represented an extensive network in 1996 that covered approximately 2,000 square miles and extended up to 25 miles from the site. In conjunction with the radiological effluent monitoring program (chapter 5, "Radiological Effluent Monitoring"), the program enables SRS to monitor ambient radiological conditions and determine site contributions of radioactive materials to the environment.

Routine Radiological surveillance activities are performed by the Environmental Protection Department's Environmental Monitoring Section (EMS) and by the Savannah River Technology Center (SRTC). The Savannah River also is monitored by other groups, including the South Carolina Department of Health and Environmental Control (SCDHEC) and the Georgia Department of Natural Resources (GDNR).

As part of the radiological surveillance program, routine surveillance of all radiation exposure pathways (ingestion, inhalation, immersion, and submersion) is performed on all environmental media that may lead to a measurable annual dose at the site boundary. This chapter summarizes surveillance results of the atmosphere (air and rainwater), surface water (seepage basins, site streams, and the Savannah River), drinking water, food products (terrestrial and aquatic), wildlife, soil, sediment, and vegetation. Also summarized are results of extensive monitoring of ambient gamma radiation levels performed on site, at the site boundary, and in population centers (surrounding communities). A description of the surveillance program and 1996 results for groundwater can be found in chapter 10, "Groundwater."

All results discussed in this chapter are based on available samples and/or analyses. Because of sampling and/or analytical difficulties, some sample analyses may be missing. Problems may have arisen with sample collection, such as loss of power to the sampling site or inaccessibility to the sampling site (locked gates, flooding, etc.) Results for collected samples can be rejected after analysis for such reasons as insufficient sample volume, low chemical yield, or equipment failure.

The ± value reported with individual results is a counting uncertainty; the ± value reported with averages (means) is a standard deviation. The lower limit of detection (LLD) often varies because of counting times and other factors. Nominal LLDs for the types of analyses being performed on the various environmental surveillance media are presented in tables 6–9 through 6–12, which can be found at the end of this chapter.

In 1996, approximately 10,000 radiological analyses were performed on approximately 5,000 samples (not including groundwater) Analytical results from 1996 appear in *SRS Environmental Data for 1996* (WSRC–TR–97–0077). Information on the rationale for the radiological environmental surveillance program can be found in chapter 3, "Environmental Program Information." Data from earlier years can be found in previous SRS environmental reports and data publications. Document numbers for these can

be found in appendix E, "Environmental Monitoring Reports."

A complete description of the SRS radiological environmental surveillance program can be found in section 1105 of the *Savannah River Site Environmental Monitoring Section Plans and Procedures*, WSRC–3Q1–2, Volume 1 (SRS EM Program). Changes in the site's missions led to a comprehensive review of the radiological surveillance program in 1995. As a result, adjustments were implemented in several parts of the program that year and in 1996—without reducing the overall ability of the program to produce critical information. Details about specific changes are presented in the discussions of the affected program areas.

Air

Description of Surveillance Program

EMS maintains an extensive network of 23 sampling stations in and around SRS to monitor the concentration of radioactive materials in the air. These locations are divided into four subgroups, as follows:

- onsite
- site perimeter
- a control location at 25 miles
- selected major population centers at 25 and 100 miles

Figure 6–1 shows all the sampling locations except the 25- and 100-mile stations.

The air surveillance program helps determine the impact (if any) of site operations on the environment and evaluates trends in airborne radionuclide concentrations. The program also is used to verify atmospheric transport models and to support emergency response activities in the event of an unplanned release of radioactive material to the atmosphere.

Surveillance Results

Chapter 5 details the types and quantity of radioactive material released to the environment from SRS activities in 1996. Except for tritium, specific radionuclides were not routinely detectable at the site perimeter. Both onsite and site perimeter/offsite activity concentrations were similar to levels observed in previous years.

Gross Alpha and Gross Beta

Gross alpha and gross beta activity analyses are performed on glass fiber filter papers. Although they cannot provide concentrations of specific radionuclides, these measurements are useful in providing information for trending of the total activity in an air sample or in screening samples.

A summary of the monitoring results from 1990–1996 is presented in table 6–1. Although both the average gross alpha and average gross beta results are slightly lower than the 1995 results, they are still consistent with historical trends. As observed in previous years, no significant difference was observed between the average concentration measured on site near the operating facilities and the average concentration observed at the site perimeter.

Gamma-Emitting Radionuclides

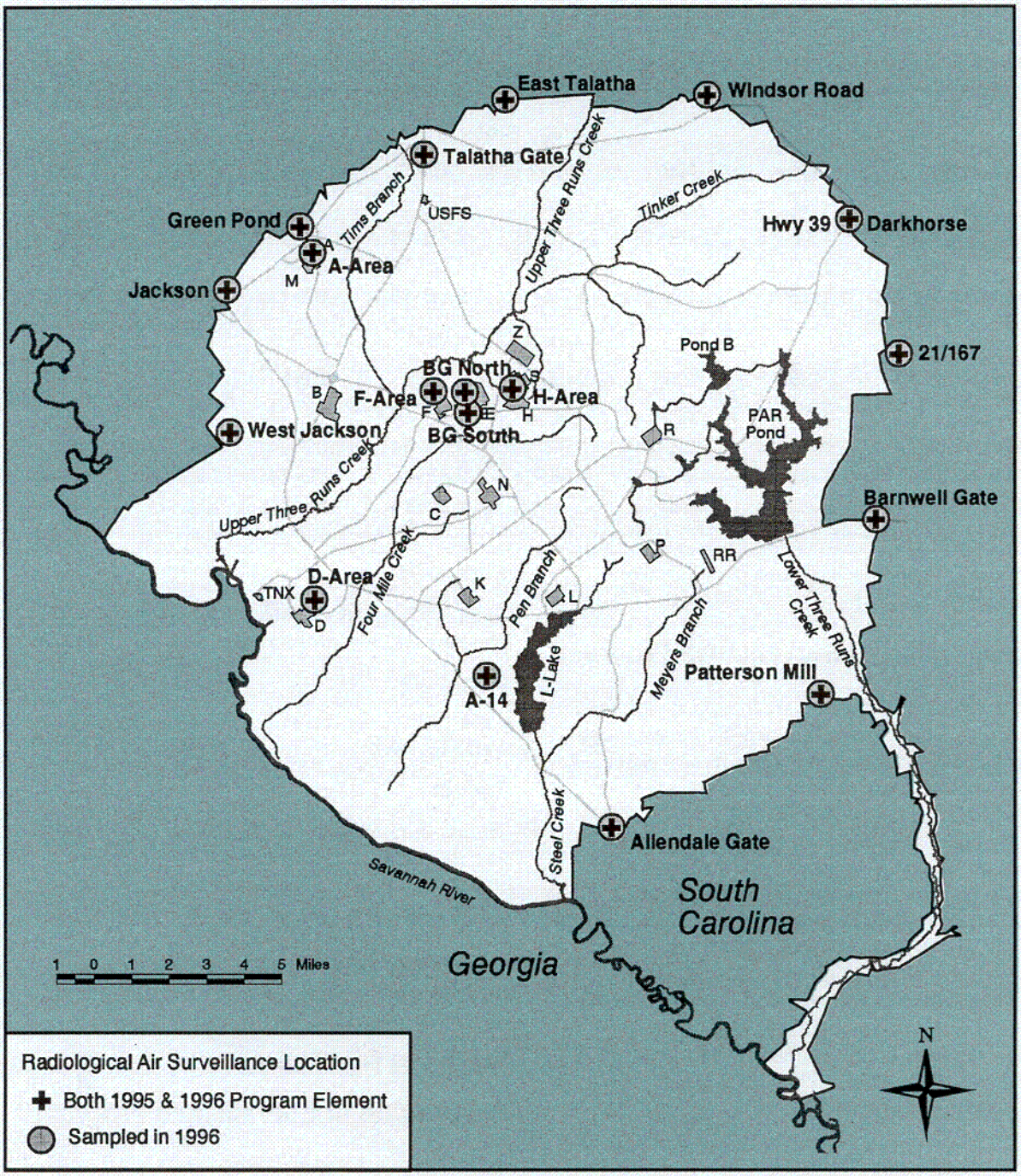
Glass fiber filters and activated charcoal canisters are collected weekly and analyzed for gamma-emitting radionuclides. In 1996, no manmade gamma-emitting radionuclides were observed above the nominal LLD. These results are consistent with historical results, which indicate a small number of samples with detectable activity.

Tritium

Tritium-in-air analyses are conducted on biweekly silica gel samples. Tritium is released as part of routine SRS operations and becomes part of the natural environment. Monitoring assures that it poses no health risk to the surrounding population. Consistent with the SRS source term, tritium concentrations generally decrease with increasing distance from the tritium facilities near the center of the site. In addition, the analytical results agree with the predictions of the SRS transport and dose assessment model, as detailed in Chapter 7, "Potential Radiation Doses."

Plutonium and Strontium

Glass fiber filters are composited either weekly or monthly and analyzed for plutonium isotopes (plutonium-238 and plutonium-239) and total strontium (strontium-89,90). These radionuclides are released in small quantities as part of routine site operations—primarily from the separations areas. The observed concentrations of the radionuclides were similar to historical levels; most locations were near or below the nominal LLD. Likewise, the distribution pattern of the isotopes was similar to that observed in previous years—the concentrations generally were higher near the center of the site, as expected from the source term. The concentrations



EPD/GIS Map

Figure 6–1 Radiological Air Surveillance Stations

The SRS air surveillance program consists of 19 stations located on site or along the site perimeter, as well as (not shown) three stations approximately 25 miles from the site perimeter (located at the Highway 301 Bridge over the Savannah River, the Augusta Lock and Dam, and the Aiken airport) and one approximately 100 miles from the site perimeter (at Savannah, Georgia).

then showed a decrease to background levels or detection limits at the site boundary and beyond.

Rainwater

SRS maintains a network of rainwater sampling sites as part of the air surveillance program. These stations

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Table 6–1
Average Gross Alpha and Gross Beta Measured in Air (μCi/mL), 1990–1996

	Average Gross Alpha						
Locations	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
On site	1.3E–15	2.5E–15	1.8E–15	1.9E–15	1.4E–15	1.5E–15	1.1E–15
Site perimeter	1.1E–15	2.6E–15	1.8E–15	1.8E–15	1.4E–15	1.4E–15	1.0E–15
25-mile radius	1.0E–15	2.5E–15	1.7E–15	1.8E–15	1.4E–15	1.4E–15	1.0E–15
100-mile radius	1.3E–15	2.6E–15	1.7E–15	2.0E–15	1.8E–15	1.6E–15	9.4E–16
	Average Gross Beta						
Locations	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
On site	1.8E–14	1.8E–14	1.9E–14	1.8E–14	1.7E–14	1.8E–14	1.5E–14
Site perimeter	1.8E–14	1.8E–14	1.9E–14	1.9E–14	1.8E–14	1.8E–14	1.5E–14
25-mile radius	1.8E–14	1.8E–14	1.8E–14	1.8E–14	1.8E–14	1.8E–14	1.6E–14
100-mile radius	1.9E–14	1.8E–14	1.7E–14	2.0E–14	1.8E–14	1.8E–14	1.4E–14

are used to measure deposition of radioactive materials.

Description of Surveillance Program

Rainwater collection pans are located at each routine air surveillance station (figure 6–1). Ion-exchange resin columns are placed at 10 of these locations. At each of these locations, rain collected in the pan passes through the column and into a collection bottle. Both the ion-exchange resin column and the collected liquid is returned to the laboratory for analysis. The column is analyzed for gamma-emitting radionuclides, gross alpha, gross beta, plutonium-238, plutonium-239, and strontium-89,90, while the rainwater is analyzed for tritium. At all other locations, the collected rainwater is returned to the laboratory and analyzed for tritium only. Ion-exchange column sampling is performed monthly, while rainwater sampling is performed biweekly.

Surveillance Results

Gamma-Emitting Radionuclides

As in 1995, no detectable manmade gamma-emitting radionuclides were observed.

Gross Alpha and Gross Beta

The gross alpha and gross beta results were consistent with those of 1995; no increasing or decreasing trend was evident. This implies that the observed values are natural background and do not indicate any contribution directly attributable to SRS.

Plutonium

As in 1995, no detectable levels of plutonium-238 or plutonium-239 were observed.

Strontium

As in 1995, no detectable levels of strontium-89,90 were observed.

Tritium

Tritium-in-rain values were highest at those locations near the center of the site and at D-Area. This is consistent with the H-Area and D-Area effluent release points that routinely release tritium. As with tritium in air, concentrations generally decreased as distance from the effluent release point increased (figure 6–2); this observation also is consistent with the source term and with atmospheric transport.

Gamma Radiation

Description of Surveillance Program

Ambient gamma exposure rates in and around SRS are monitored by an extensive network of dosimeters. The site uses the thermoluminescent dosimeter (TLD) to quantify integrated gamma exposure on a quarterly basis. The TLD performs this function accurately, reliably, and relatively inexpensively.

SRS has been monitoring ambient environmental gamma exposure rates with TLDs since 1965. The information provided by this program is used primarily to determine the impact (if any) of site operations on the gamma exposure environment and to evaluate trends in environmental exposure levels. Other potential uses include

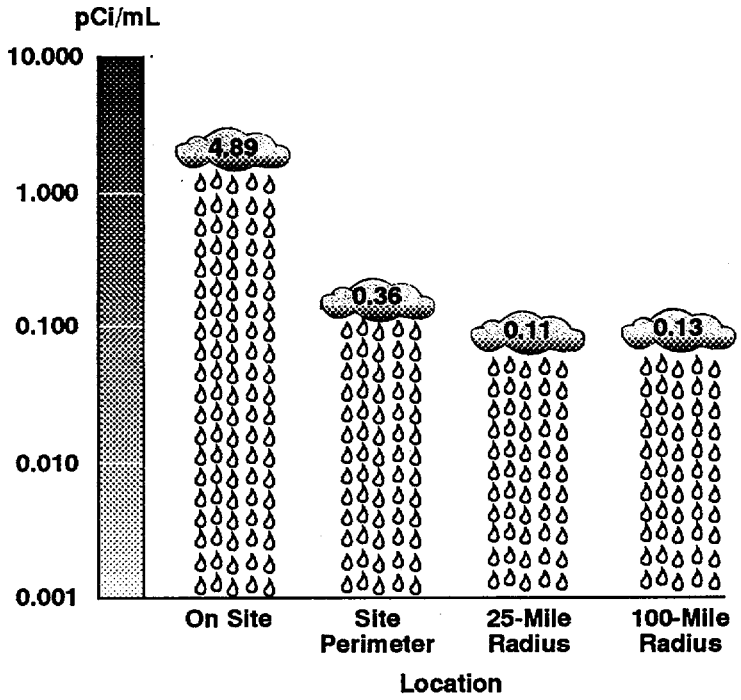

Figure 6–2 Average Concentration of Tritium in Rainwater

Tritium concentrations in rainwater (shown here in pCi/mL), generally decrease as the distance from the site increases.

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- support of routine and emergency response dose calculation models
- assistance in determining protective action recommendations in the event of an unplanned release of gamma-emitting radionuclides
- confirmatory accident assessment

The SRS ambient gamma radiation monitoring program is divided into five subprograms, as follows: onsite operating areas, site perimeter stations, population centers, air surveillance stations, and NRC/Vogtle (stations co-located with Nuclear Regulatory Commission and Georgia Power Company locations that monitor potential exposures from Georgia Power's Vogtle Electric Generating Plant). All TLDs are exchanged quarterly.

A second technical evaluation of the radiological environmental surveillance program—conducted in 1996 because of continuing changes in site missions and as part of an overall comprehensive review of the WSRC environmental monitoring program—resulted in extensive changes to the gamma radiation surveillance program. Most of the changes were implemented in midyear, as 196 of 327 monitoring stations were eliminated (table 6–2).

As a result of these modifications, most gamma exposure monitoring is conducted on site and at the site perimeter. Monitoring continues to be conducted in population centers within approximately 9 miles (15 km) of the site boundary, but only limited monitoring is conducted beyond this distance and at the 25- and 100-mile air surveillance stations.

Table 6–2
1996 Gamma Radiation Surveillance Program Changes

Subprogram	Change(s)
Site operating areas	Eliminate 26 locations (70 remaining)
Site perimeter stations	Eliminate 170 locations (nine remaining)
Population centers	No changes (nine remaining)
Air surveillance stations	No changes (25 remaining)
NRC/Vogtle	No changes (18 remaining)

Table 6–3
TLD Surveillance Results Summary for 1996

Monitoring Subprogram	Mean Exposure (mrem per year)	Maximum Exposure (mrem per year)	Maximum-Exposure Location
On site	99	252	N-Area #5
Site perimeter	85	99	Perimeter #42
Air surveillance	78	116	BG North
Population centers	87	108	Williston, SC
NRC/Vogtle	64	85	NRC #5

Surveillance Results

In general, 1996 gamma radiation surveillance program results indicated gamma exposure rates consistent with those observed in 1995. As expected, results from several onsite monitoring locations showed clearly elevated exposure rates. As in 1995, the maximum annual exposure was observed on site at Location 5 in N-Area; this location is near facilities where work is performed on steam generators. The 1996 exposure at this location was approximately 252 mrem. The remainder of the onsite locations were no greater than levels measured at the site perimeter or off site. This follows a long–term trend.

Site perimeter and offsite locations were consistent with previously published historical results. The exposures at these locations show some variation based on normal site-to-site and year-to-year differences in the components of natural ambient gamma exposure levels. This phenomena also is observed at a majority of the onsite monitoring locations because operations in many areas have been reduced or discontinued. Table 6–3 summarizes the 1996 surveillance results.

Seepage Basins

During previous years of operation, SRS discharged liquid effluent to seepage basins to allow for the decay and natural removal of radioactivity in the water before it reached onsite streams. The practice of discharging water to the seepage basins was discontinued in 1988, but water accumulating in the basins from other sources continues to be monitored by EMS because of potential contamination from the basin soil.

Description of Surveillance Program

Seepage basin water is analyzed for gross alpha, gross beta, and tritium content. Analyses for specific radionuclides are determined by the makeup of previous releases to the basins.

In 1996, aqueous samples were scheduled to be collected annually from the TNX seepage basin, monthly from the Solid Waste Disposal Facility (SWDF), and quarterly from the A-Area, C-Area, L-Area, and P-Area seepage basins. As part of the E-Area expansion plan, EMS also monitors two basins, E-Basin North and E-Basin South, on a monthly basis. Because of dry conditions, not all scheduled samples were collected from the C-Area, L-Area, and P-Area basins, the SWDF basin, and E-Basin South. Seepage basin surveillance locations are shown in figure 6–3.

Seepage basin water is analyzed for gross alpha, gross beta, tritium, strontium, and gamma-emitting radionuclides. Analyses for specific radionuclides are determined by the makeup of previous releases to the basins.

Surveillance Results

Sampling results from 1996 for seepage basin water were similar to those from previous years, largely because liquid effluents no longer introduce new activity to the basins. For most samples, results from 1996 are slightly lower than results from 1995. Tritium results were slightly lower in 1996 than in 1995 for three of six locations. Tritium values for 1996 at the C-Area, L-Area, and P-Area basins were only slightly higher than in 1995, with the P-Area basin containing the highest activity. The C-Area basin contained the highest beta activity, the majority of which was identified as cesium-137 and cobalt-60. Activity levels for cobalt and cesium were lower at all locations than those reported in 1995. Analysis of uranium/plutonium activities by alpha spectroscopy began in July 1995; this allows results to be reported for individual isotopes of uranium and plutonium. Average uranium and plutonium activities reported in

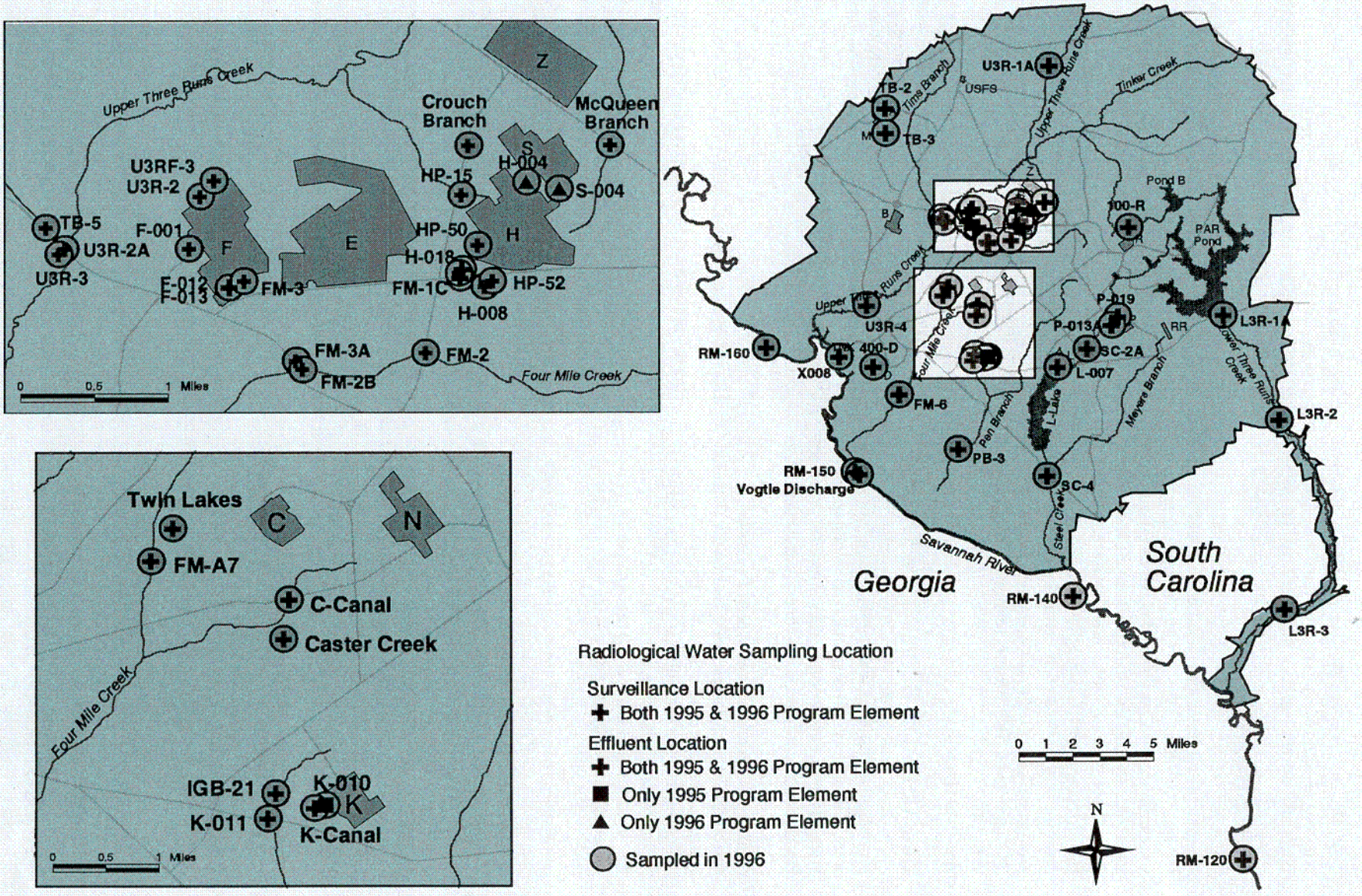

Figure 6–3 Radiological Surface-Water Sampling Locations
Surveillance and effluent sampling points are located on SRS seepage basins and streams and on the Savannah River.

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1996 were lower at the TNX seepage basin than those reported in 1995. Strontium levels in the L-Area basin also were lower than those reported in 1995.

Site Streams

Continuous surveillance is used on several SRS streams, including Tims Branch, Upper Three Runs Creek, Four Mile Creek (also known as Fourmile Branch), Pen Branch, Steel Creek, and Lower Three Runs Creek. Stream water sampling locations that monitor below process areas serve to detect and quantify levels of radioactivity in liquid effluents that are being transported to the Savannah River. In 1996, 23 samplers on SRS streams served as environmental surveillance points. Stream surveillance locations are shown in figure 6–3.

Description of Surveillance Program

From January through June 1996, stream samples were collected weekly and analyzed as either weekly, biweekly, or monthly composites. From July through December, stream samples were collected every other week and analyzed as either biweekly or monthly composites. Frequency and types of analyses performed on each sample are based on the potential quantity and type of radionuclides likely to be present in the water at the surveillance station. Generally, tritium determinations, gamma and alpha spectroscopy, and gross alpha and gross beta screening are performed on stream water. Monthly composites also are analyzed for strontium-89,90—another likely byproduct of SRS operations. Analytical schemes for particular stream locations are documented in the SRS EM Program. The site implemented a new sample reporting regime in 1996 that requires the laboratory to report all gamma spectroscopy results for cobalt-60 and cesium-137 and all alpha spectroscopy results for uranium-234, 235, and 238 and plutonium-238 and 239, even though the results may be below the approximate detection limits listed on tables 6–9, "Representative Lower Limits of Detection for Gamma Analysis of Water and Air Samples," and 6–11, "Representative Lower Limits of Detection for Radiological Analysis of Plutonium and Uranium by Alpha Spectroscopy."

Surveillance Results

The average gross alpha, gross beta, and tritium concentrations at downstream locations near the creek mouths are presented in table 6–4. A graph showing the average tritium concentration over a 9-year period is presented in figure 6–4. The locations of these stations, well below all points at which radioactivity is introduced into the respective streams, ensure that adequate mixing has taken place and that a representative sample is being analyzed. Concentrations at surveillance station U3R-1A (above process effluents and runoff locations on Upper Three Runs Creek) and at an Edisto River surveillance station in the Aiken State Park above SRS are listed for comparison purposes in table 6–4. Sampling at the Edisto River surveillance station was discontinued in July 1996 as part of the reduction in the radiological surveillance program. The following sections contain discussions of surveillance results from each of the major SRS creeks.

Tims Branch

A tributary of Upper Three Runs Creek, Tims Branch receives effluents from M-Area and SRTC. A surveillance point on Tims Branch, TB-5, is located downstream of all release points and before entry into Upper Three Runs Creek. Tritium was below the nominal short count LLD in Tims Branch in 1996, and gross alpha and beta measurements, while above the detection limits, are comparable to levels seen above SRS at the U3R-1A and the Edisto sampling locations.

Upper Three Runs Creek

Upper Three Runs Creek receives discharges from the Effluent Treatment Facility (ETF), flow from Tims Branch, effluent from the Naval Fuels Facility, and stormwater runoff from F-Area and H-Area. Tritium, the predominant radionuclide detected in Upper Three Runs Creek, is discharged primarily from the ETF. The average concentration of tritium in 1996 at U3R-4, located on SRS Road A, was (2.42 ± 2.01)E–06 μCi/mL, which was 12.1 percent of the 2.00E–05-μCi/mL EPA drinking water standard for tritium—up slightly from 11 percent in 1995. Gross alpha concentrations in Upper Three Runs Creek were consistent with 1995 levels. Average cobalt-60 concentrations were less than the nominal LLD and average cesium-137 concentrations were only slightly above the nominal LLD. Average concentrations for isotopes of uranium (uranium-234, 235, and 238) were slightly above the nominal LLD, and average concentrations for isotopes of plutonium (plutonium-238 and 239) all were below the nominal LLD.

Four Mile Creek

Four Mile Creek receives effluents from F-Area, H-Area, and C-Area, as well as from water that has migrated from seepage basins and is outcropping into the stream. Four Mile Creek transported the majority of radioactivity present in SRS streams in 1996, mostly in the form of gross beta-gamma activity and

Table 6–4
Average 1996 Concentration of Radioactivity in SRS and Surveillance Station Waters (μCi/mL)

Location[a]	Gross Alpha	Gross Beta	Tritium
Lower Limits of Detection	6.23E–10	1.55E–09	1.30E–06[b]
Onsite Downstream Locations			
Tims Branch (TB–5)	(1.94 ± 1.60)E–09	(2.21 ± 1.00)E–09	(8.89 ± 2.78)E–07
Upper Three Runs (U3R–4)	(1.84 ± 1.68)E–09	(1.43 ± 1.28)E–09	(2.42 ± 2.01)E–06
Four Mile Creek (FMC–6)	(4.52 ± 5.10)E–10	(8.66 ± 3.77)E–09	(2.10 ± 0.17)E–04
Pen Branch (PB–3)	(3.07 ± 7.36)E–10	(1.20 ± 0.80)E–09	(6.22 ± 1.15)E–05
Steel Creek (SC–4)	(2.48 ± 3.27)E–10	(1.42 ± 0.81)E–09	(7.54 ± 0.86)E–06
Lower Three Runs (L3R–2)	(3.70 ± 4.15)E–10	(1.70 ± 0.72)E–09	(1.12 ± 0.30)E–06
Onsite Surveillance Station (for comparison purposes)			
Upper Three Runs (U3R–1A)	(2.14 ± 1.01)E–09	(1.16 ± 0.71)E–09	(4.60 ± 2.92)E–07
Lower Limit of Detection			4.07E–07[c]
Offsite Surveillance Station (for comparison purposes)			
Edisto River	(7.43 ± 3.61)E–10	(1.12 ± 0.39)E–09	(1.94 ± 0.97)E–07

a Site surveillance locations are near mouths of streams.
b Lower limit of detection for tritium by short count
c Lower limit of detection for tritium by long count

tritium. The gross beta-gamma is made up of strontium-89,90 (outcropping from retired seepage basins) and cesium-137 (from direct releases and resuspension of activity deposited in the streambed). The amount of tritium transported in Four Mile Creek was approximately 58 percent of the total amount reaching the Savannah River in 1996. Because the highest tritium concentrations are present at surveillance points along Four Mile Creek, and not at the stations monitoring direct releases, most of the tritium transport is due to outcropping activity from retired seepage basins and from the SWDF. This activity has decreased significantly since the F-Area and H-Area seepage basins were closed in 1988 (figure 6–4).

Pen Branch

Pen Branch receives discharges from K-Area and flow from a tributary, Indian Grave Branch. Because K-Reactor has not operated since 1992, tritium detected in Pen Branch was due to water entering from Indian Grave Branch, which carries tritium outcropping from the K-Area percolation field and seepage basins. The average tritium concentration at PB–3 in 1996 was (6.22 ± 1.15)E–05 μCi/mL, which was consistent with 1995 levels. Because 1995 concentrations had shown a significant increase over those of 1994, an investigation was conducted in 1996 to determine the cause of the increase; the study identified a previously unmonitored groundwater tritium migration source that enters the stream above PB–3. Average cobalt-60 concentrations were less than the nominal LLD and average cesium-137 concentrations were only slightly above it. Average concentrations for uranium-234 and 238 were slightly above the nominal LLD, while average concentrations for uranium-235 were below the nominal LLD. Average concentrations for isotopes of plutonium all were below the nominal LLD. Average strontium concentrations were lower than those reported in 1995.

Steel Creek

Steel Creek receives releases from L-Area effluents and tritium migration from P-Area seepage basins. When P-Area diverts water away from PAR Pond to Steel Creek, the area's discharges are transported to the stream. All releases enter L-Lake, water from which overflows into Steel Creek and is monitored at SC–4. Gross alpha and beta concentrations at SC–4 were below the nominal LLD in 1996. The average tritium concentration at SC–4 was (7.54 ± 0.86)E–06 μCi/mL. Because the highest

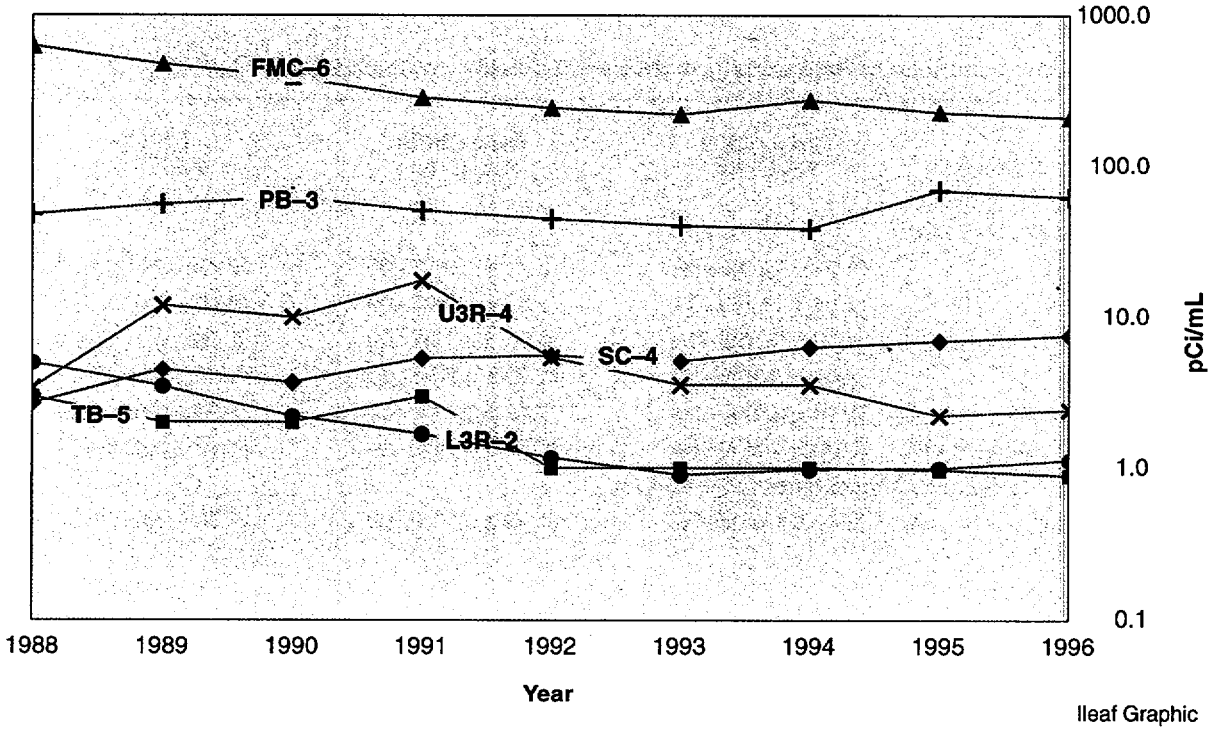

Figure 6–4 Average Tritium Concentration in SRS Streams, 1988–1996
Stream water analysis shows a decrease in the concentration of tritium in most SRS streams.

tritium concentration, (4.07 ± 0.08)E–05 μCi/mL, was measured at the surveillance station at SC–2A, and not at the direct-release monitoring stations in L-Area and P-Area, activity being transported in Steel Creek is attributed to outcropping from the P-Area seepage basins.

Lower Three Runs Creek

Lower Three Runs Creek receives overflow from PAR Pond, a manmade pond that receives discharges from P-Area. Gross beta concentrations in PAR Pond and Lower Three Runs Creek are above the nominal LLD; this is attributable to low concentrations of cesium-137 from previous releases during P-Area and R-Area operations. Average gross alpha and tritium concentrations are below the nominal LLD. Average concentrations for cobalt-60 and cesium-137 in 1996 were slightly above the nominal LLD. Average concentrations for isotopes of uranium were slightly above the nominal LLD, and average concentrations for isotopes of plutonium all were below the nominal LLD. Average strontium concentrations at L3R–2 were slightly higher than 1995 concentrations. Average strontium concentrations at L3R–1A and L3R–3 were lower than 1995 concentrations.

Savannah River

Continuous surveillance is performed along the Savannah River at points above and below SRS and below the point at which Plant Vogtle liquid discharges enter the river. In 1996, five locations along the river served as environmental surveillance points. River sampling locations are shown in figure 6–3.

Description of Surveillance Program

The Savannah River, which provides SRS its western boundary for a 35-mile stretch, is analyzed to determine what effect the site's effluents have on the river water. Gross screening for alpha and beta emitters, along with determinations of specific radionuclides, such as tritium and gamma emitters, is performed on weekly, biweekly, and monthly composites. The analysis of strontium-89,90 samples collected on the Savannah River during 1996 was omitted in 1996 because of a scheduling error.

Surveillance Results

Gross Alpha, Gross Beta, and Tritium

The average concentrations of gross alpha, gross beta, and tritium at river locations are presented in table

6–5. The order of the locations begins at RM–160, above the site, and ends at RM–120, after all site streams enter the Savannah River. Samplers situated between RM–160 and RM–120 are located at regular intervals along the SRS boundary and where Plant Vogtle discharges feed into the river.

Tritium is the predominant radionuclide detected above background levels in the Savannah River. The highest average concentration in 1996, (1.47 ± 0.77)E–06 μCi/mL, was measured at RM–150. The average concentration above SRS, measured at RM–160, was (0.95 ± 1.42)E–07 μCi/mL. The average concentration at RM–120, located on U.S. Highway 301 below SRS, was (1.16 ± 0.39)E–06 μCi/mL. The RM–120 concentration was less than 6 percent of the 2.00E–05-μCi/mL drinking water standard set by EPA for tritium in drinking water. The average tritium concentrations were lower at all sampling locations than in 1995.

Tritium Transport in Streams and River

Tritium is introduced into SRS streams and the Savannah River from production areas on site. Because of the mobility of tritium in water and the quantity of the radionuclide released during the years of SRS operations, a tritium balance has been performed annually since 1960. The balance is evaluated among the following alternative methods of calculation:

- tritium releases from effluent release points and calculated seepage basin and SWDF migration (direct releases)
- tritium transport in SRS streams and the last sampling point before entry into the Savannah River (stream transport)
- tritium transport in the Savannah River downriver of SRS after subtraction of any measured contribution above the site (river transport)

Figure 6–5 shows graphic and numeric summaries of the last 37 years of direct releases, stream transport, and river transport determined by EMS.

In 1996, tritium transport decreased for direct releases and stream and river transport to the lowest levels in the past 37 years.

General agreement between the three calculational methods of annual tritium transport—measurements at the source, stream transport, and river transport—serves to validate SRS sampling schemes and counting results. Differences between the various methods can be attributed to uncertainties arising in the collection and analytical processes, including determinations of water flows and varying transport times. Because of the close agreement, and because it can be independently verified by offsite agencies, the river transport value has been chosen for use in annual environmental dose calculations.

Drinking Water

EMS collects drinking water samples from locations at SRS and at water treatment facilities that use Savannah River water. Potable water is analyzed at offsite treatment facilities to ensure that SRS operations are not adversely affecting the water supply and to provide voluntary assurance that drinking water is below EPA drinking water standards for radionuclides. Analysis in surrounding towns and communities was discontinued in 1996 as part of the reduction in the radiological surveillance program.

Description of Surveillance Program

Sampling on site consists of monthly grab samples at production areas and quarterly grab samples at nonproduction and perimeter stations. Collected monthly are samples from

Table 6–5
Average 1996 Concentration of Radioactivity in the Savannah River (μCi/mL)

Location Lower Limits of Detection	Gross Alpha 6.23E–10	Gross Beta 1.55E–09	Tritium 4.07E–07
RM–120	(1.07 ± 2.41)E–10	(1.81 ± 0.51)E–09	(1.16 ± 0.39)E–06
RM–140	(1.24 ± 3.17)E–10	(1.92 ± 0.69)E–09	(1.44 ± 0.60)E–06
RM–150	(2.71 ± 3.21)E–10	(1.80 ± 0.50)E–09	(1.47 ± 0.77)E–06
Vogtle discharge	(2.67 ± 3.72)E–10	(1.85 ± 0.65)E–09	(9.96 ± 8.73)E–07
RM–160	(1.43 ± 2.40)E–10	(1.96 ± 0.62)E–09	(0.95 ± 1.42)E–07

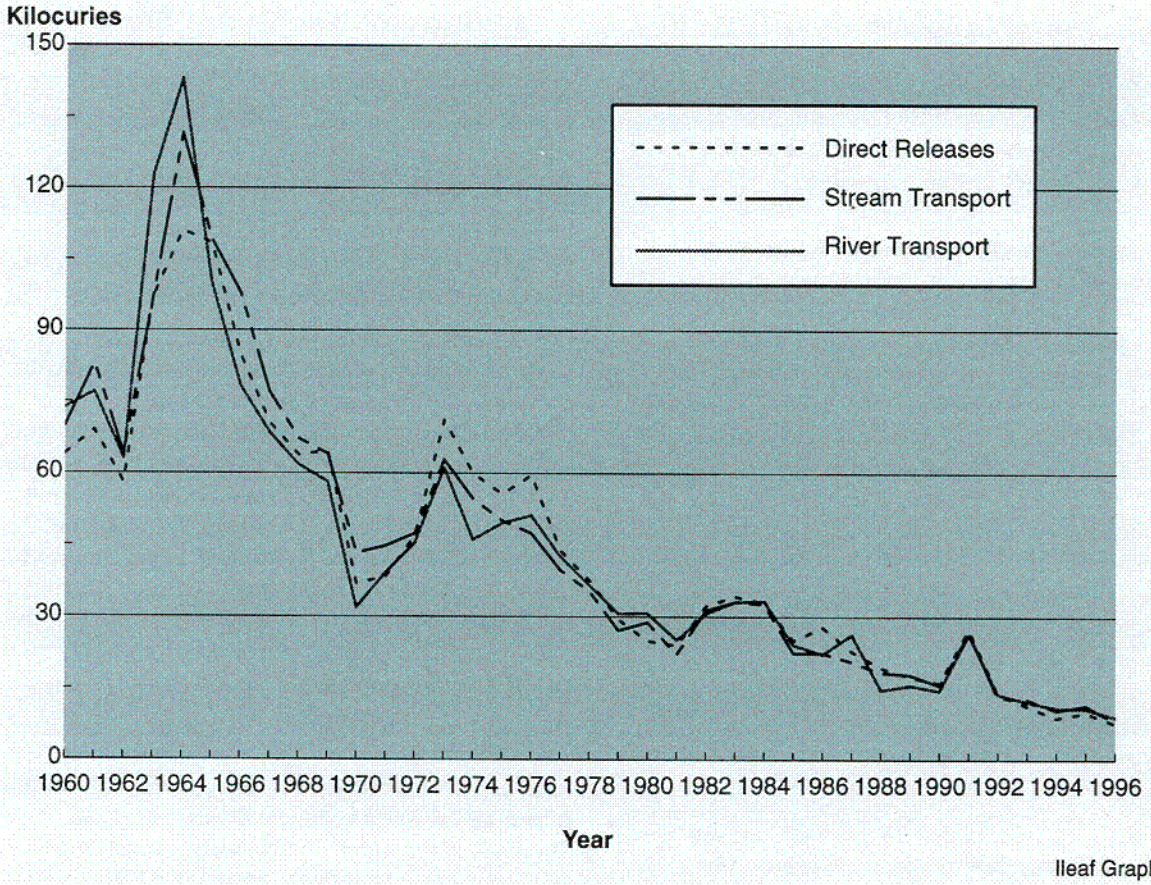

Figure 6–5 SRS Tritium Transport Summary, 1960–1996

SRS has maintained a tritium balance of direct releases, stream transport, and river transport since 1960 in an effort to account for and trend tritium releases in liquid effluents from the site. The general downward slope over time indicates that tritium transport has decreased as production has slowed and effluent controls have been developed.

- two water treatment plants downriver of SRS that supply treated Savannah River water to Beaufort and Jasper counties in South Carolina and to Port Wentworth, Georgia
- the North Augusta (South Carolina) Water Treatment Plant
- the D-Area treatment facility on site

At all these facilities, raw and finished water samples are collected daily and composited for analysis by EMS. All drinking water samples are screened for alpha and beta emitters and analyzed specifically for tritium. Drinking water samples are analyzed at least once a year for strontium-89,90; however analysis of the 1996 samples was omitted inadvertently.

Surveillance Results

Gross Alpha and Gross Beta

All drinking water samples collected by EMS are screened for gross alpha and gross beta concentrations to determine if activity levels warrant further analysis. No samples collected in 1996 exceeded EPA's 1.50E–08-μCi/mL alpha activity limits or 5.00E–08-μCi/mL beta activity limits. As in previous years, the highest average alpha concentration—(1.39 ± 0.13)E–09 μCi/mL at the 701-5G Aiken Barricade (Talatha Gate)—has been characterized for specific alpha activity, with at least a partial source of activity due to radium-226. No sample's average exceeded 8.00E–09 μCi/mL of beta activity. This concentration is the EPA limit for strontium-90, which is the most restrictive beta-emitting radionuclide.

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Strontium

No drinking water samples collected and analyzed by EMS for strontium-89,90 exceeded the 1.90E–09-μCi/mL detection limit of the EMS laboratories. This limit is approximately 25 percent of the EPA drinking water standard for strontium-90.

Tritium

No drinking water samples collected and analyzed by EMS exceeded the 2.00E–05-μCi/mL EPA tritium limit. Detectable levels of tritium were present in the drinking water samples collected monthly from the Beaufort-Jasper and Port Wentworth water treatment facilities. These levels reflect the introduction of tritium from SRS operations into the Savannah River. The average tritium concentration in finished water at Beaufort-Jasper in 1996, (9.16 ± 2.74)E–07 μCi/mL, was 5 percent of the EPA drinking water limit. The average tritium concentration at Port Wentworth, (9.88 ± 2.77)E–07 μCi/mL, was 5 percent of the EPA drinking water limit.

Terrestrial Food Products

The terrestrial food products surveillance program consists of radiological analyses of food product samples typically found in the Central Savannah River Area (CSRA). Because radioactive materials can be transported to man through the consumption of milk and other food products containing radioactivity, food product samples are analyzed to determine what effects, if any, SRS operations have on them. Data from the food product surveillance program are not used to show direct compliance with any dose standard; however, the data can be used as required to verify dose models and determine environmental trends.

Description of Surveillance Program

Meat, Fruit, and Greens

The food products surveillance program divides the area that surrounds the site, approximately nine miles (15 km) beyond its perimeter, into four quadrants: northeast, southeast, southwest, and northwest. Samples of food—including meat (beef or chicken), fruit (peaches or melons), green vegetables (collards), and milk—are collected from one location within each of the quadrants and from a control location within an extended (to 25 miles beyond the perimeter) southeast quadrant. All food samples are collected annually except milk, which is collected monthly for analysis of tritium and gamma-emitting radionuclides and quarterly for analysis of strontium-90. During 1996, fruit was unavailable for collection from two locations—northwest and southwest.

The EMS analysis of food products changed in 1996 to allow for the measurement of specific isotopes of plutonium (plutonium-238 and plutonium-239). This replaced the previously used nonspecific uranium/plutonium procedure. Food samples also are analyzed for gamma-emitting radionuclides, tritium, and strontium-89,90.

Milk

During 1996, EMS collected milk samples at five dairies within a 25-mile radius of SRS and from locally produced inventories of a major distributor.

Milk samples are analyzed for tritium and gamma-emitting radionuclides, primarily cesium-137 and iodine-131. Additional milk samples are collected quarterly and analyzed for strontium-90; however, the collection of one of the quarterly milk samples for strontium-90 analysis was omitted inadvertently in 1996.

Surveillance Results

Gamma-Emitting Radionuclides

The only manmade gamma-emitting radionuclide detected in food products, excluding milk, was cesium-137. The maximum concentration, (4.79 ± 0.49)E–02 pCi/g, was measured in beef from the 15-km northwest quadrant. Cesium-137 concentrations at the control location were below the nominal LLD. Generally, concentrations of cesium-137 in indicator samples were similar to those measured at the control location, although some locations showed detectable activity. These concentrations were similar to those observed in previous years.

Cesium-137 also was the only manmade gamma-emitting radionuclide detected in milk samples during 1996. Measured average concentrations ranged from a high of (4.16 ± 1.50)E–03 pCi/mL to a low below the nominal LLD. The mean concentrations measured in 1996 were similar to those measured in 1995.

Iodine-131 was not detected in any 1996 milk samples. Because of its short physical half-life (8 days), iodine-131 generally is not detected, except shortly after tests of nuclear weapons or in the wake of events such as the Chernobyl incident. There were no announced nuclear weapons tests or other major nuclear incidents in 1996.

Tritium

Tritium concentrations ranged from a high of (1.68 ± 0.45)E–01 pCi/g, measured in beef from the 15-km southeast quadrant, to below the nominal LLD in several samples. The concentrations were similar to those measured in 1995.

Tritium in milk and other samples is attributed to releases from SRS. Milk from most dairies showed detectable concentrations of tritium at some point during 1996. The maximum concentration, (6.69 ± 1.28)E–01 pCi/mL, was measured at a Jackson, South Carolina, location. The minimum concentration from other local sampling locations was below the nominal LLD. Tritium concentrations measured in milk in 1996 were similar to those in 1995 and generally reflected atmospheric releases from the site.

Strontium

All strontium-89,90 concentrations in food products, excluding milk, were below the nominal LLD and generally were within the ranges observed during past years.

Strontium-90 analysis was performed on milk from the six sampling locations. Measured concentrations ranged from a high of (9.22 ± 2.67)E–03 pCi/mL in the Denmark, South Carolina, area to a low below the LLD. The mean concentrations measured in 1996 were similar to those measured in 1995.

Plutonium

Concentrations of plutonium-238 in food products, excluding milk, during 1996 ranged from a high of (4.42 ± 0.42)E–03 pCi/g, measured in fruit collected from the 15-km northeast quadrant to a low below the nominal LLD. Plutonium-239 concentrations in food products all were below the nominal LLD. Plutonium-238 and plutonium-239 concentrations in food products, excluding milk, during 1996 were similar to the 1995 concentrations.

Aquatic Food Products

Description of Surveillance Program

The aquatic food product surveillance program consists of both fish (freshwater and marine) and shellfish. To determine the potential dose and risk to the public from consumption of these fish, both are sampled.

Nine surveillance points for the collection of fish are located on the Savannah River (figure 6–6). These include

- the Augusta Lock and Dam area (control location), above the site
- five areas where site streams enter the Savannah River
- the U.S. Highway 301 bridge, below the site
- Stokes Bluff Landing, below the site
- the U.S. Highway 17A bridge area, below the site

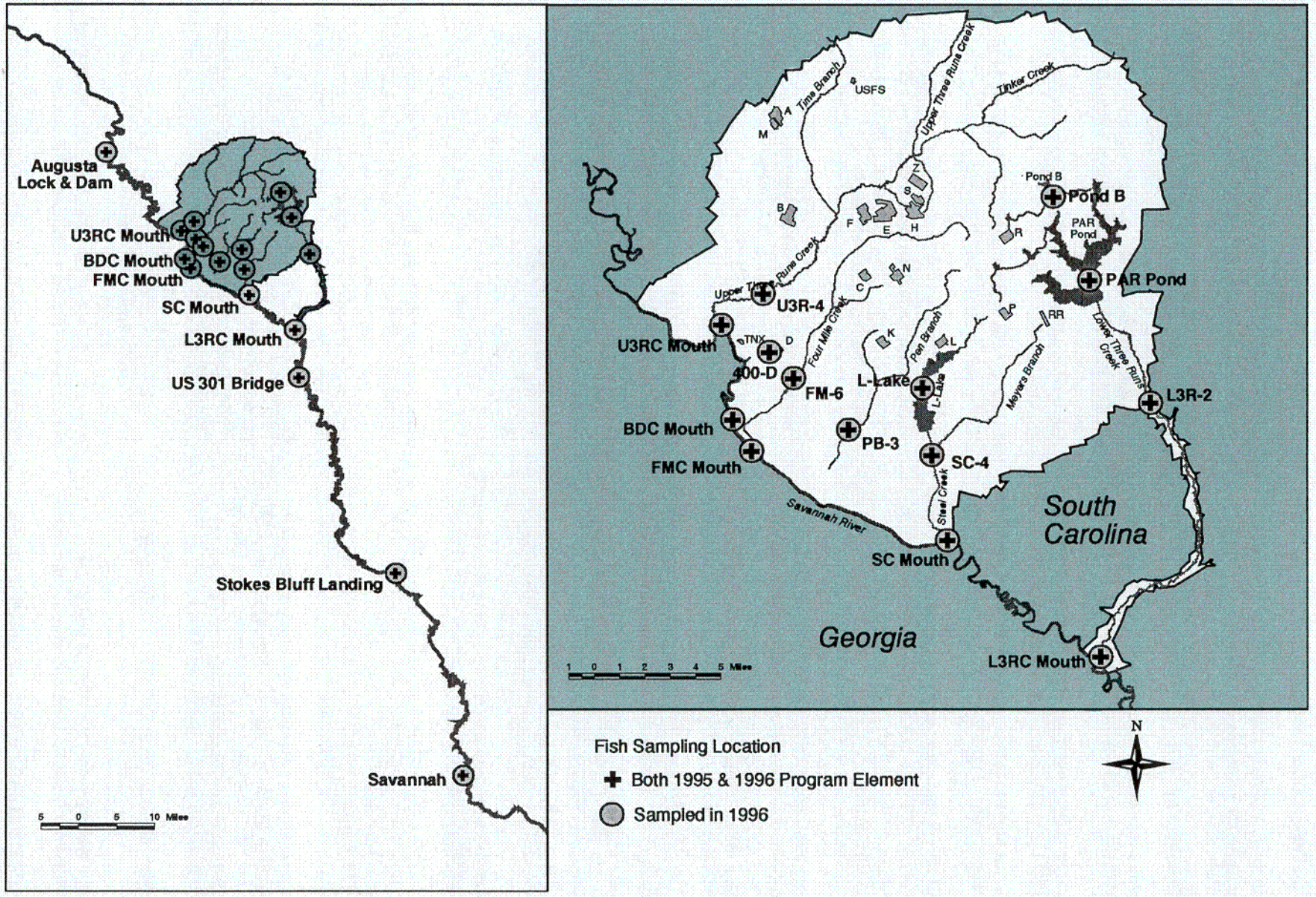
Nine surveillance points for fish collection also are located within the SRS boundary. These points include PAR Pond, L-Lake, Pond B, Lower Three Runs Creek, Upper Three Runs Creek, Beaver Dam Creek, Pen Branch, Steel Creek, and Four Mile Creek. In 1996, not enough fish could be collected for composite samples (five from the same category per location) from Upper Three Runs Creek, Four Mile Creek, Pen Branch, Lower Three Runs Creek at Patterson Mill, or Beaver Dam Creek.

Freshwater fish are grouped into one of three categories: bass, panfish (bream or crappie), or catfish. Marine (saltwater) fish, collected from the U.S. Highway 17A bridge area, also are grouped into one of three categories: predatory fish, filter feeders, or bottom-dwelling fish. Sea trout and bass were placed in the predatory group; mullet in the filter feeder group; and catfish and flounder in the bottom-dwelling group. The fish are grouped in this manner because they are the most sought-after fish in the Savannah River, according to the latest creel survey conducted by the Fisheries Management Section of the Georgia Department of Natural Resources Wildlife Resources Division.

For analysis purposes, five fish from each category at each collection location are combined to create a composite. Composites are divided into edible (meat fillet only) and nonedible (scales, skin, head, fins, viscera, bone) portions and analyzed for gross alpha and gross beta for all locations. Fish collected from Augusta Lock and Dam downstream through the U.S. Highway 301 bridge also are analyzed for strontium-89,90; plutonium-238 and plutonium-239; tritium; and gamma-emitting radionuclides.

In the shellfish surveillance program, samples of oysters and crabs are collected on the coast near Savannah, Georgia. The shellfish are analyzed for gross alpha, gross beta, strontium-89,90, and gamma-emitting radionuclides.

Calculations of risk from the consumption of fish from the Savannah River can be found in chapter 7.



EPD/GIS Graphic

Figure 6–6 SRS Fish Sampling Points on the Savannah River

SRS collects fish (for both radiological and nonradiological analyses) from the Savannah River above, adjacent to, and below the site, as well as at Stokes Bluff Landing and near Savannah, Georgia.

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Surveillance Results

In the following surveillance results discussion, uncertainty values are provided because most measurements were at or near the LLD.

Freshwater Fish

Savannah River In 1996, for the first time, all categories of fish from all nine Savannah River locations were collected. Composites of each category were analyzed for gross alpha and gross beta.

Gross alpha activities in the offsite edible composites ranged from a high of (4.62 ± 2.08)E–01 pCi/g in a bass from Stokes Bluff Landing to a low below the LLD. The maximum gross alpha activity—(9.15 ± 7.45)E–01 pCi/g, in a nonedible composite—was measured in a catfish from the Steel Creek river mouth location.

The maximum edible gross beta activity from the Savannah River, (4.97 ± 0.55)E+00 pCi/g, was measured in a bass composite from the mouth of Steel Creek. This concentration was slightly lower than the maximum nonedible gross beta activity, 5.08 ± 0.69E+00 pCi/g, measured in a bass from the mouth of Four Mile Creek.

Cesium-137 and cobalt-60 were the only manmade, gamma-emitting radionuclides detected in 1996 fish composites. The maximum cesium-137 activity in edible fish from the Savannah River, (2.99 ± 0.08)E+00 pCi/g, was measured in a bass composite from the mouth of Steel Creek. The maximum cesium-137 concentration in nonedible fish from off site, (1.53 ± 0.06)E+00 pCi/g, was measured in a bass composite from the mouth of Steel Creek.

In 1996, both edible and nonedible composite portions were analyzed for strontium-89,90. The maximum strontium-89,90 concentration was (2.61 ± 0.05)E+00 pCi/g in a nonedible bass from the mouth of Four Mile Creek.

The maximum tritium concentration at the control location (Augusta Lock and Dam, upstream of SRS) was (7.08 ± 4.92)E–02 pCi/g, measured in a bream composite. The maximum tritium concentration downstream and/or adjacent to the site, (2.67 ± 0.01)E+01 pCi/g, was found in a bass composite from the mouth of Four Mile Creek.

Onsite Streams and Ponds Gross alpha and gross beta analyses were performed on edible fish composites collected from SRS streams and ponds. Gross alpha concentrations ranged from a high of (0.54 ± 1.22)E–01 pCi/g in a PAR Pond bream to lows below the nominal LLD in other composites. Gross beta concentrations ranged from a high of (1.44 ± 0.06)E+01 pCi/g in a Pond B bream to lows below the nominal LLD in other composites.

Cesium-137 and cobalt-60 were the only manmade, gamma-emitting radionuclides detected in fish from onsite streams and ponds. The maximum cesium-137 concentration in an onsite edible composite, (3.87 ± 0.08)E+01 pCi/g, came from a Pond B bream composite; the minimum, (3.06 ± 0.38)E–01 pCi/g, came from a bream from the Steel Creek at Road A location.

Cobalt-60 was detected at (5.20 ± 2.38)E–02 pCi/g in a bass sample from Pond B.

Marine Fish

Bass, catfish, and mullet were collected in 1996 from the U.S. Highway 17A bridge area. The gross alpha concentrations ranged from a high of (0.73 ± 1.64)E–01 pCi/g in a bass to a low below the LLD in other composites; the gross beta concentrations ranged from a high of (2.13 ± 0.35)E+00 pCi/g in a catfish to a low below the LLD in other composites.

Shellfish

A sample of oysters and a sample of crabs—both from near the mouth of the Savannah River—were collected in 1996. Analytical results showed that no manmade radionuclides above the nominal LLD were present in the samples.

Deer and Hogs

Description of Surveillance Program

Annual hunts, open to members of the general public, are conducted at SRS to control the site's deer and feral hog populations and to reduce animal-vehicle accidents. Before any animal is released to a hunter, EMS uses portable sodium iodide detectors to perform field analysis for cesium-137. The resulting dose from consumption is calculated for each animal, and each hunter's cumulative total is tracked. Media samples (muscle and/or bone) are collected periodically for laboratory analysis based on a set frequency, on cesium–137 levels, and/or on exposure limit considerations.

Surveillance Results

During 1996, 1,685 deer and 109 feral hogs were taken from the site as part of the controlled hunt program. This compares with 1,152 deer and 47 feral hogs taken during the 1995 hunts. The number of hunts was increased from 12 to 14 in 1996 as part of the site's ongoing wildlife management program.

One animal—a deer—was confiscated in 1996. The cesium-137 activity in the animal, as measured by field instruments, was 166 pCi/g. This measurement was verified by post-hunt laboratory analysis, which indicated a concentration of 150 pCi/g. Because consumption of the edible portion of this deer by an individual would result in an exposure exceeding DOE's annual individual dose limit for members of the general public (100 mrem), the deer was retained by SRS personnel. The discussion below summarizes results from animals released to hunters during 1996; therefore, it does not include the confiscated animal described above.

Gamma-Emitting Radionuclides

In 1996, the maximum field measurement of cesium-137 in deer muscle was approximately 21 pCi/g, while the mean cesium-137 concentration was approximately 5 pCi/g. In feral hogs, the maximum field measurement of cesium-137 in muscle was approximately 16 pCi/g, while the mean concentration was approximately 4 pCi/g.

Each animal is monitored prior to release, and the field measurements are supplemented by laboratory analyses. Samples are collected from approximately 10 percent of the animals processed, including every 10th animal monitored and any animal that results in a hunter's annual dose exceeding 25 mrem—either alone or in combination with previous animals killed by the hunter. In 1996, 192 samples from 169 animals were collected and analyzed for gamma-emitting radionuclides; tables in *SRS Environmental Data for 1996* include measurements only from these animals.

As observed during previous hunts, cesium-137 was the only manmade gamma-emitting radionuclide detected during laboratory analysis. Generally, the cesium-137 concentrations measured by the field and lab methods were comparable. Field measurements ranged from approximately 1 pCi/g to 16 pCi/g, while lab measurements ranged from approximately 1 pCi/g to 15 pCi/g.

Strontium

Strontium levels are determined in some of the animals analyzed for cesium-137. Typically, muscle and bone samples are collected for analysis from the same animals checked for cesium-137, and the samples are analyzed for strontium-89,90.

In 1996, 47 muscle samples from 24 animals were collected for strontium analysis. Only two of the samples showed detectable strontium-89,90—one at 0.04 pCi/g and the other at 0.05 pCi/g. These results are consistent with those observed during previous hunts—most animals do not have detectable strontium-89,90 in muscle tissue, and generally only low levels are present in the remainder of the animals.

In addition, 23 bone samples were collected from 23 animals for strontium-89,90 analysis. As observed in previous hunts, the analytical results indicated a wide range of strontium-89,90 concentrations, with levels ranging from a minimum of approximately 3 pCi/g to a maximum of approximately 92 pCi/g. Generally, the strontium-89,90 concentrations in bone tissue appear to be slightly higher than those observed in 1995. As expected, the concentrations in bone tissue were significantly higher than in muscle. This is because strontium, whether stable or radioactive, is chemically similar to calcium and thus tends to accumulate in bone.

Turkeys

Description of Surveillance Program

Wild turkeys are trapped on site by the South Carolina Wildlife and Marine Resources Department and used to repopulate South Carolina game areas. All turkeys are monitored for cesium-137 with portable sodium iodide detectors before leaving SRS. No turkey above 25 pCi/g is released off site.

Surveillance Results

EMS monitored 68 turkeys in 1996. Concentrations of cesium-137 generally were similar to those measured in the past, with all results 5.0 pCi/g or less. This compares to a maximum concentration in 1995 of 1.0 pCi/g and a maximum in 1994 of 10 pCi/g (with a minimum of 1 pCi/g).

Beavers

Description of Surveillance Program

The U.S. Forest Service administers a contract for the trapping of beavers in selected areas within the SRS perimeter. The purpose of trapping is to reduce the beaver population in specific areas of the site and thereby minimize dam-building activities that can result in flood damage to timber stands, primary and secondary roads, and railroad beds. All beavers are monitored for cesium-137 with a portable sodium iodide detector and disposed of in the SRS sanitary landfill.

Surveillance Results

EMS monitored 84 beavers in 1996. The maximum cesium-137 concentration was 10.5 pCi/g (the same as in 1995), measured in an animal trapped on Pen

Branch. The minimum concentration was 1.0 pCi/g (also the same as in 1995). These results compare with a 1994 maximum of 22 pCi/g and minimum of 1 pCi/g, and with a 1993 maximum and minimum of 47 pCi/g and 1 pCi/g, respectively.

Soil

The SRS soil monitoring program provides

- data for long-term trending of radioactivity deposited from the atmosphere (both wet and dry)
- information on the concentrations of radioactive materials in the environment

Routine and nonroutine SRS atmospheric releases, as well as worldwide fallout, are monitored in this program. The concentrations of radionuclides in soil vary greatly among locations because of differences in rainfall patterns and in the mechanics of retention and transport in different types of soils. Because of this program's design, a direct comparison of data from year to year is not appropriate.

Description of Surveillance Program

Soil samples were collected in 1996 from four uncultivated and undisturbed locations in F-Area, H-Area, Z-Area, and E-Area (burial ground)—one sample from each area—and from four onsite quadrant locations near the site perimeter, as shown in figure 6–7. One location approximately 100 miles from SRS—Savannah, Georgia—also was sampled. Changes implemented in 1995 as part of the overall comprehensive review of the environmental monitoring program reduced the total number of sampling locations from 24 that year to nine in 1996. Additional changes—implemented in September 1996—further reduced the number of locations to five for 1997.

Hand augers or other similar devices are used in sample collection. The samples are analyzed for gamma-emitting radionuclides, strontium-89,90, plutonium-238, and plutonium-239. The rationale for each sampling site is explained in the SRS EM Program.

Surveillance Results

Gamma-Emitting Radionuclides

Cesium-137 was observed at levels above the nominal LLD in 1996 at seven of the eight onsite locations and at the offsite location. The highest concentration detected on site, (5.91 ± 0.40)E–01 pCi/g, was in a sample taken from the northwest quadrant, and the lowest was below the nominal LLD. The concentration at the 100-mile-radius location was (2.82 ± 0.23)E–01 pCi/g.

Plutonium

Plutonium-238 was observed above the nominal LLD at four of the eight onsite locations and at the offsite location. The highest onsite concentration was (7.84 ± 1.60)E–03 pCi/g, in the northwest quadrant; the lowest was below the nominal LLD. Plutonium-239 was observed above the nominal LLD at six of the eight onsite locations and at the offsite location. The highest onsite concentration was (2.05 ± 0.26)E–02 in the northwest quadrant; the lowest was below the nominal LLD. The offsite concentration was (1.84 ± 0.60)E–03 pCi/g.

Strontium

Soil samples from all locations were analyzed for strontium-89,90, and all were below the nominal LLD.

Sediment

Sediment sample analysis measures the movement, deposition, and accumulation of long-lived radionuclides in stream beds and in the Savannah River bed. Because of the continuous deposition and remobilization occurring in the stream and river beds, significant year-to-year differences may be evident, but the data obtained can be used to observe long-term environmental trends.

Description of Surveillance Program

Sediment samples are collected annually at 15 locations: nine in the Savannah River and six in site streams (figure 6–8). Samples are obtained from the top 8 cm of sediment in areas where fine sediment accumulates and most radionuclides concentrate. Sediments are analyzed for gamma-emitting fission and activation products, strontium-89,90, plutonium-238, and plutonium-239.

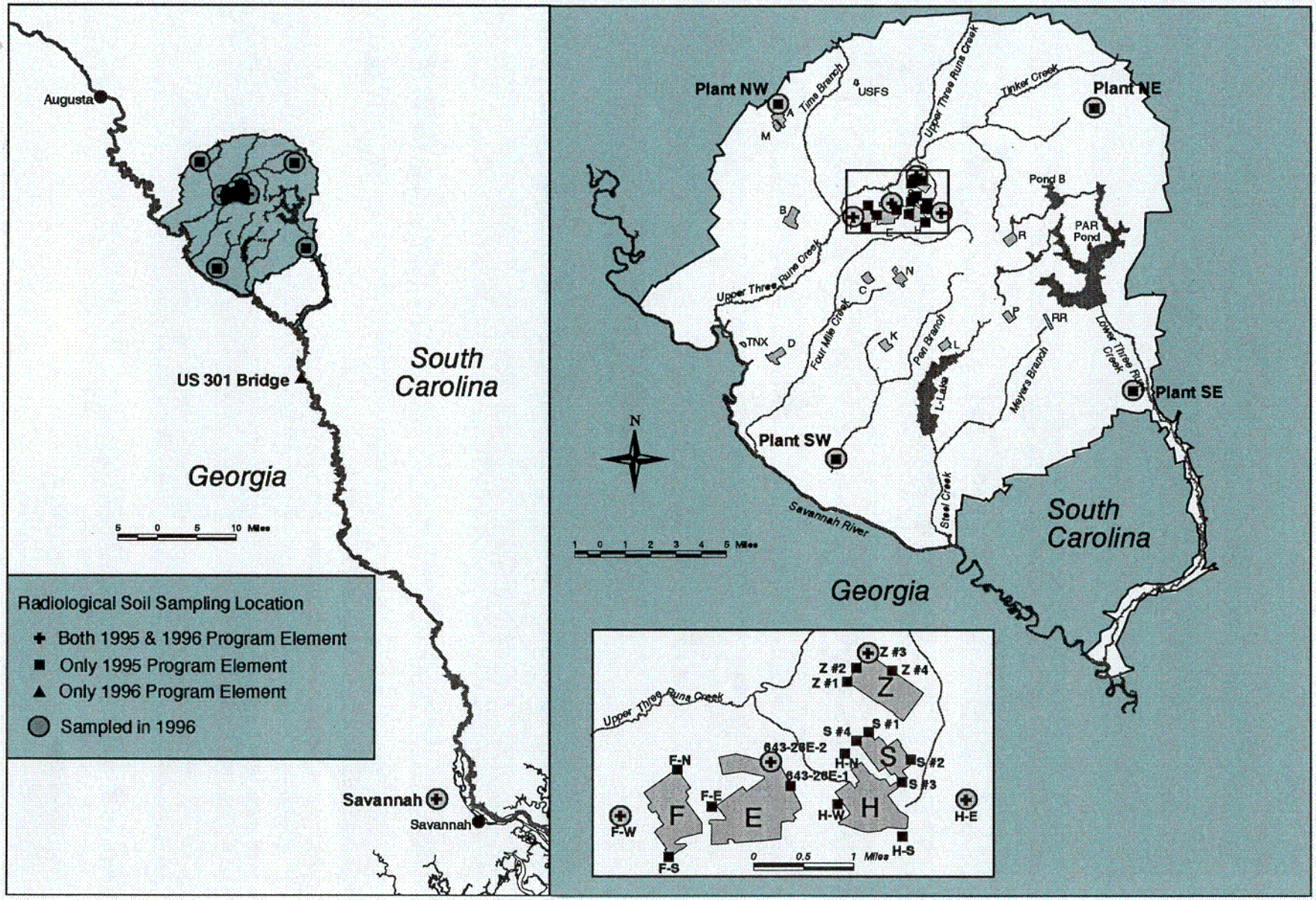
Surveillance Results

Concentrations of radionuclides in river sediment during 1996 were similar to those detected upriver in the control sample from Demiere's Landing. Maximum activities were observed in samples obtained from Steel Creek, Four Mile Creek, and Pen Branch.

Gamma-Emitting Radionuclides

Cesium-137 and Cobalt-60 were the only manmade gamma-emitting radionuclides observed in river and stream sediments during 1996.

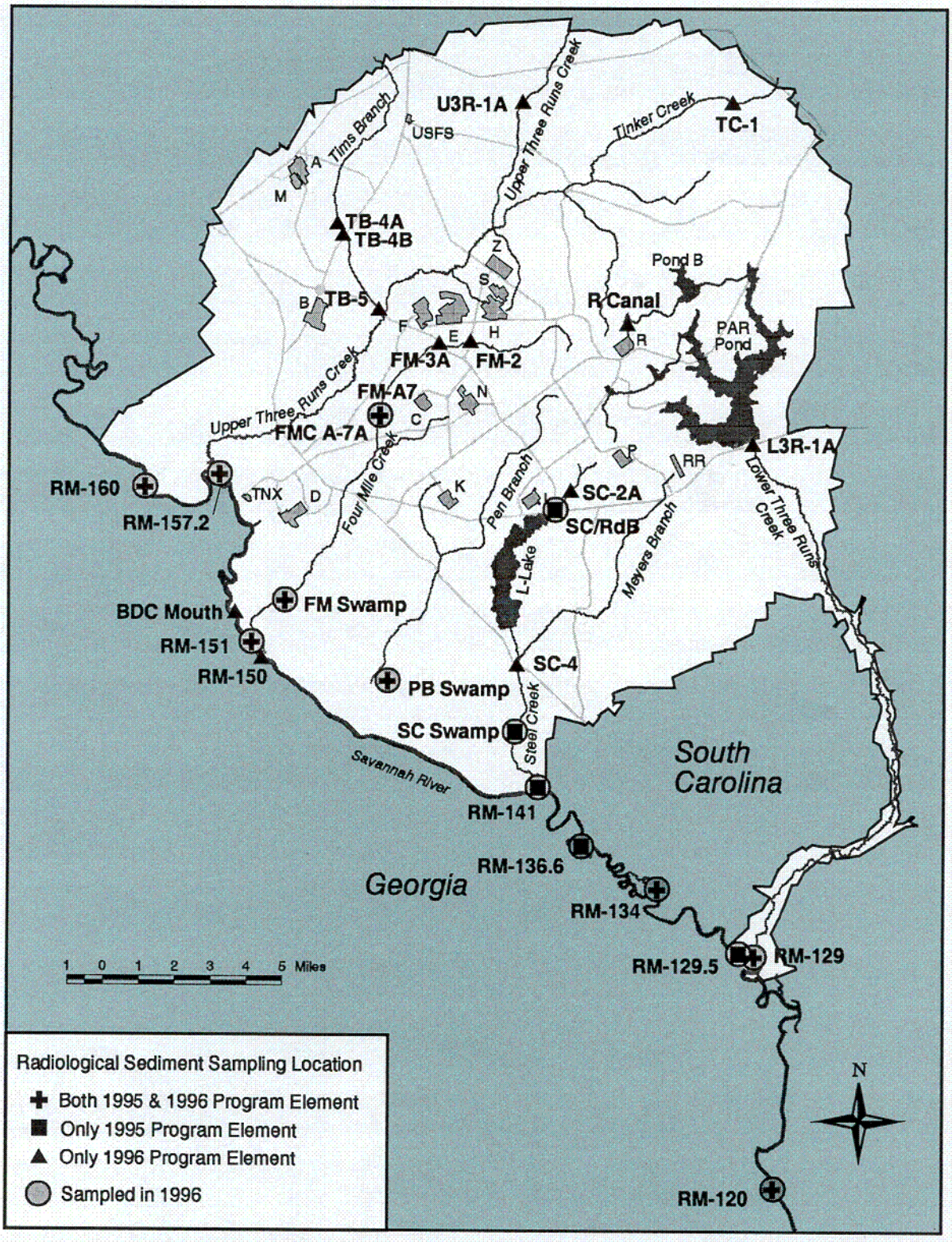
The highest cesium-137 concentration, (4.25 ± 0.45)E–01 pCi/g, was detected in sediment



EPD/GIS Graphic

Figure 6–7 Radiological Soil Sampling Locations

SRS collected soil samples in 1996 from eight onsite (including four perimeter) locations and from one offsite location (Savannah, Georgia).



EPD/GIS Graphic

Figure 6–8 Radiological Sediment Sampling Locations

Sediment samples were collected in 1996 at nine Savannah River locations—upriver of, adjacent to, and downriver of the site—and six site stream locations.

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taken from below Four Mile Creek; the lowest was below the nominal LLD. Also, the Lower Three Runs Creek Mouth location reflected more typical concentrations in 1996 than it had during the previous 3 years, when higher than normal concentrations could have been caused by changes in PAR Pond. Generally, cesium-137 concentrations were slightly higher in stream sediments than in river sediments. This is to be expected because the streams receive radionuclide-containing liquid effluents from the site. Most radionuclides settle out and deposit on the stream bed before reaching the river.

Cobalt-60 was detected in sediment from the following locations:

- Steel Creek Swamp Discharge
- Pen Branch Swamp Discharge
- Four Mile A–7A
- River Mile 129.5 and River Mile 134
- Control Location (River Mile 160.5, Demiere's Landing)

The highest concentration, (1.92 ± 0.12)E–01 pCi/g, was measured at Four Mile A–7A; the lowest was below the nominal LLD.

Plutonium

Concentrations of plutonium-238 in sediment ranged from a high of (2.09 ± 0.14)E–01 pCi/g at the Four Mile A–7A location to a low below the nominal LLD. Concentrations of plutonium-239 ranged from a high of (7.18 ± 0.56)E–02—also at the Four Mile A–7A location—to a low below the nominal LLD. As expected, concentrations of these isotopes in streams generally were higher than concentrations in the river. Changes observed when these data are compared to previous years probably are due to the effects of resuspension and deposition, which occur constantly in sediment media.

Strontium

The maximum strontium-89,90 concentration in sediment in 1996, (1.32 ± 0.24)E–01 pCi/g, which occurred on Four Mile Creek at Road A-7, is lower than the results reported in 1994 and 1995. The change in magnitude probably is due to the year-to-year variations cited earlier. The minimum strontium concentration was below the nominal LLD.

Grassy Vegetation

The radiological program for grassy vegetation is designed to collect and analyze samples from onsite and offsite locations to determine radionuclide concentrations. Vegetation samples are obtained to complement the soil and sediment samples in order to determine the environmental accumulation of radionuclides and help confirm the dose models used by SRS. Furthermore, the program provides information that can be used to determine the effect, if any, of various radioactive material operations on the surrounding vegetation.

Typically, grasses are collected for vegetation because of their year-round availability. Bermuda grass is preferred because of its importance as a pasture grass for dairy herds.

Description of Surveillance Program

Vegetation samples are obtained from

- locations containing soil radionuclide concentrations that are expected to be higher than normal background levels
- locations receiving water that may have been contaminated

Until mid-1995, these samples were collected at 174 locations in and around SRS, including four "areas," 13 basins, the burial ground (outside and inside), the site perimeter, and the 25- and 100-mile-radius locations near the environmental air monitoring stations. As a result of the comprehensive review of the environmental monitoring program, and because data from previous years indicated little or no contamination, all four 25-mile-radius and three of four 100-mile-radius sampling locations were retired in 1995. The 25-mile-radius locations were used to accumulate trending data, while the 100-mile-radius locations served as control locations and provided historical baseline information. In 1996, SRS continued to collect quarterly samples at the 100-mile-radius location in Savannah, Georgia.

In 1996, sampling was discontinued on site at inside-burial ground and area locations, and the sampling frequency at outside-burial ground and site perimeter locations was reduced from quarterly to annually. Figure 6–9 shows the 116 locations sampled on site during 1996. By the end of 1996, the vegetation surveillance program was designed to collect samples annually at 100 onsite locations and one offsite location (Savannah)—a 40-percent reduction from the 174 locations sampled in early 1995.

Onsite sampling locations encircle burial ground and basin locations. Site perimeter air monitoring stations provide sampling within each 30-degree sector around the site boundary. The offsite sampling

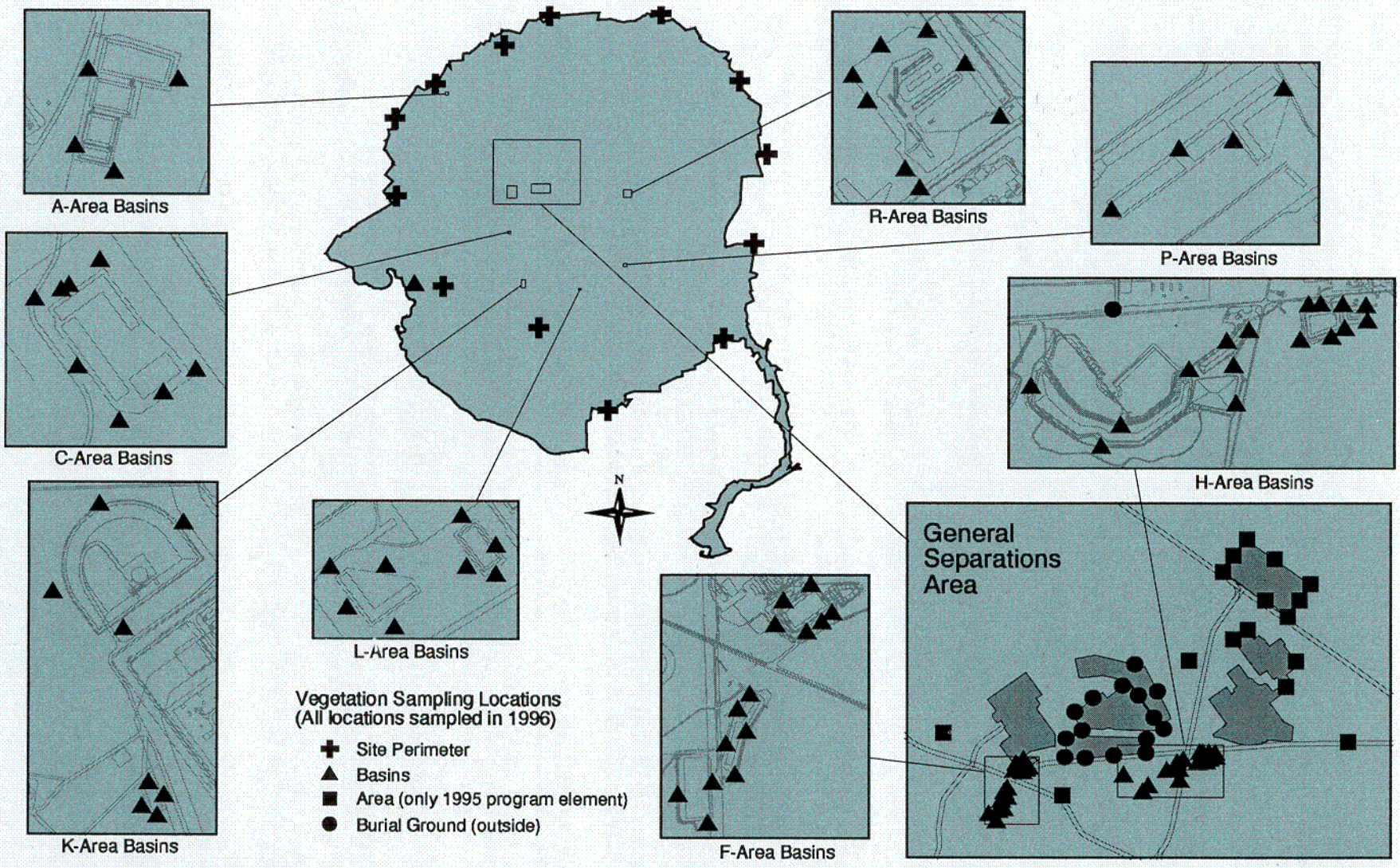

Figure 6–9 SRS Onsite Vegetation Sampling Locations

Vegetation samples were collected for radiological analysis from 116 onsite locations and one offsite (Savannah, Georgia) in 1996.

C10

location, selected as a control site, is near the environmental air monitoring station in Savannah.

Vegetation samples are analyzed for gross alpha and gross beta, gamma-emitting radionuclides, tritium, and strontium because vegetation can be contaminated externally by the deposition of airborne radioactive contaminants (i.e., from fallout) and internally by uptake, from soil or water, by the roots. While the program makes no attempt to differentiate between contributions of the external and internal contaminations, contributions can be approximated when naturally occurring radionuclide concentrations in local soils are known.

The sampling and analysis programs for grassy vegetation are documented in WSRC–3Q1–2, Volume 1, Section 1105.3.10.2. Operational details of sample collection are in procedure manual WSRC–3Q1–3, while analytical procedures are in WSRC–3Q1–4 and WSRC–3Q1–6.

Surveillance Results

Before 1996, the vegetation surveillance program was divided into three broad areas: quarterly surveillance samples, annual basin samples (chemical, retention, and seepage), and quarterly and annual SWDF (burial ground) samples. Because all program changes were not fully implemented until mid-year, surveillance results are discussed on the basis of these three areas. All results are based on dry weight.

Quarterly Surveillance Samples

Sixty percent fewer vegetation samples were collected at the 16 onsite and 14 site perimeter quarterly surveillance sampling locations during 1996. (The 16 onsite locations are down from 18 in 1995, when samples from two locations were grouped with SWDF.) Analytical results are summarized in table 6–6.

Gross Alpha and Gross Beta The 1996 gross alpha levels detected in onsite, site perimeter, 25-mile-radius, and 100-mile-radius samples generally are comparable to 1995 gross alpha levels. An examination of the gross beta values revealed no significant difference between the onsite surveillance locations and the offsite locations.

Many of the gross alpha results (from both onsite and offsite samples) were at or below the LLD, as indicated by the relatively large analytical uncertainties and negative concentrations. Even though many of the gross alpha concentrations are present at the LLD, it is appropriate to state that the data are comparable to those of previous years because the methods for collection, preparation, and analysis have not changed since 1992. Variations in worldwide fallout patterns and in concentrations of naturally occurring radionuclides in the soil contribute to the differences in the gross beta concentrations.

Gamma-Emitting Radionuclides Most vegetation samples are composited for analysis of gamma-emitting radionuclides. Samples are composited by area (F-Area, H-Area) and by radius (perimeter, 25-mile, and 100-mile). S-Area and Z-Area samples are not composited but are analyzed individually.

An abundance of naturally occurring radionuclides, such as potassium-40, were detected in vegetation samples, which is to be expected. Cesium-137, the only manmade gamma-emitting radionuclide detected in the 1996 quarterly vegetation samples, was detected in samples from most locations, but most of the results were only slightly above the typical cesium-137 LLD.

Strontium The relatively low levels of strontium-89,90 detected in 1996 are similar to the levels detected since 1993. The differences in the results from year to year can be attributed to the variable strontium distribution in the surrounding soils.

As was the case with the gross alpha results, some of the strontium-89,90 levels were at or below the LLD, as indicated by the large analytical uncertainty or negative concentrations.

Tritium Onsite and site perimeter tritium concentrations generally were higher than the concentrations in vegetation samples collected from the 100-mile-radius location. These higher concentrations on site and at the site perimeter are attributed to atmospheric tritium releases from SRS.

Chemical, Retention, and Seepage Basin Samples

Vegetation samples are collected annually in the vicinity of the chemical, retention, and seepage basins. All samples from a specific operating area are composited for analysis of gross alpha, gross beta, gamma-emitting radionuclides, and strontium-89,90. Maximum concentrations are presented in table 6–7.

Gross Alpha and Gross Beta Gross alpha activity levels in vegetation samples taken at basin locations were below the LLD. Generally, the levels were consistent with the background levels observed off site and on the site perimeter.

Gross beta activity was detected in all vegetation samples analyzed. In general, the gross beta activity

Table 6–6
Maximum Radionuclide Concentrations in Vegetation from Quarterly Surveillance Samples (pCi/g)

Surveillance Ring	Maximum	Location
Gross Alpha		
Onsite	(3.16 ± 1.19)E+00	200-F #13
Site Perimeter	(3.41 ± 2.05)E+00	Windsor Road
100-Mile Radius	(1.33 ± 3.50)E–01[a]	Savannah, GA[b]
Gross Beta		
Onsite	(2.86 ± 0.12)E+01	Z-Area #6
Site Perimeter	(2.35 ± 0.17)E+01	Jackson
100-Mile Radius	(8.13 ± 1.28)E+00	Savannah, GA[b]
Cobalt-60		
Onsite	(5.27 ± 4.18)E–02[a]	S–Area #3
Site Perimeter	(6.52 ± 2.72)E–02[a]	(Composite)
100-Mile-Radius	(1.04 ± 2.37)E–02[a]	(Composite)[b]
Cesium-137		
Onsite	(8.73 ± 0.75)E–01	Z-Area #2
Site Perimeter	(6.31 ± 0.40)E–01	(Composite)
100-Mile-Radius	(1.26 ± 0.41)E–01	(Composite)[b]
Strontium		
Onsite	(7.89 ± 1.40)E–01	Z-Area #1 (Composite)
Site Perimeter	(7.95 ± 1.62)E–01	(Composite)
100-Mile-Radius	(4.67 ± 1.55)E–01[a]	Savannah, GA[b]
Tritium		
Onsite	(7.98 ± 0.10)E+01	200–H #10
Site Perimeter	(1.33 ± 0.03)E+00	East Talatha
100-Mile-Radius	(5.12 ± 3.44)E–02	Savannah, GA[b]

a Activity is less than the lower limit of detection (LLD). Representative LLDs appear in tables 6–11 and 6–12.
b Savannah, GA, is the only offsite location at which vegetation samples are collected.

detected was at or near background levels observed off site and on the site perimeter.

Gamma-Emitting Radionuclides As in 1995, cesium-137 was the only manmade gamma-emitting radionuclide detected in basin samples; it was present in a majority of the retention and seepage basin vegetation samples. Generally, the concentrations were present at levels comparable to those detected at the site perimeter, but slightly greater than the offsite levels.

Strontium Strontium-89,90 was detected in about half the samples; concentrations in the basin vegetation generally were greater than in the site perimeter and offsite vegetation. However, most values were near or slightly lower than last year's values.

The year-to-year variability of the results probably is attributable to the variable strontium distribution in the surrounding soils and the fact that the vegetation could have been collected from a slightly different location within the immediate area.

Solid Waste Disposal Facility Samples

When vegetation is available, samples are collected annually outside the SWDF to determine if there is significant uptake of radioactivity from the buried waste. During 1996, samples were collected at 13 of 15 locations immediately outside the SWDF fence; vegetation was not available for sampling at two

Table 6–7
Maximum Radionuclide Concentrations in Vegetation from Chemical, Seepage, and Retention Basins (pCi/g)

	Maximum	Location
Gross Alpha	(7.21 ± 6.09)E–01[a]	A-Area Seepage
	(7.21 ± 6.51)E–01[a]	L-Area Chemical
Gross Beta	(2.47 ± 0.18)E+01	H-Area Retention
Cobalt-60	(4.39 ± 1.71)E–02[a]	L-Area Chemical
Cesium-137	(3.87 ± 0.20)E+00	F-Area Retention
Strontium	(1.04 ± 0.04)E+01	H-Area Retention

a Activity is less than the lower limit of detection.

Table 6–8
Maximum Radionuclide Concentrations in Vegetation from Outside the Solid Waste Disposal Facility (pCi/g)

	Maximum	Location
Gross Alpha	(4.57 ± 1.64)E+00	OBG–1
Gross Beta	(2.43 ± 0.27)E–01	OBG–7
Cobalt–60	(9.48 ± 9.63)E–01[a]	643–26E–1
Cesium-137	(1.90 ± 0.23)E+00	OBG–9
Strontium	(2.79 ± 1.78)E–01	643–26E–1

a Activity is less than the lower limit of detection.

locations because of construction activity. SWDF samples are analyzed for gross alpha, gross beta, and gamma-emitting radionuclides. Maximum concentrations are presented in table 6–8. Generally, sample results were comparable to or slightly lower than results since 1993, and all activity was at or near levels detected at the site perimeter. These results indicated no significant uptake of radioactivity from the buried waste.

Table 6–9
Representative Lower Limits of Detection for Gamma Analysis of Water and Air Samples[a]

Nuclide	pCi/L		pCi/m^2	pCi/m^3
	River Water	Stream Water	Rainwater	Air Filter
Ce-141	0.8	8	36	12
Ce-144	2.9	29	125	33
Co-58	0.6	7	29	10
Co-60	1.0	9	32	11
Cr-51	5.8	56	246	93
Cs-134	0.7	6	27	8
Cs-137	0.7	7	26	8
I-131	1.2	16	72	16
Mn-54	0.7	7	32	11
Nb-95	0.8	10	36	14
Ru-103	0.6	7	28	10
Ru-106	5.5	59	278	88
Sb-125	1.8	15	63	19
Zn-65	1.4	17	64	22
Zr-95	1.4	12	55	19

a The lower limits of detection (LLDs) are calculated at the 95% confidence level with Canberra Industries Inc.'s VAX/VMS gamma spectroscopy software. The values are based on a background measurement using a 32% relative efficiency high purity germanium detector and typical decay times and counting intervals. Chemical recoveries are assumed to be 100%. Air filter values are for a single 47mm particulate filter with a flow rate of approximately 2.5 cubic feet per minute (CFM) for 7 days (I-131 value is obtained from a charcoal cartridge). Rainwater values are for a collection area of 0.031m^2. The sample size for stream water is 1 L and for river water is 10 L. The LLDs for actual samples may be different because of variations in the sample preparation, size, and content, and because of variations in the chemical recoveries, counting efficiencies, decay times, and instrument backgrounds.