Front Cover — Bottomland areas at the Savannah River Site (SRS) feature an abundance of hardwoods, many of which display brilliant colors during the autumn months. Showing off crimson leaves here in a background of green is a swamp tupelo, or swamp blackgum (*Nyssa sylvatica* variety *biflora*), a common swamp tree found along the Atlantic and Gulf coastal plains from Delaware to Texas, and up the Mississippi River valley to Arkansas and Tennessee. At SRS, the tree often appears in drier areas of the Savannah River Swamp, in the lower reaches of small streams, and in Carolina bays. The swamp tupelo is known primarily as a valuable source of food for wildlife and pollen for honeybees—as well as for its colorful fall foliage. This year's cover photograph was taken by Al Mamatey of the Westinghouse Savannah River Company's Environmental Protection Department. The cover was designed by Eleanor Justice of the company's Management Services Department – Illustrating and Design Group.

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WSRC–TR–2001–00474

Savannah River Site
Environmental Report for 2001

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Westinghouse Savannah River Company
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Acronyms and Abbreviations

Note: Sampling location abbreviations can be found on page xiii.

A

AEC – U.S. Atomic Energy Commission

ALARA – As low as reasonably achievable

ANSP – Academy of Natural Sciences of Philadelphia

B

BCG – Biota concentration guide

BOD – Biological oxygen demand

BSRI – Bechtel Savannah River, Inc.

BTU – British Thermal Unit

C

CAA – Clean Air Act

CAAA – Clean Air Act Amendments of 1990

CAB – Citizens Advisory Board

CAS – Chemical abstract numbers

CDC – Centers for Disease Control and Prevention

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)

CFC – Chlorofluorocarbon

CFR – Code of Federal Regulations

CIF – Consolidated Incineration Facility

CLED – Contaminated large-equipment disposition

CMP – Chemicals, metals, and pesticides

COU – Catalytic oxidation unit

CSRA – Central Savannah River Area

CSSX – Caustic side solvent extraction

CSWTF – Central Sanitary Wastewater Treatment Facility

C-TOX – Chronic toxicity

CWA – Clean Water Act

CX – Categorical exclusion

D

D&D – Deactivation and decommissioning

DCG – Derived concentration guide

DOE – U.S. Department of Energy

DOE/EML – U.S. Department of Energy Environmental Measurements Laboratory

DOE–HQ – U.S. Department of Energy-Headquarters

DOE–SR – U.S. Department of Energy-Savannah River Operations Office

DUS – Dynamic underground stripping

DWPF – Defense Waste Processing Facility

DWS – Drinking water standards

E

EA – Environmental assessment

ECA – Environmental Compliance Authority

EE/CA – Engineering evaluation/cost analysis

EGG – Environmental Geochemistry Group

EIS – Environmental impact statement

EMCAP – Environmental Monitoring Computer Automation Program

EMS – Environmental Monitoring Section of the Environmental Protection Department (of Westinghouse Savannah River Company)

EPA – U.S. Environmental Protection Agency

EPCRA – Emergency Planning and Community Right-to-Know Act

EPD – Environmental Protection Department (of Westinghouse Savannah River Company)

ERA – Environmental Resource Associates

ERD – Environmental Restoration Division

ERDMS – Environmental Restoration Data Management System

ESCO – Energy Services Company

ETF – Effluent Treatment Facility

EST – Environmental Sciences and Technology Department

F

FDD – Facilities Decontamination and Decommissioning program (formerly the Facilities Disposition Division)

FFA – Federal Facility Agreement

FFCA – Federal Facility Compliance Agreement

FFCAct – Federal Facility Compliance Act

FONSI – Finding of no significant impact

G

GDNR – Georgia Department of Natural Resources

GIMS – Geochemical Information Management System

GIS – Geographic Information System

GOCO – Government-owned, contractor-operated

GPMP – Groundwater Protection Management Program Plan

GSMP – Groundwater Surveillance Monitoring Program

GSA – General Separations Area

H

HBFC – Hydrobromofluorocarbon

HCFC – Hydrochlorofluorocarbon

HEAST – *Health Effects Assessment Summary Tables* (EPA)

HVAC – Heating, ventilation, and air conditioning

HWMF – hazardous waste management facilities

I

ICRP – International Commission on Radiological Protection

ISO – International Organization for Standardization

K

KAMS – K-Area materials storage

L

LDR – Land disposal restrictions

LLD – Lower limit of detection

LLW – Low-level radioactive waste

M

MACT – Maximum achievable control technology

MAP – Mitigation action plan

MCL – Maximum contaminant level

MDA – Minimum detectable activity

MDC – Minimum detectable concentration

MDL – Minimum detectable limit

MLLW – Miixed (i.e., hazardous and radioactive) low-level radioactive waste

MOX – Mixed oxide

MRD – Mean relative difference

mrem – Millirem

MWMF – Mixed Waste Management Facility

N

NCRP – National Council on Radiation Protection and Measurements

NELAC – National Environmental Laboratory Accreditation Conference

NEPA – National Environmental Policy Act

NESHAP – National Emission Standards for Hazardous Air Pollutants

NFN – No file negative

NHPA – National Historic Preservation Act

NIST – National Institute of Standards and Technology

NOV – Notice of violation

NPDES – National Pollutant Discharge Elimination System

NRC – Nuclear Regulatory Commission

NSPS – New Standards of Performance for Stationary Sources

NWP – Nationwide permit

O

ODS – Ozone-depleting substance

P

PAR Pond – Pond constructed at Savannah River Site in 1958 to provide cooling water for P-Reactor and R-Reactor (P and R; hence, PAR)

PEIS – Programmatic environmental impact statement

pH – Measure of the hydrogen ion concentration in an aqueous solution (acidic solutions, pH from 0–6; basic solutions, pH > 7; and neutral solutions, pH = 7)

ppm – Parts per million

PQL – Practical quantitation limit

Q

QA – Quality assurance

QAP – Quality Assurance Program (Department of Energy)

QA/QC – Quality assurance/quality control

QC – Quality control

R

RBOF – Receiving Basin for Offsite Fuel

RCRA – Resource Conservation and Recovery Act

RFI/RI – RCRA facility investigation/remedial investigation

ROD – Record of decision

ROSRS – Remote-operations size-reduction system

RQ – Reportable quantity

RTF – Replacement Tritium Facility

S

SARA – Superfund Amendments and Reauthorization Act

SCDHEC – South Carolina Department of Health and Environmental Control

SCHWMR – South Carolina Hazardous Waste Management Regulations

SDWA – Safe Drinking Water Act

SEIS – Supplemental environmental impact statement

SESI – Shealy Environmental Services, Inc.

S&HO – Safety and Health Operations

SIRIM – Site Item Reportability and Issues Management

S&M – Surveillance and maintenance

SRARP – Savannah River Archaeological Research Program

SREL – Savannah River Ecology Laboratory

SRIP – Savannah River implementation procedure

SRL – Savannah River Laboratory (now Savannah River Technology Center)

SRS – Savannah River Site

SRTC – Savannah River Technology Center (formerly Savannah River Laboratory)

STP – Site treatment plan

SU – Standard unit

SUD – Site Utilities Division of Westinghouse Savannah River Company

SVE – Soil vapor extraction

SWD – Solid Waste Division

SWDF – Solid Waste Disposal Facility

SWMF – Solid Waste Management Facility

T

TCLP – Toxicity Characteristic Leaching Procedure

TLD – Thermoluminescent dosimeter

TMDL – Total maximum daily load

TPBARS – Tritium producing burnable absorber rods

TRU – Transuranic waste

TSCA – Toxic Substances Control Act

TSS – Total suspended solids

U

USFS–SR – U.S. Department of Agriculture Forest Service–Savannah River

USGS – U.S. Geological Survey

V

VIA – Values impact assessment

VOC – Volatile organic compound

W

WET – Whole effluent toxicity

WIPP – Waste Isolation Pilot Plant

WSRC – Westinghouse Savannah River Company

Sampling Location Information

Note: This section contains sampling location abbreviations used in the text and/or on the sampling location maps. It also contains a list of sampling locations known by more than one name (see next page).

Location Abbreviation	Location Name/Other Applicable Information
4M	Four Mile
4MC	Four Mile Creek
BDC	Beaver Dam Creek
BG	Burial Ground
EAV	E-Area Vaults
FM	Four Mile
FMC	Four Mile Creek (Fourmile Branch)
GAP	Georgia Power Company
HP	HP (sampling location designation only; not an actual abbreviation)
HWY	Highway
KP	Kennedy Pond
L3R	Lower Three Runs
NRC	Nuclear Regulatory Commission
NSB L&D	New Savannah Bluff Lock & Dam
PAR	"P and R" Pond
PB	Pen Branch
RM	River Mile
SC	Steel Creek
SWDF	Solid Waste Disposal Facility
TB	Tims Branch
TC	Tinker Creek
TNX	Multipurpose Pilot Plant Campus
U3R	Upper Three Runs

Sampling Locations Known by More Than One Name

Augusta Lock and Dam; New Savannah Bluff Lock and Dam

Beaver Dam Creek; 400–D

Four Mile Creek–2B; Four Mile Creek at Road C

Four Mile Creek–6; Four Mile Creek at Road A–13–2

Lower Three Runs–2; Lower Three Runs at Patterson Mill Road

Pen Branch–3; Pen Branch at Road A–13–2

R-Area downstream of R–1; 100–R

River Mile 118.8; U.S. Highway 301 Bridge Area; Highway 301; US 301

River Mile 129.1; Lower Three Runs Mouth

River Mile 141.5; Steel Creek Boat Ramp

River Mile 150.4; Vogtle Discharge

River Mile 152.1; Beaver Dam Creek Mouth

River Mile 157.2; Upper Three Runs Mouth

River Mile 160.0; Dernier Landing

Steel Creek at Road A; Steel Creek–4; Steel Creek–4 at Road A; Steel Creek at Highway 125

Tims Branch at Road C; Tims Branch–5

Tinker Creek at Kennedy Pond; Tinker Creek–1

Upper Three Runs–4; Upper Three Runs–4 at Road A; Upper Three Runs at Road A; Upper Three Runs at Road 125

Upper Three Runs–1A; Upper Three Runs–1A at Road 8

Chapter 1

Environmental Compliance

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Contributing authors' names appear on page 24.

THE goal of the Savannah River Site (SRS)—and that of the U.S. Department of Energy (DOE)—is positive environmental stewardship and full regulatory compliance, with zero violations. The site's employees maintained progress toward achievement of this goal in 2001, as demonstrated by examples in this chapter.

The site's compliance efforts were near-perfect again in 2001. No notices of violation (NOVs) were issued in 2001 under the Resource Conservation and Recovery Act (RCRA), the Safe Drinking Water Act (SDWA), or the Clean Water Act (CWA). Two NOVs were issued to SRS during 2001—one, associated with permit requirement compliance, was issued under the Clean Air Act (CAA); the other, related to an oil release, was issued under the South Carolina Pollution Control Act. Under the CWA, the site's National Pollutant Discharge Elimination System (NPDES) compliance rate was 99.6 percent. Also, 274 National Environmental Policy Act (NEPA) reviews of newly proposed actions were conducted and formally documented in 2001, and only one of the year's 799 Site Item Reportability and Issues Management (SIRIM) program-reportable events was categorized as environmental; it was classified as an off-normal event.

Some key regulations with which SRS must comply—and its compliance status on each—are noted in the chart on the next page.

Compliance Activities

Compliance with environmental regulations and with DOE orders related to environmental protection is a critical part of the operations at SRS. Assurance that onsite processes do not impact the environment adversely is a top priority, and management of the environmental programs at SRS is a major activity. All site compliance activities are overseen by one or more regulatory bodies, including the U.S. Environmental Protection Agency (EPA) and the South Carolina Department of Health and Environmental Control (SCDHEC). Significant effort and funding have been dedicated to ensuring that site facilities and operations comply with all requirements.

Resource Conservation and Recovery Act

RCRA was passed in 1976 to address the problem of solid and hazardous waste management. The law requires that EPA regulate the management of solid and hazardous wastes, such as spent solvents, batteries, and many other discarded substances deemed potentially harmful to human health and the environment. Amendments to RCRA regulate nonhazardous solid waste and some underground storage tanks.

RCRA also is responsible for managing inactive land-based facilities that were operating in 1982 and nonland-based facilities that were operating in 1980. RCRA requires that these inactive facilities be closed. If they cannot be clean-closed, RCRA issues permits for postclosure care and possible corrective actions. These facilities also are subject to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements; however, through the SRS Federal Facility Agreement (FFA) with EPA and SCDHEC, it was agreed that if the facilities met the RCRA closure and postclosure requirements, they would not be subject to any additional CERCLA requirements.

Under RCRA, hazardous waste generators are responsible for managing every aspect of the generation, treatment, storage, and disposal of the waste; this is referred to as "cradle-to-grave" management. Hazardous waste generators, including SRS, must follow specific requirements for handling these wastes. For many waste management activities, RCRA requires permits for owners and operators of operating facilities.

Some of the Key Regulations SRS Must Follow

Legislation	**What it Requires/*SRS Compliance Status***
RCRA Resource Conservation and Recovery Act (1976)	♦ The management of hazardous and nonhazardous wastes and of underground storage tanks containing hazardous substances and petroleum products – *In compliance*
FFCAct Federal Facility Compliance Act (1992)	♦ The development by DOE of schedules for mixed waste treatment to avoid waiver of sovereign immunity and to meet LDR requirements – *In compliance*
CERCLA; SARA Comprehensive Environmental Response, Compensation, and Liability Act (1980); Superfund Amendments and Reauthorization Act (1986)	♦ The establishment of liability, compensation, cleanup, and emergency response for hazardous substances released to the environment – *SRS placed on National Priority List in December 1989*
CERCLA/TITLE III (EPCRA) Emergency Planning and Community Right-to-Know Act (1986)	♦ The reporting of hazardous substances used on site (and their releases) to EPA, state, and local planning units – *In compliance*
NEPA National Environmental Policy Act (1969)	♦ The evaluation of the potential environmental impact of federal activities and alternatives; in 2001, WSRC conducted 274 reviews of newly proposed actions – *In compliance*
SDWA Safe Drinking Water Act (1974)	♦ The protection of public drinking water systems; enacted in 1974, amended in 1980, 1986 – *In compliance*
CWA; NPDES Clean Water Act (1977); National Pollutant Discharge Elimination System	♦ The regulation of liquid discharges at outfalls (e.g., drains or pipes) that carry effluents to streams – *In compliance*
CAA; NESHAP Clean Air Act (1970); National Emission Standards for Hazardous Air Pollutants	♦ The establishment of air quality standards for hazardous air emissions, such as radionuclides and benzene – *In compliance*
TSCA Toxic Substances Control Act (1976)	♦ The regulation of use and disposal of PCBs – *Nation has inadequate disposal capacity for radioactive PCBs generated and currently stored at SRS*

EPA is responsible for all hazardous waste regulations. However, EPA can delegate this authority to a state when the state passes laws and regulations that meet or exceed the EPA hazardous waste regulations. The state plan then must be approved by EPA. The agency has approved South Carolina's plan and delegated RCRA authority to SCDHEC. Similarly, the Federal Facility Compliance Act (FFCAct) gives the state authority to enforce land disposal restrictions (LDRs) for mixed wastes, which contain both hazardous and radioactive wastes. Also, SCDHEC has been authorized by the FFCAct to play the key role in the implementation of the FFCAct statute and was the lead regulatory agency for implementation of the SRS Site Treatment Plan (STP), which addresses storage and treatment of mixed waste. More information on waste management at SRS can be found in chapter 2, “Environmental Management.”

SRS received no RCRA-related NOVs during 2001.

Land Disposal Restrictions

The 1984 RCRA amendments established LDRs to minimize the threat of hazardous constituents migrating to groundwater sources. Hazardous wastes were banned from land disposal unless certain treatment requirements were met. LDRs do not allow storage of hazardous wastes except for the purpose of accumulating such quantities as are necessary to facilitate proper recovery, treatment, or disposal.

The same restrictions apply to mixed wastes. Because SRS did not have the capacity to treat all mixed wastes according to the applicable LDR standards, an LDR Federal Facility Compliance Agreement (FFCA) was signed in March 1991 between DOE’s Savannah River Operations Office (DOE–SR) and EPA Region IV (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee). The FFCA was an independent compliance instrument initiated by SRS and was not part of the FFCAct statute described below. The goal of the FFCA was to address SRS mixed waste compliance with LDRs. The FFCA was terminated September 29, 1995—by mutual consent of SRS and EPA—when the STP consent order became effective.

Treatability variances are an option available to waste generation facilities if alternate treatment methods are appropriate for specific waste streams. SRS has identified certain mixed waste streams that are potential candidates for a treatability variance. The STP references four treatability variances for mixed wastes with special problems that prevent treatment according to LDR standards. Two of the variances, completed and sent to EPA headquarters in September 1997, were for tritiated water with mercury and for silver saddles (silver nitrate-coated ceramic devices designed to take up iodine gas). A third variance, for plastic/lead/cadmium Raschig rings (packing material spacers used for criticality control), was submitted September 7, 1999. These three are pending approval. With respect to the fourth variance, an interpretation was received from EPA in August 2001 regarding the treatment of radioactively contaminated lead-acid batteries. EPA considers these batteries to be radioactive lead solids; therefore, if appropriate standard treatment methods (i.e., macroencapsulation) were employed, the recovery of lead would not be necessary and SRS would not need a treatability variance for this waste.

Federal Facility Compliance Act

The FFCAct was signed into law in October 1992 as an amendment to the Solid Waste Disposal Act to add provisions concerning the application of certain requirements and sanctions to federal facilities. For mixed waste, the FFCAct provided a 3-year extension (until October 1995) of the LDR compliance date so that DOE sites could investigate mixed waste volumes in storage, evaluate treatment capacities, and develop STPs with schedules for mixed waste treatment for approval by their state or federal regulatory agencies.

Westinghouse Savannah River Company (WSRC) submitted a mixed waste inventory report January 13, 1993, and DOE Headquarters (DOE–HQ) issued a complexwide report—*U.S. Department of Energy Interim Mixed Waste Inventory Report: Waste Streams, Treatment Capacities, and Technologies*—April 21, 1993, to state governors and to regulatory agencies in states that host DOE sites. This was followed by a comment period for the regulators and states. DOE–HQ provided an update to the mixed waste inventory report in April 1994.

On March 30, 1995, DOE–SR submitted an STP that addressed the development of capacities and technologies for treating SRS mixed wastes in accordance with LDRs, as required by the FFCAct. This plan was approved with modifications, and the STP consent order was executed September 29, 1995.

As required by the STP consent order, SRS issued an annual update to the STP by April 30, 2001. The update identified changes in the mixed waste treatment status, including the addition of new mixed waste streams. STP updates will continue to be produced annually unless the consent order is modified.

Underground Storage Tanks

The 19 underground storage tanks at SRS that house petroleum products—such as gasoline and diesel fuel—and hazardous substances, as defined by CERCLA, are regulated under Subtitle I of RCRA.

These tanks require a compliance certificate annually from SCDHEC to continue operations. SCDHEC conducts an annual compliance inspection and records audit prior to issuing the compliance certificate. The inspection/audit for 2002 will be conducted by SCDHEC early in the year.

The site closed and removed one underground storage tank in 2001.

High-Level Radioactive Waste Tank Closure

The primary regulatory goal of SRS's waste tank closure process at the F-Area and H-Area high-level tank farms is to close the tank systems in a way that protects public health and the environment in accordance with South Carolina Regulation 61–82, "Proper Closeout of Wastewater Treatment Facilities." This must be accomplished in compliance with the requirements of RCRA and CERCLA, under which the high-level waste tank "farms" will be remediated. A general tank closure plan presents the environmental regulatory standards and guidelines pertinent to closure of the waste tanks and describes the process for evaluating and selecting the closure configuration (the residual source term and method of stabilizing the tanks systems' residual waste material). The plan also describes the integration of high-level waste tank system closure with existing commitments to remove waste from the tanks before closure and to ultimately remediate the entire area (including soils and groundwater) surrounding the tank farms.

Tank 20F, a 1.3-million-gallon, single-shelled, carbon steel vessel, and tank 17F, with the same construction and capacity, were closed in 1997. Prior to the initiation of closure activities, all but approximately 1,000 gallons of waste in tank 20F and 2,400 gallons in tank 17F were removed and further processed.

The assessment of soils and groundwater around the waste tanks is being deferred until complete closure of a geographical grouping of tank systems and their associated support services. Currently, the tank 17F and tank 20F systems cannot be isolated practically from other operational systems (tanks 18F and 19F and the 1F evaporator) for the purpose of assessing potential remedial actions.

The FFA requires closure of tank 19F in 2003 and tank 18F in 2004. The removal of waste from tank 19F was completed in November 2001. The waste residual characterization will be completed in 2002. A tank 19F closure module subsequently will be prepared and submitted to SCDHEC for approval prior to the initiation of closure activities. The general plan for high-level waste tank system closure was revised and submitted in March 2000 to DOE–HQ, EPA, and SCDHEC for approval, as required by DOE Order 435.1 ("Radioactive Waste Management"). EPA and SCDHEC approved the plan in September 2000.

DOE determined in October 1998 that SRS should perform a tank closure environmental impact statement (EIS) before conducting any further closure activities. A record of decision (ROD) on this action, originally scheduled for December 1999, was expected during 2001 but was delayed because of changes required as a result of the terrorist attacks on September 11.

RCRA 3004(u) Program

The hazardous waste permit issued to SRS in September 1987 (and renewed in October 1995) requires that the site institute a program for investigating and, if necessary, performing corrective actions at solid waste management units under RCRA 3004(u). The RCRA 3004(u) requirements have been integrated with CERCLA requirements in the FFA. The integration of RCRA and CERCLA regulatory requirements is expected to provide a more cost-effective and focused investigation and remediation process. The RCRA/CERCLA program status is detailed under the CERCLA section of this chapter.

Waste Minimization Program

The SRS Waste Minimization Program is part of a broad, ongoing effort to prevent pollution and minimize waste on site. The program is designed to meet the requirements of RCRA, of DOE orders, and of applicable executive orders.

Comprehensive Environmental Response, Compensation, and Liability Act

SRS was placed on the National Priority List in December 1989, under the legislative authority of CERCLA (Public Law 96–510), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA, Public Law 99–499). CERCLA assigns liability and provides for compensation, cleanup, and emergency response for hazardous substances released to the environment.

In accordance with Section 120 of CERCLA, DOE, EPA Region IV, and SCDHEC entered into the FFA, which became effective August 16, 1993. Declaration of the effective date resulted in the FFA being an enforceable agreement. The FFA sets the milestones for the investigation and remediation of waste management units at SRS and for the integration of CERCLA and RCRA 3004(u) requirements.

The FFA also identifies about 300 site evaluation units for which investigations are required. These are suspect areas that are screened to determine if additional investigation and possible remediation are warranted. Site evaluation reports on 16 areas were submitted to EPA Region IV and SCDHEC in 2001.

Releases or potential releases from RCRA/CERCLA waste management units are evaluated under the FFA.

Work plans detailing the proposed investigations for the RCRA/CERCLA units must be approved by both EPA Region IV and SCDHEC prior to implementation.

Remediation under CERCLA imposes requirements in addition to existing RCRA requirements. CERCLA requires remedial decisions to be based on the results of a baseline risk assessment, which examines present and future risk to human health and the environment from the waste unit, using conservative, EPA Region IV-approved exposure scenarios.

CERCLA also requires public participation in the selection of remediation alternatives. A significant step in this process is the development of a Proposed Plan, which highlights key aspects of the remedial investigation and feasibility study. The plan also provides a brief analysis of remedial alternatives that were considered, identifies the preferred alternatives, and tells the public how it can participate in the remedy selection process. After consideration of public comments and further analysis, decisions are made and documented in a ROD, which presents the selected remedy and provides the rationale for that selection. Also included in this process is the establishment of an administrative record file that documents the remediation alternatives and provides for public review of them.

Details of the site's environmental program are provided in the *Federal Facility Agreement Annual Progress Report for Fiscal Year 2001*, WSRC–RP–2001–4166.Preparation of this report is required under terms of the FFA.

SRS's 2001 environmental restoration activities were highlighted by

- the issuance of signed RODs on (1) the A-Area Burning/Rubble Pits (731–A and –1A) and A-Area Rubble Pit (731–2A) Interim Action, (2) Old Radioactive Waste Burial Ground Solvent Tanks Interim Action, and (3) Miscellaneous Chemical Basin/Metals Burning Pit Interim Action
- the initiation of RCRA Facility Investigation/Remedial Investigation characterizations on A-Area Burning/Rubble Pits (731–A, –1A) and Rubble Pit (731–2A), (2) D-Area Expanded Operable Unit (488–D, 489–D, and 484–10D), (3) Heavy Equipment Wash Basin and Central Shops Burning/Rubble Pit (631–5G), (4) Formulae Branch Integrator Operable Unit, (5) Savannah River Floodplain Swamp Integrator Operable Unit, and (6) H-Area Groundwater Operable Unit
- the initiation of remedial actions at (1) the P-Area Bingham Pump Outage Pits, (2) the L-Area Bingham Pump Outage Pits, and (3) the C-Area Reactor Seepage Basins
- the continuation of remedial actions initiated prior to fiscal year 2001 on (1) the A-Area Burning/Rubble Pits and Rubble Pit, (2) the CMP Pits Interim Action, (3) the K-Area Reactor Seepage Basin, (4) the Miscellaneous Chemical Basin/Metals Burning Pit, (3) the C-Area Burning/Rubble Pit (131–C) Interim Action, (4) the Old F-Area Seepage Basin (904–49G), and (5) the TNX Groundwater Operable Unit (082–G) Interim Action
- the completion of remedial actions at (1) the SRL Seepage Basins, (2) the F-Area Retention Basin, and (3) the L-Area Oil/Chemical Basin

Table 1–7 ("SRS 2001 Environmental Restoration Activities"), beginning on page 22, includes a more complete presentation of the site environmental restoration program's environmental restoration activities. A listing of all operable units at SRS can be found in appendix C ("RCRA/CERCLA Units List") and appendix G ("Site Evaluation List") of the FFA.

Emergency Planning and Community Right-to-Know Act

Two related federal acts were passed within a period of 4 years to help protect the public and the environment. The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 was established as a freestanding provision of SARA. EPCRA requires facilities to notify state and local emergency planning entities about their hazardous chemical inventories and to report releases of hazardous chemicals. The Pollution Prevention Act of 1990 expanded the Toxic Chemical Release Inventory report to include source reduction and recycling activities.

Tier II Inventory Report

Under Section 312 of EPCRA, SRS completes an annual Tier II Inventory Report for all hazardous chemicals present at the site in excess of specified quantities during the calendar year. Hazardous chemical storage information is submitted to state and local authorities by March 1 for the previous calendar year.

Toxic Chemical Release Inventory Report

Under Section 313 of EPCRA, SRS must file an annual Toxic Chemical Release Inventory report by July 1 for the previous year. SRS calculates chemical releases to the environment for each regulated chemical that exceeds its established threshold and reports the release values to EPA on Form R of the report. The release values include chemical releases to air, water, land, underground injection, and offsite transfers. EPA treats offsite transfers as releases to the environment for reporting purposes. The transfers actually are shipments of waste to EPA-approved facilities for further treatment, storage, disposal, or recycling.

Form R for 2000 was submitted to EPA in June 2001. Eight chemicals, with releases totaling 248,332 pounds, exceeded the "manufactured," "processed," or "otherwise used" threshold and were reported to EPA for 2000. This compares with twelve chemicals (281,056 pounds of releases) exceeding the threshold for 1999 and 10 chemicals (160,580 pounds of releases) for 1998. In 1997, in response to EPA guidance, the site modified its calculation protocol for the estimation of metal emissions from coal-fired units. Coal combustion represented more than 90 percent of the total 2000 release inventory. Releases from waste immobilization activities at the Defense Waste Processing Facility (DWPF) and reprocessing operations at the canyon facilities represented less than 3 percent of the total releases for 2000.

A breakdown of the comparison of toxic chemical releases from 1998 through 2000 is presented in table 1–1. Site operations, which determine these releases, are expected to remain relatively steady until new missions are funded.

Nitrate, chromium, and zinc compounds were the largest contributors to the total reportable releases in 2000. Nitrates released via NPDES outfalls and metals-to-land disposal represented the two major receiving media. Wackenhut changed training ammunition in 1998 to environmentally friendly "green bullets" (lower lead content), which reduced the volume of lead discharged to land. Hexane, toluene, and xylene disappeared in 2000 because of a change in gasoline formulation used on site.

Executive Order 12856

Executive Order 12856 requires that all federal facilities comply with right-to-know laws and pollution prevention requirements. The order requires that federal facilities meet EPCRA reporting requirements and develop voluntary goals to reduce releases of toxic chemicals 50 percent on a DOE complexwide basis by the end of 1999—a goal accomplished by the complex. SRS complies with the applicable reporting requirements for EPCRA, as indicated in table 1–2, and the site incorporates the toxic chemicals on the Toxic Chemical Release Inventory report into its pollution prevention efforts.

National Environmental Policy Act

NEPA establishes policies and goals for the protection, maintenance, and enhancement of the human environment in the United States. NEPA's purpose is to provide the federal government with a process for implementing these goals. The act requires consideration of environmental factors during the planning process for all major federal activities that could significantly affect the quality of the environment. In practice, NEPA provides a means to evaluate the potential environmental impact of such proposed activities and to examine alternatives to those actions.

Although implemented at SRS by the Energy Research and Development Administration during the 1970s, a formal maintenance and operations NEPA compliance group was not established on site until 1982. The ongoing mission of this group is to make recommendations regarding the level of NEPA review of site-proposed action and to prepare draft documentation supporting DOE–SR compliance with NEPA at SRS.

In 2001, 274 reviews of newly proposed actions were conducted at SRS and formally documented through categorical exclusions (CXs), notifications of previous NEPA coverage, environmental assessments (EAs), NEPA values impact assessments (VIAs), engineering evaluations/cost analyses (EE/CAs), or EISs.

WSRC also provided technical support to DOE–SR for the preparation of supplemental environmental impact statements (SEISs) and programmatic environmental impact statements (PEISs).

The types and numbers of NEPA activities conducted at SRS during 2001 are presented in table 1–3. Among the specific activities were the following:

- The final EA and FONSI on the proposed offsite transportation of certain low-level radioactive waste (LLW) and mixed (i.e., hazardous and radioactive) low-level radioactive waste (MLLW) from SRS were issued February 15. This EA evaluated the potential for significant impacts associated with the proposed shipment of five LLW or MLLW forms to offsite facilities for treatment and/or final disposal. The purpose of the proposed action is to provide DOE with a viable near-term treatment and disposal option for these waste forms. DOE needed to take action in a cost-effective and timely manner because onsite treatment and disposal capabilities for these waste forms does not exist at this time and/or it would be more beneficial to DOE to dispose of the waste at another location. In

Table 1–1 Releases and Offsite Transfers of Toxic Chemicals (in Pounds) by SRS During 1998, 1999, and 2000 Reporting Years (Reported Under EPCRA Section 313)

1998

Chemical	Air Emissions	Water Discharges	Land Disposal	Offsite Transfers	Total Releases
Chromium compounds	168	3	2,203	236	2,610
Formic acid	7,400	0	0	0	7,400
HCFC 22	14,160	0	0	0	14,160
Lead	5	47	6,601	308	6,961
Lithium carbonate	16	0	0	0	16
Methyl tert-butyl ether	1	0	0	0	1
Nitrate compounds	26	19,721	95,000	9	114,756
Nitric acid	3,530	0	0	11	3,541
Sodium nitrite	2	0	8,000	0	8,002
Zinc compounds	577	621	1,933	2	3,133
Totals	**25,885**	**20,392**	**113,737**	**566**	**160,580**

1999

Chemical	Air Emissions	Water Discharges	Land Disposal	Offsite Transfers	Total Releases
Chromium compounds	1,001	10	31,100	27	32,138
Formic acid	6,832	0	12	0	6,844
n-Hexane	430	0	0	10	440
Lead	6	35	4,800	1,500	6,341
Lithium carbonate	7	0	0	0	7
Naphthalene	57	0	0	3	60
Nitrate compounds	201	28,165	0	86	28,452
Nitric acid	3,500	0	0	273	3,773
Sodium nitrite	7	0	3	8	18
Toluene	1,030	0	5	69	1,104
Xylene	350	0	0	400	750
Zinc compounds	4,046	4,034	193,000	49	201,129
Totals	**17,467**	**32,244**	**228,920**	**2,425**	**281,056**

2000

Chemical	Air Emissions	Water Discharges	Land Disposal	Offsite Transfers	Total Releases
Chromium compounds	835	14	27,801	0	28,650
Formic acid	2,201	0	0	0	2,201
Lead	10	16	4,900	762	5,688
Mercury compounds	829	1	0	3	833
Nitrate compounds	712	34,830	0	801	36,343
Nitric acid	5,420	0	0	60	5,480
Sodium nitrite	0	0	1	49	50
Zinc compounds	14,024	2,367	150,055	8	166,454
Totals	**24,031**	**37,228**	**182,757**	**1,683**	**245,699**

Table 1–2 2001 SRS Reporting Compliance with Executive Order 12856

EPCRA Citation	Activity Regulated	Reported per Applicable Requirement
302–303	Planning Notification	Not Required[a]
304	Extremely Hazardous Substances Release Notification	Not Required[a]
311–312	Material Safety Data Sheet/ Chemical Inventory	Yes
313	Toxic Release Inventory Reporting	Yes

a Not required to report under provisions of “Executive Order 12856 and SARA Title III Reporting Requirements”

addition, the estimated volume of these wastes likely would exceed regulatory limits for post-generation storage. This situation would not be consistent with the agreements between DOE and the State of South Carolina concerning MLLW management under the site STP that was developed pursuant to the FFCAct. Violating these agreements could result in fines and penalties for DOE, as well as suspension of the site’s RCRA permit.

Table 1–3 Types/Quantity of NEPA Activities at SRS During 2001

Type of NEPA Documentation	Number
Categorical Exclusion	251
Tiered to Previous NEPA Documentation	20
Environmental Assessment	4
Programmatic Environmental Assessment	2
Engineering Evaluation/Cost Analysis	1
Values Impact Assessment	1
Environmental Impact Statement	4
Supplemental Environmental Impact Statement	1
Programmatic Environmental Impact Statement	1
Total	285[a]

a Eleven of the 285 NEPA activities were carryovers from 2000, leaving 274 newly proposed actions in 2001.

- DOE issued the fifth ROD related to the final PEIS on DOE Waste Management July 25. The first ROD dealt with decisions for the management of transuranic waste, while the second was concerned with the disposal of nonradioactive hazardous waste. The third ROD dealt with decisions for the storage of high-level radioactive waste, and the fourth dealt with the management of low-level and mixed radioactive waste types within the DOE complex. The fifth ROD revised DOE’s decision for transuranic waste, electing to transfer approximately 300 cubic meters of contact-handled transuranic waste from the Mound Plant in Ohio to SRS for storage, characterization, and repackaging prior to sending it to the Waste Isolation Pilot Plant in New Mexico for disposal. The contact-handled transuranic waste will be shipped to SRS in specially designed rail cars under an exemption granted by the U.S. Department of Transportation.

- The ROD for the SRS Salt Processing Alternatives final SEIS was issued October 17. The SEIS considered alternatives for separating the high-activity fraction from the low-activity fraction of the high-level radioactive salt wastes now stored in underground tanks at SRS. Based on the analysis in the SEIS and the results of laboratory scale research and development and independent reviews, DOE determined that any of the alternatives evaluated could be implemented with only small and acceptable environmental impacts. This ROD covers DOE’s decision to implement the alternative for caustic side solvent extraction for separation of radioactive cesium from the SRS salt wastes.

Table 1–4 SRS Project NEPA Documentation Activities During 2001

Project Name	Level of NEPA Documentation
DOE Waste Management	PEIS
Disposition of Scrap Metals	PEIS
Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada	EIS
High-Level Waste Salt Disposition Alternatives at SRS	EIS
SRS High-Level Waste Tank Closure	EIS
Removal, Transportation, and Storage of Radioisotopic Thermoelectric Generators from Burnt Mountain, Alaska	PEA
Storage, Transportation, and Disposition of Potentially Reusable Uranium Materials	PEA
Alternative Approach for the DWPF Glass Waste Canister Storage Facility at SRS	EA
Construction and Operation of the Low Enriched Uranium Loading Station and Modification to the Existing Highly Enriched Uranium Blending Facilities at SRS	EA
Offsite Transportation of Certain Low-Level and Mixed Radioactive Waste from SRS for Treatment and Disposal at Commercial Facilities	EA
Natural Resources Management Activities at SRS	EA
Closure of the R-Reactor Disassembly Basin at SRS	EE/CA
Remediation of TNX-Area Operable Unit at SRS	VIA

Key: PEIS — Programmatic Environmental Impact Statement
EIS — Environmental Impact Statement
PEA — Programmatic Environmental Assessment
EA — Environmental Assessment
EE/CA — Engineering Evaluation/Cost Analysis
VIA — Values Impact Statement

Table 1–4 contains a complete list of NEPA documentation activities conducted at SRS during 2001.

Five new department NEPA coordinators completed the SRS certification program during 2001. The total number of certified department NEPA coordinators supporting various contractor organizations on site remained at 37 because of the transfer of five coordinators to other assignments.

The SRS NEPA Program continues to improve the sitewide computerized NEPA database/tracking system, which was developed for reporting and analysis purposes. An SRS NEPA home page was available to offsite computer users by means of the Internet. The home page contained (1) electronic copies of SRS EAs and EISs, (2) monthly NEPA reports, and (3) hot links to other NEPA web sites. However, public access to this home page has been suspended in the wake of the events of September 11.

Safe Drinking Water Act

The federal SDWA—enacted in 1974 to protect public drinking water supplies—was amended in 1980, 1986, and 1996. SRS drinking water is supplied by 18 separate systems, all of which utilize groundwater sources. The A-Area, D-Area, and K-Area systems are actively regulated by SCDHEC and are classified as nontransient/noncommunity systems because each serves more than 25 people. The remaining 15 site water systems, each of which serves fewer than 25 people, receive a lesser degree of regulatory oversight.

Samples are collected and analyzed periodically by SRS and SCDHEC to ensure that site domestic water systems meet SCDHEC and EPA bacteriological and chemical drinking water quality standards. All samples collected in 2001 met these standards.

Lead and copper analyses are required periodically for the three large systems. During 2001, lead and copper compliance sampling was performed for the A-Area consolidated system. Results were substantially below the SCDHEC action levels of 15 parts per billion for lead and 1,300 parts per billion for copper. Under the SCDHEC-approved, ultrareduced monitoring plan, lead and copper sampling will not be required for A-Area consolidated system again until 2004. The D-Area and K-Area water systems were sampled for lead and copper in 2000. They also were below the SCDHEC limits, and they will not require compliance sampling again until 2003.

The B-Area Bottled Water Facility, which was approved for operation 1998, is listed as a public water system by SCDHEC. Results from quarterly bacteriological analyses and annual complete chemical analyses performed in 2001 met SCDHEC and FDA water quality standards. The bottled water facility is not subject to the lead and copper requirements.

SCDHEC conducted its biannual survey of the A-Area, D-Area, and K-Area domestic water systems in March 2001. Survey results indicated a "satisfactory" rating.

No NOVs were issued to SRS in 2001 under the SDWA.

Clean Water Act

National Pollutant Discharge Elimination System

The CWA of 1972 created the NPDES program, which is administered by SCDHEC under EPA authority. The program is designed to protect surface waters by limiting releases of nonradiological effluents into streams, reservoirs, and wetlands. Radiological effluents are limited under DOE orders. Discharge limits are set for each facility to ensure that SRS operations do not adversely impact water quality.

SRS had three NPDES permits in 2001, as follows:

- *One permit for industrial wastewater discharge (SC0000175)*
- *Two general permits for stormwater discharge (SCR000000 for industrial and SCR100000 for construction)*

More information about the NPDES permits can be found in chapter 6, "Nonradiological Effluent Monitoring."

All results of monitoring for compliance with the industrial wastewater discharge permit and the general permit for utility water discharge were reported to SCDHEC in the monthly Discharge Monitoring Reports, as required by the permits.

The annual 2-week audit of SRS wastewater facilities and NPDES outfalls, normally conducted by SCDHEC in October, was postponed until 2002 in the wake of the events of September 11. The audit will be conducted in early 2002.

All monitoring for compliance with the industrial stormwater discharge permit was evaluated and recorded in the pollution prevention plan for each outfall, as required by that permit. The individual outfall pollution prevention plans were combined to form a site pollution prevention plan, which was developed and implemented in 1993 and updated in 1996 for identified stormwater outfalls. Effective in 1998, individual outfall pollution prevention plans are kept at specific operations facilities, where they can be updated as needed. They are submitted to the Environmental Protection Department (EPD) annually. Each plan identifies facility areas where "best management practices" and/or "best available technology" should be implemented to prevent or mitigate the release of pollutants with stormwater runoff.

The pollution prevention plan was revised in November 2001. A new category of outfalls ("Administrative") was created to capture stormwater outfalls not exposed to pollutants. The revised plan ensures that all outfalls are evaluated annually.

The outfalls covered by the modified industrial stormwater permit (SCR000000) were reevaluated in 1998. This resulted in the development of a new sampling plan, which was implemented in 1999 and underwent only minor modifications in 2000 and no changes in 2001.

All construction activity that would result in a land disturbance of 5 or more acres must be permitted. The nine land areas associated with industrial activity from construction were permitted as required in 2001 under permit SCR100000. The pollution prevention plan for this permit also requires a sediment reduction and erosion control plan.

Under the Code of Federal Regulations (CFR) Oil Pollution Prevention regulation (40 CFR 112), SRS must report petroleum product discharges of 1,000 gallons or more into or upon the navigable waters of the United States, or petroleum product discharges in harmful quantities that result in oil sheens. No such incidents occurred at the site during 2001.

SRS has an agreement with SCDHEC to report petroleum product discharges of 25 gallons or more to the environment. One such incident in this category occurred at the site during 2001 and was reported appropriately.

Notices of Violation (NPDES)

SRS's 2001 compliance rate for NPDES under the CWA was 99.6 percent. No NOVs were issued to the site under NPDES in 2001 by SCDHEC or EPA. However, an NOV was issued (by SCDHEC) to the site under the South Carolina Pollution Control Act for an oil release at a NPDES-permitted stormwater outfall.

In a 1998 NOV, SCDHEC had cited 13 violations involving flow, total suspended solids, fecal coliform, copper, and toxicity that occurred from January through July of that year. Corrective actions were implemented in all the cases, but because no resolution could be reached on SRS's toxicity problems, SCDHEC turned over the enforcement action to EPA, which issued an NOV to the site August 3, 1999. The NOV, which detailed exceedances (including toxicity) and missing samples from 1996 through 1999, was discussed during an August 25, 1999, meeting (involving SRS, EPA, and SCDHEC) at which site representatives offered explanations for each point cited. EPA still had not determined a course of action by the end of 2001.

A toxicity problem at outfall A-11 resurfaced in October 1999, and a toxicity identification evaluation was implemented at that time. The evaluation was still under way at the end of 2001. Results of 2001 toxicity tests at SRS NPDES outfalls are presented in *SRS Environmental Data for 2001*, and additional discussion of the site's toxicity problems appears in chapter 6.

SCDHEC issued SRS a consent order October 11, 1999, addressing compliance with the site's NPDES permit at outfall A–01. The consent order gave SRS until October 2001 to comply with lead, copper, chlorine, and toxicity parameters at this outfall and until April 2002 to comply with the mercury parameter. During 2000, a wetland treatment system was designed and built to address these problems. The system, which began operating in November 2000, was fine-tuned between January and October 2001 to ensure compliance with permit limits. The outfall was in compliance with permit metal and total residual chlorine limits during the last 3 months of 2001.

SRS had 24 exceedances of permit parameters in 2001. A list of these—including outfall locations, probable causes, and corrective actions—can be found in chapter 6 (table 6–5).

Dredge and Fill; Rivers and Harbors

The CWA, Section 404, "Dredge and Fill Permitting," as amended, and the Rivers and Harbors Act, Sections 9 and 10, "Construction Over and Obstruction of Navigable Waters of the United States," protect U.S. waters from dredging and filling and construction activities by the permitting of such projects. Dredge and fill operations in U.S. waters are defined, permitted, and controlled through implementation of federal regulations in 33 CFR (U.S. Army Corps of Engineers) and 40 CFR (EPA).

In 2001, SRS conducted activities under five nationwide permits (NWPs) as part of the NWP program (general permits under Section 404), but under no individual Section 404 permits. The activities were as follows:

- Dam construction on an unnamed tributary to Four Mile Creek (also known as Fourmile Branch) for the Mixed Waste Management Facility Groundwater Interim Measures project was conducted under NWP 38, "Hazardous Waste Cleanup."
- A preconstruction notification under NWP 13, "Bank Stabilization," was submitted to the U.S. Army Corps of Engineers to allow stabilization of the SRS boat dock on the Savannah River. The project has been approved by the Corps but has not been started.
- A preconstruction notification under NWP 27, "Wetland Restoration," was submitted to the Corps to permit the plugging of ditches in 16 SRS Carolina bays under the SRS Carolina Bay Restoration Project.
- Repairs of the dam at the New Fire Pond near Road F were conducted under NWP 3, "Maintenance."
- Existing Sampling platforms on Upper Three Runs at Road C and Highway 125 were placed under NWP 5, "Scientific Measuring Devices."

Construction in Navigable Waters

SCDHEC Regulation 19–450, "Permit for Construction in Navigable Waters," protects the state's navigable waters through the permitting of any dredging, filling, construction, or alteration activity in, on, or over state navigable waters, in or on the beds of state navigable waters, or in or on land or waters subject to a public navigational servitude. The only state navigable waters at SRS are Upper Three Runs Creek (through the entire site) and Lower Three Runs Creek (upstream to the base of the PAR Pond Dam).

SRS applied to SCDHEC for an after-the-fact "Construction in Navigable Waters" permit in October 2001 for two existing sampling platforms in Upper Three Runs at Road C and Highway 125.

Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act restricts the application of restricted pesticides through a state-administered certification program. SRS complies with these requirements through procedural guidelines, and the site's pesticide procedure provides guidelines for pesticide use and requires that applicators of restricted-use pesticides be state certified. A pesticide-use task group evaluates planned pesticide programs to ensure that they are acceptable and that appropriate pesticides are used, so that impacts on the environment are minimal. The task group also

- maintains records of pest control activities
- assists in disseminating pesticide-use information to site contractors

SRS pesticide programs typically include such activities as the maintenance of roadways, gravel areas, and fence lines through the use of herbicides.

Clean Air Act

Regulation, Delegation, and Permits

The CAA provides the basis for protecting and maintaining air quality. Some types of SRS air emissions, such as radioactive sources and ozone-depleting substances (ODSs), are regulated by EPA, but most are regulated by SCDHEC, which must ensure that its air pollution regulations are at least as stringent as the CAA's. This is accomplished through SCDHEC Regulation 61–62, "Air Pollution Control Regulations and Standards."

Under the CAA, and as defined in federal regulations, SRS is classified as a "major source" and, as such, is assigned one permit number (0080–0041) by SCDHEC. In this permit, each emission source is identified by the area designation, by a point identification number, and by a source description. SRS holds operating and construction permits or exemptions from SCDHEC's Bureau of Air Quality, which regulates nonradioactive toxic and criteria pollutant emissions from approximately 172 point sources, several of which have specific emission limits.

As of May 1994, SCDHEC had completed renewal of all SRS operating permits, which are valid for 5 years. Because of ongoing work on the Title V permit, SCDHEC granted extensions of the operating permits in 1998 and 1999 and of the construction permits in 2000. The extensions will be valid until the new Title V permit is issued. Of the 172 point sources, 133 operated in some capacity during 2001. The remaining 39 either were under construction or were being maintained in a "cold standby" status.

During 2001, SCDHEC conducted compliance inspections of 102 permitted sources at SRS, reviewing 141 permitted parameters. The inspections included

- biennial stack tests
- annual compliance inspections

As a result of the annual compliance inspections, the site achieved a compliance rate of 99 percent—and received one NOV—under the CAA in 2001.

National Emission Standards for Hazardous Air Pollutants

The National Emission Standards for Hazardous Air Pollutants (NESHAP) is a CAA-implementing regulation that sets air quality standards for air emissions containing hazardous air pollutants, such as radionuclides, benzene, and asbestos. The NESHAP regulations found in 40 CFR 61 are divided into subparts based on specific hazardous pollutant categories, such as Subpart H for radionuclides and Subpart M for asbestos. The Clean Air Act Amendments (CAAA) of 1990 revised the original list of hazardous air pollutants. The revised list of 189 air pollutants includes all radionuclides as a single item. Regulation of these pollutants has been delegated to SCDHEC; however, EPA Region IV continues to partially regulate radionuclides.

SRS, like most South Carolina industrial complexes, uses a number of chemicals identified by SCDHEC as toxic air pollutants and by EPA as hazardous air pollutants. These include many common consumer products—e.g., off-the-shelf bug sprays, correction fluids, paints, sealers, janitorial cleaning supplies, gasoline for vehicles—as well as a number of typical industrial chemicals, such as degreasers, solvents, metals, batteries, and diesel fuel. But SRS has at least one category, radionuclides, not found in typical industrial settings. During the course of normal operations, some radionuclides are released to the air.

NESHAP Radionuclide Program Subpart H of NESHAP was issued December 15, 1989, after which an evaluation of all air emission sources was performed to determine compliance status. DOE–SR and EPA Region IV signed an FFCA October 31, 1991, providing a schedule to bring SRS's emissions monitoring into compliance with regulatory requirements. An amendment to the FFCA, signed August 16, 1993, provided an extension to the original FFCA through February 10, 1995, to accomplish additional monitoring equipment upgrades. The upgrades were completed on time, and the FFCA was officially closed—and the site declared compliant—by EPA Region IV May 10, 1995. The SRS NESHAP radionuclide program continues to change to incorporate sampling, monitoring, and dose assessment practices that meet or exceed the requirements of 40 CFR 61, Subpart H.

During 2001, the maximally exposed individual effective dose equivalent, calculated using the NESHAP-required CAP88 computer code, was estimated to be 0.05 mrem (0.0005 mSv), which is 0.5 percent of the 10-mrem-per-year (0.10-mSv-per-year) EPA standard (chapter 5, "Potential Radiation Doses").

NESHAP Nonradionuclide Program SRS uses many chemicals identified as toxic or hazardous air pollutants, but most of these chemicals are not regulated under the CAA or under federal NESHAP regulations. Except for asbestos, SRS facilities and operations do not fall into any of the "categories" listed in the subparts. Under Title III of the federal CAAA of 1990, EPA in December 1993 issued a final list of hazardous air pollutant-emitting source categories potentially subject to maximum achievable control technology standards. These standards were being developed and issued over a 10-year period that ended in November 2000; however, because of the number and complexity of the new standards to be developed, EPA was not able to meet the original schedule, which was arranged according to

- the effects of each pollutant
- the industry group source category
- the abatement technology available

EPA is not issuing another schedule, but rather is assigning revised due dates for the remaining new regulations in what is referred to as a "unified agenda."

In an attempt to regulate hazardous or toxic air pollutants in South Carolina, SCDHEC established Air Pollution Control Regulation 61–62.5, Standard No. 8, "Toxic Air Pollutants," in June 1991. To demonstrate compliance with this standard, SRS completed and submitted an air emissions inventory and air dispersion modeling data for all site sources in 1993. The submitted data demonstrated compliance by computer modeling the accumulated ambient concentration of individual toxic air pollutants at the boundary line and comparing them to the Standard No. 8 maximum allowable concentrations. To ensure continued compliance with Standard No. 8, new sources of toxic air pollutants must be permitted. This requires submittal of appropriate air permit applications and air dispersion modeling. Sources with emissions below a threshold of 1,000 pounds per month of any single toxic air pollutant may be exempted from permitting requirements. During 2001, 10 sources of toxic air pollutants either were issued a construction permit or exempted from permitting requirements.

NESHAP Asbestos Abatement Program Asbestos is a naturally occurring mineral. Because of its availability, low cost, and unique properties, the U.S. construction industry used asbestos extensively from after World War II through the mid 1970s. The construction of SRS began in the early 1950s, and asbestos-containing material can be found throughout the site. The danger from exposure to airborne asbestos fibers was virtually unknown during the early years at the site. Today, however, it is well established that unprotected exposure to airborne asbestos fibers can lead to asbestosis, lung cancer, mesothelioma, and other diseases.

SRS began an asbestos abatement program in 1988 and continues to manage asbestos-containing material by "best management practices." Site compliance in asbestos abatement, as well as demolitions, falls under South Carolina and federal regulations, including SCDHEC Regulation R.61–86.1 ("Standards of Performance for Asbestos Projects") and 40 CFR 61, Subpart M ("National Emission Standards for Asbestos").

Asbestos-containing material is managed at SRS through the following control options:

- an operations and maintenance program
- enclosure
- encapsulation
- repair
- removal

Many site demolition, renovation, and maintenance projects require the removal of asbestos-containing material. During 2001, SRS personnel removed and disposed of an estimated 835 square feet and 1,570 linear feet of regulated asbestos-containing material.

In addition, contractors removed and disposed of an estimated two square feet and 220 linear feet of regulated asbestos-containing material. Only qualified, asbestos-trained personnel are permitted to handle the material, and they must follow Occupational Safety and Health Administration standards and practices for its removal and disposal.

Radiological asbestos waste, removed by SRS personnel and contractors who are not permanent SRS employees, was disposed of at the SRS low-level burial ground, which is approved by SCDHEC as a disposal site. Nonradiological asbestos waste removed by SRS personnel was disposed of at the Three Rivers Landfill, located on site. Nonradiological asbestos waste removed by contractors was disposed of at SCDHEC-approved offsite landfills.

Other CAA Requirements

Only a few of the major sections of the CAA and its 1990 amendments and regulations have had—or are expected to have—a significant impact on SRS sources and facilities. These include Title V, "Permits," and Title VI, "Stratospheric Ozone Protection." The other regulations impacting SRS facilities are implemented primarily in SCDHEC Regulation 61–62 and in existing operating or construction permits.

Title V Operating Permit Program As previously indicated**,** the CAAA of 1990 also include, under Title V, a major new permitting section expected to have a significant impact on the site through increased reporting and recordkeeping requirements. The primary purpose of this permitting program is to establish federally enforceable operating permits for major sources of air emissions. The implementation plan for this program was submitted to EPA in 1993 by the State of South Carolina and subsequently approved by EPA in June 1995. SRS then submitted an extensive application package for site air emission sources by the March 15, 1996, deadline set forth in the implementation plan, Regulation 62.70, "Title V Operating Permit Program."

SRS and SCDHEC have been developing the Title V (Regulation 62.70) operating air permit since 1996. In September 1998, SRS received a draft Part 70 permit from SCDHEC and subsequently submitted comments back to SCDHEC on October 1 of that year. However, the permitting process has been on hold for the past 3 years because of the departure of SCDHEC's permit engineer for SRS and because of higher priority permitting needs in the state during 2000 and most of 2001. SCDHEC resumed the permit preparation process in July 2001 and provided the site with another complete preliminary draft air permit in November for review and comment. Comments were transmitted December 5 to SCDHEC, which on December 21 opened the SRS Draft Part 70 Air Permit (No. 0080–0041) for public comment. The public comment period will close January 21, 2002.

Ozone-Depleting Substances Title VI of the CAAA of 1990 addresses stratospheric ozone protection. This law requires that EPA establish a number of regulations to phase out the production and consumption of ODSs. The substances commonly are used as refrigerants in air conditioning and cooling systems; as degreasers and cleaners; as spray-can propellants; as fire suppressants (Halon); as laboratory extractions; and in many other common consumer products.

Several sections of Title VI of the CAAA of 1990, along with recently established EPA regulations found in 40 CFR 82, apply to the site. The ODSs are regulated in three general categories, as follows:

- *Class I substances* – chlorofluorocarbons (CFCs), Halons, carbon tetrachloride, methyl chloroform, methyl bromide, and hydrobromofluorocarbons (HBFCs)
- *Class II substances* – hydrochlorofluorocarbons (HCFCs)
- *Substitute substances*

The "Savannah River Site Refrigerant Management Plan," completed and issued in September 1994, provides guidance to assist SRS and DOE in the phaseout of CFC refrigerants and equipment.

The site has

- purchased certified recycling equipment
- trained and certified technicians where required
- implemented required recordkeeping and leak-tracking for large cooling systems
- implemented proper labeling and other recordkeeping requirements
- permanently shut down and evacuated six chillers that utilized CFC refrigerants
- replaced 30 of 35 chillers that utilized CFC refrigerants with equipment containing non-CFC refrigerants
- transferred excess CFC–11 (or R–11) refrigerant to the Defense Logistics Agency facility in Richmond, Virginia.

SRS has reduced CFC refrigerant usage more than 99 percent, based on 1993 data. The site used 480 pounds of CFC refrigerants in 2000 and reduced that amount to 450 pounds in 2001.

The SRS CAAA of 1990 Title V operating air permit application includes ODS emission sources. All large (greater than or equal to 50-pound charge) heating, ventilation, and air conditioning/chiller systems for which there are recordkeeping requirements are included as fugitive emission sources.

SRS is phasing out its use of Halon as a result of the DOE 1999 Pollution Prevention and Energy Efficient Leadership Goal to eliminate use of Class I ODSs by 2010 "to the extent economically practicable." A Halon 1301 alternative study was completed by the site's fire protection and systems engineering groups in 2000 to (1) recommend alternative fire suppression agents to replace Halon 1301 and (2) provide a method for assigning modification priorities to site fire protection systems that use Halon 1301.

Additionally, a Halon 1301 phaseout plan and schedule is being developed by Fire Protection Engineering to help meet DOE's goal. The plan includes an SRS Halon 1301 fire suppression system inventory that identifies systems in operation, systems abandoned in place, and systems that have been dismantled and taken to the DOE complex's Halon repository, located at SRS. At the end of 2001, there were 110 operating systems and 84 systems abandoned in place.

Halon 1301 total inventory on site has increased—from 75,089 pounds in 1995 to 93,941 pounds in 2001. At the end of 2001, the site had an inventory of 55,193 pounds of stored Halon 1301, including 3,191 pounds received from other DOE sites during 2001. In addition, 23,061 pounds are contained in the 110 operating systems, and 15,687 pounds of Halon 1301 are contained in the 84 systems that have been abandoned in place.

As part of the national program to phase out their use, portable Halon 1211 fire extinguishers have been replaced at SRS as they reached the end of their useful lives. During 2001, all the Halon 1211 units remaining on site were shipped to the Defense Logistics Agency facility in Richmond. SRS no longer has a Halon 1211 inventory.

As is the case with refrigerants, all personnel working with the site's nine Halon 1301 fire suppression systems and its Halon 1301 recycling and recharging operations have been trained in Halon emissions reduction. Training is based on vendor information for specific systems and on National Fire Protection Association-recommended practices required by Halon emissions reduction regulations.

Air Emissions Inventory

SCDHEC Regulation 61–62.1, Section III ("Emissions Inventory"), requires compilation of an air emissions inventory for the purpose of locating all sources of air pollution and defining and characterizing the various types and amounts of pollutants. To demonstrate compliance, SRS personnel conducted the 1993 comprehensive air emissions inventory, compiling source information from as far back as 1985. Guidelines and procedures were written to

- ensure that all radiological and nonradiological sources had been accounted for
- ensure documentation of all vents and stacks for each building
- better characterize emission points from site processes
- calculate emissions based on design capacity, maximum potential emissions, and actual emissions for a selected period of time
- provide consistency in recording appropriate data

The inventory identified approximately 5,300 radiological and nonradiological air emission sources. Source operating data and calculated emissions from 1990 were used to establish the SRS baseline emissions and to provide data for air dispersion modeling. This modeling was required to demonstrate sitewide compliance with Regulation 61–62.5, Standard No. 2, "Ambient Air Quality Standards," and Standard No. 8.

Regulation 61–62.1, Section III, requires that inventory data be updated and *recorded* annually but only *reported* every even calendar year. The emissions inventory is updated each year in accordance with SRS procedures and guidelines. Calendar year 2000 operating data for *permitted and other significant* sources were *reported* to SCDHEC in 2001. Because data collection for all SRS sources begins in January and requires up to 6 months to complete, this report provides emissions data for calendar year 2000 (table 6–4 of this document for criteria pollutants and table 45, *SRS Environmental Data for 2000*, WSRC–TR–2000–00329, for toxic/hazardous air pollutants). Compilation of 2001 data will be completed in 2002 and reported in the *SRS Environmental Report for 2002*.

Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) gives EPA comprehensive authority to identify and control chemical substances manufactured, imported, processed, used, or distributed in commerce in the

United States. Reporting and recordkeeping are mandated for new chemicals and for any chemical that may present a substantial risk of injury to human health or the environment. EPD and Industrial Hygiene personnel coordinate reporting and recordkeeping requirements under TSCA.

Polychlorinated biphenyls (PCBs) have been used in various SRS processes. The use, storage, and disposal of these organic chemicals are specifically regulated under 40 CFR 761, which is administered by EPA. SRS has a well-structured PCB program that complies with this TSCA regulation, with DOE orders, and with WSRC policies.

The site's 2000 PCB document log was completed prior to the July 1, 2001, deadline in full compliance with 40 CFR 761. Also, SRS's report on 2000 PCB disposal activities (ESH–FSS–2001–00089) was prepared and submitted to EPA Region 4 prior to the July 15, 2001, deadline. The disposal of nonradioactive PCBs routinely generated at SRS is conducted at EPA-approved facilities within the regulatory time frame. For many forms of radioactive PCB wastes, disposal capacity is not yet available, and the wastes must remain in long-term storage. Such wastes are held in TSCA-compliant storage facilities in accordance with 40 CFR 761. Site plans call for the disposal of incinerable radioactive PCB wastes at the TSCA incinerator in Oak Ridge, Tennessee, as the State of Tennessee approves the disposal plans. The first shipment of such wastes to the Oak Ridge incinerator occurred in September 2001.

In August 1993, PCBs were confirmed to be present as a component of dense nonaqueous phase liquids in samples from two groundwater monitoring wells around the M-Area hazardous waste management facility. Regulators were notified, and a modification to the RCRA Part B Permit Application to address the discovery of PCBs was submitted to SCDHEC in December 1993. Any waste generated was handled according to the appropriate TSCA and RCRA requirements. Environmental Restoration Division and Savannah River Technology Center (SRTC) personnel continue to study ways to remediate the dense nonaqueous phase liquids.

In 1996 and subsequent years, site personnel discovered PCBs in certain painted surfaces and in other solid forms within several facilities constructed prior to TSCA. As such discoveries were made, SRS worked with EPA—as necessary—on related TSCA compliance issues. Current TSCA regulations prohibit the use and distribution in commerce of these forms of PCBs above specified concentrations. In December 1999, however, EPA issued a proposed rule to authorize the continued use of these forms of PCBs. A final rule is expected in 2002.

Endangered Species Act

The Endangered Species Act of 1973, as amended, provides for the designation and protection of wildlife, fish, and plants in danger of becoming extinct. The act also protects and conserves the ecosystems on which such species depend.

Several threatened and endangered species exist at SRS. The site conducts research on the wood stork, the red-cockaded woodpecker, the bald eagle, the shortnose sturgeon, and the smooth purple coneflower. Programs designed to enhance the habitat of such species are in place.

No biological assessments and/or biological evaluations were prepared for NEPA documents for new projects at SRS in 2001. However, to ensure the protection of threatened and endangered species, biological assessments and biological evaluations—which are required under NEPA—were conducted by the U.S. Department of Agriculture Forest Service–Savannah River (USFS–SR) to evaluate potential impacts of forestry related activities.

None of these activities was found to have had any significant potential impact on threatened and endangered species.

The biological assessment for the river water system shutdown EIS concluded in 1996 that the proposed action could affect the bald eagle, the alligator, and the wood stork. Consultations conducted between SRS and the U.S. Fish and Wildlife Service required the site to perform studies on the bald eagle. The studies were completed in 1999, and a report of the findings is expected to be issued in 2002. The results of this report will determine if a mitigation plan should be implemented.

National Historic Preservation Act

The National Historic Preservation Act (NHPA) of 1966, Section 106, governs the protection and preservation of archaeological and historical resources. SRS ensures that it is in compliance with this act through the site-use process. All sites being considered for activities such as construction are evaluated by the University of South Carolina's Savannah River Archaeological Research Program (SRARP) group to ensure that archaeological or historic sites are not impacted. Reviews of timber compartment prescriptions include surveying for archaeological concerns and documenting areas of importance with regard to historic and prehistoric significance.

SRARP personnel reviewed 76 site-use packages and surveyed 2,078 acres in support of SRS project activities during 2001. Most of the site-use packages were found to have no activities of significant impact in terms of the NHPA, but 12 of them resulted in surveys being conducted because of the potential for land alteration in 2001. SRARP personnel also surveyed 2,849 acres during 2001 in support of onsite forestry activities.

The surveys of all 4,927 of these acres resulted in the investigations of 92 new archaeological sites and in revisits to 46 previously recorded sites for cultural resources management.

In support of the Mixed Oxide Fuel Facility project, preliminary test excavations were conducted in December 2001 to determine locations for large-scale excavation of the project site. Large-scale excavation will be conducted in early 2002.

Floodplains and Wetlands

Under DOE General Provisions, 10 CFR, Part 1022 ("Compliance with Floodplains/Wetlands Environmental Review Requirements"), establishes policies and procedures for implementing DOE's responsibilities in terms of compliance with Executive Orders 11988 ("Floodplain Management") and 11990 ("Protection of Wetlands"). Part 1022 includes DOE policies regarding the consideration of floodplains/wetlands factors in planning and decision making. It also includes DOE procedures for identifying proposed actions involving floodplains/wetlands, providing early public reviews of such proposed actions, preparing floodplains/wetlands assessments, and issuing statements of findings for actions in floodplains.

Executive Orders 11988, "Floodplain Management," and 11990, "Protection of Wetlands"

Executive Order 11988, "Floodplain Management," was established to avoid long- and short-term impacts associated with the occupancy and modification of floodplains. The evaluation of impacts to SRS floodplains is ensured through the NEPA Evaluation Checklist and the site-use system. Site-use applications are reviewed for potential impacts by WSRC, DOE–SR, the USFS–SR, and the Savannah River Ecology Laboratory (SREL), as well as by professionals from other organizations.

Executive Order 11990, "Protection of Wetlands," was established to mitigate adverse impacts to wetlands caused by the destruction and modification of wetlands and to avoid new construction in wetlands wherever possible. Avoidance of impact to SRS wetlands is ensured through the site-use process, various departmental procedures and checklists, and project reviews by the SRS Wetlands Task Group. Many groups and individuals—including scientists at SRTC, SREL, and EPD—review site-use applications to ensure that proposed projects do not impact wetlands.

No floodplain or wetland assessments were conducted at SRS during 2001.

Environmental Release Response and Reporting

Response to Unplanned Releases

Environmental Monitoring Section (EMS) personnel respond to unplanned environmental releases—both radiological and nonradiological—upon request by area operations personnel.

No unplanned environmental releases that occurred at SRS in 2001 required the sampling and analysis services of EMS. If the services of EMS personnel are requested, the samples collected are given priority in preparation and, if radiological in nature, priority in the counting room. Data are validated, and a determination is made as to whether there has been an actual release. If there has been, then consequences to the public and the environment are determined.

Occurrences Reported to Regulatory Agencies

"Federally permitted" releases comply with legally enforceable licenses, permits, regulations, or orders. Under the Atomic Energy Act, for example, releases of SRS radionuclides are federally permitted as long as public dose standards in DOE orders are not exceeded.

If a nonpermitted release to the environment of a reportable quantity (RQ) or more of a hazardous substance (including radionuclides) occurs, CERCLA requires notification of the National Response Center. Also, the CWA requires that the National Response Center be notified if an oil spill causes a "sheen" on navigable waters, such as rivers, lakes, or streams. Oil spill reporting was reinforced with liability provisions in CERCLA's National Contingency Plan.

Other CERCLA provisions allow exemptions from reporting a release of an RQ or more of a hazardous substance if the release is federally permitted or covered by a continuous-release notification. A continuous-release notification provides an exemption from reporting each release of a specific hazardous substance greater than an RQ. The site submitted two continuous-release notifications in 1992—for ethylene glycol and for asbestos, each of which had a statutory RQ of 1 pound. SRS withdrew the request for continuous-release notification status for ethylene glycol in 1995, when EPA made an adjustment to that RQ. The asbestos continuous-release notification request was retracted during 1999 with the completion of deactivation and decommissioning activities at the D-Area Heavy Water Facility.

SRS had no CERCLA-reportable releases in 2001. This performance compares with no such releases reported during 2000, one during 1999, one during 1998, and three during 1997.

Seven notifications—not required by CERCLA—were made by the site to regulatory agencies during 2001. One of these was a "courtesy notification" made to inform SCDHEC of equipment malfunctions. Four were the result of an agreement to notify SCDHEC about sewage and petroleum product releases. The agreement requires reporting of sewage releases "equal to or greater than 100 gallons" and of petroleum product releases "equal to or greater than 25 gallons" unless the releases come in contact with "waters of the state." In these cases, releases in any amount are to be reported—whether for sewage or for petroleum products. Of the remaining two notifications, one involved an opacity issue that was later resolved and the other concerned the discovery of a white powder ultimately determined to be harmless.

EPCRA (40 CFR 355.40) requires that reportable releases of extremely hazardous substances or CERCLA hazardous substances be reported to any local emergency planning committees and state emergency response commissions likely to be affected by the release. No EPCRA-reportable releases occurred in 2001.

It is SRS policy to notify SCDHEC and the Georgia Department of Natural Resources (GDNR) of any occurrence that may interest state regulatory agencies. Although not required by law, these courtesy notifications enhance environmental protection objectives. In 1997, SRS expanded the plan for the courtesy notifications in response to a request by local governments. The expanded notification plan includes such occurrences as shelter alarms and stack monitoring alarms, even though they may be false alarms.

Site Item Reportability and Issues Management Program

The Site Item Reportability and Issues Management (SIRIM) program, mandated by DOE Order 232.1A (which superceded DOE Order 232.1), "Occurrence Reporting and Processing of Operations Information," is designed to ". . . establish a system for reporting of operations information related to DOE-owned or operated facilities and processing of that information to provide for appropriate corrective action. . . ." It is the intent of the order that DOE be ". . . kept fully and currently informed of all events which could: (1) affect the health and safety of the public; (2) seriously impact the intended purpose of DOE facilities; (3) have a noticeable adverse effect on the environment; or (4) endanger the health and safety of workers."

The SIRIM program at SRS is designed to meet the requirements of DOE Order 232.1A by ensuring that

- all occurrences specified are identified in a timely manner, categorized, and reported
- proper corrective actions are taken in a timely manner
- all reportable occurrences are reviewed to assess significance and root causes
- occurrence reports to DOE operations are disseminated to prevent the recurrence of similar events

All SIRIM events are classified in one of the following categories: (1) facility condition; (2) environmental; (3) personnel safety; (4) personnel radiation protection; (5) safeguards and security; (6) transportation; (7) value-based reporting; (8) facility status; (9) nuclear explosive safety (not applicable at SRS); or (10) cross-group items. The impact—or the anticipated impact—of each event is categorized as follows (based on criteria in site procedures):

- *Emergency* – the most serious event; requires increased alert status for onsite and, in specific cases, offsite authorities
- *Unusual occurrence* – a nonemergency event that has significant impact or potential for impact on safety, environment, health, security, or operations
- *Off-normal occurrence* – an abnormal or unplanned event or condition that deviates from established standards or specifications

Table 1–5
Environmentally Related Unusual Occurrence Reported Through SIRIM in 2001

Discovery Date	Occurrence	Report No. (SR–WSRC–)	Cause/Explanation[a]
Dec. 8	500 gallons of sludge water released to the ground; no environmental release in excess of reportable quantities	REACL–2001–0013	Solenoid valve failure

a SRS takes followup corrective actions to minimize impact on the environment.

Of the 799 SIRIM-reportable events in 2001, only one was categorized as environmental; it was classified as an off-normal occurrence (table 1–5).

Assessments/Inspections

The SRS environmental program is overseen by a number of organizations, both outside and within the DOE complex. In 2001, the WSRC environmental appraisal program consisted of self and independent assessments. The program employs total-quality management concepts that support the site's four imperatives of safety, disciplined operations, continuous improvement, and cost effectiveness. It also ensures recognition of noteworthy practices, identification of performance deficiencies, and initiation and tracking of associated corrective actions until they are satisfactorily completed. The primary objectives of the WSRC assessment program are to ensure compliance with regulatory requirements and to foster continuous improvement. The program is an integral part of the site's Integrated Safety Management System and supports the SRS Environmental Management System, which continues to be certified to the standards of International Organization for Standardization (ISO) 14001. (ISO 14000 is a family of voluntary environmental management standards and guidelines.)

WSRC conducted seven environmental program-level assessments in 2001. Areas assessed included

- land disturbance field verification
- Operation and Maintenance (O&M) administrative compliance
- secondary containment adequacy
- proper chemical storage
- Ozone Depleting Substance (ODS) accounting
- NEPA education/field compliance
- pesticide administrative compliance

During 2001, personnel from DOE–SR's Environmental Quality and Management Division again performed direct oversight and evaluation of WSRC's self-assessment program to help ensure that the program continues to meet the needs and expectations of DOE Order 5482.1B, "Environment, Safety, and Health Appraisal Program"; Savannah River Implementation Procedure (SRIP) 200, chapter 223.4, "SR Technical Assessment Program"; and SRIP 450.1, "SR Environmental Protection Program." Completed assessments have met with positive results; routine assessments have promoted improvement and helped ensure the adequacy of environmental programs and operations at SRS.

SCDHEC, EPA, and DOE–HQ also provide external inspections of the SRS environmental program for regulatory compliance. Agency representatives performed five comprehensive compliance inspections in 2001, as follows:

- *Inspection of Environmental Monitoring and Surveillance Programs by DOE's Office of Independent Environmental, Safety, and Health Oversight (EH–2)* – An inspection by EH–2 personnel in January identified positive attributes in the environmental surveillance and monitoring programs at SRS. With few exceptions, the program was characterized as well-designed, comprehensive, and effectively implemented. Sound and well-documented technical justifications were identified for most of the activities supporting the radiological environmental monitoring and surveillance program. The radiological air program was found to be effective, proactively ensuring implementation of regulatory requirements. The auditors also noted that SRS had made significant achievements in monitoring groundwater contamination. The EH–2 inspection identified areas where program improvements were considered appropriate. Three "issues" were identified that required changes to achieve full compliance with DOE Orders 5400.1 ("General Environmental

Protection Program") and 5400.5 ("Radiation Protection of the Public and the Environment") and their associated technical guidance. Also, seven "observations" recommended changes for consistency with best management operating practices. One issue and one observation subsequently were reevaluated and judged not to be deficiencies requiring corrective actions. A corrective action plan was developed to address all the remaining issues and observations. Corrective measures have been implemented to add several select analyses to the annual environmental surveillance program, to improve facility-specific effluent air program protocols, and to strengthen and formalize SRS groundwater monitoring program documents, data evaluation, and reporting practices.

- *Annual Air Compliance Inspection* – SCDHEC's Bureau of Air Quality conducted an inspection of SRS in March. Results indicated that the site generally was in compliance with air pollution regulations and/or the requirements of the Bureau of Air Quality permit. However, the site was found to have failed to follow a requirement contained in the site air permit in that a differential pressure gauge associated with the A-Area baghouse had not been operated and maintained properly. Immediate actions were taken by the responsible organizations to correct and prevent recurrence of this issue.

- *Domestic Water System Sanitary Survey* – SCDHEC conducted a sanitary survey of domestic water systems at SRS in March. Three areas of the site program implementation were identified as "needs improvement": (1) the railroad yard system storage tank required installation of an isolation valve; (2) the L-Area Fire Station system storage tank's exterior was determined to be rusted and in need of maintenance; and (3) operational inconsistencies were found with the flow-testing of fire hydrants associated with the A-Area water system. Immediate actions were taken by the responsible organizations to correct and prevent recurrence of these issues.

- *RCRA Compliance Evaluation Inspection* – SCDHEC personnel inspected SRS in June for compliance with South Carolina Hazardous Waste Management Regulations (SCHWMR), as amended. No deficiencies were noted during the inspection. Suggestions were offered regarding various items such as secondary containment for all satellite containers holding liquids. The inspector stated that SRS has an excellent Hazardous Waste Management System in place. The formal report had not been received at the end of 2001.

- *Annual Underground Storage Tank Inspection* – SCDHEC personnel performed their annual inspection of the site's underground storage tanks in October. Results indicated that each of the tanks was fully compliant with regulatory requirements.

Environmental Permits

SRS had 621 construction and operating permits in 2001 that specified operating levels for each permitted source. This compares with 655 such permits in 2000, 684 in 1999, 697 in 1998, and 675 in 1997. Table 1–6 summarizes the permits held by the site during the past 5 years. These numbers reflect only permits obtained by WSRC for itself and for other SRS contractors that requested assistance in obtaining permits. It also should be noted that these numbers include some permits that were voided or closed some time during the calendar year (2001).

Environmental Training

The site's environmental training program identifies training activities to teach job-specific skills that protect the employee and the environment while satisfying regulatory training requirements. Regularly scheduled classes in this program at SRS include the Environmental Laws and Regulation Overview, Environmental Compliance Authority Modules, and Department NEPA Coordinator courses. Special training sessions held in 2001 included the McCoy RCRA Seminar and the Applied CAA course, both offered by DOE's former National Environmental Training Organization.

Facility Decommissioning

With the rapidly declining need for a large nuclear weapons stockpile, many SRS facilities no longer are needed to produce or process nuclear materials. They have become surplus and must be dispositioned safely and economically. Many of them are large and complex and contain materials that, if improperly handled or stored, could be hazardous. SRS faces a major task in the cleanup, reuse, safe storage, and demolition of these facilities. The Facilities Decommissioning Division (later renamed the Facilities Disposition Division) was established in 1996 to meet this challenge. The site's 2001 deactivation and decommissioning activities are discussed in chapter 2.

Table 1–6
SRS Construction and Operating Permits, 1997–2001

Type of Permit	Number of Permits				
	1997	1998	1999	2000	2001
Air	198	202	200	199	172
U.S. Army Corps of Engineers 404	1	1	0	0	0
Army Corps of Engineers Nationwide Permit	6	6	4	1	5
Domestic Water	186	194	203	203	203
Industrial Wastewater	84	83	86	77	70
NPDES–Discharge	1	1	1	1	1
NPDES–General Utility	1	1	1	1	0
NPDES–No Discharge	1	1	1	1	1
NPDES–Stormwater	2	2	2	2	2
RCRA	1	1	1	1	1
Sanitary Wastewater	137	139	141	133	133
SCDHEC 401	2	2	1	1	1
SCDHEC Navigable Waters	4	4	0	0	1
Solid Waste	5	5	5	5	4
Underground Injection Control	17	31	18	23	20
Underground Storage Tanks	29	24	20	7[a]	7
Totals	675	697	684	655	621

a This number was revised to reflect the actual number of permits that included requirements for 20 underground storage tanks.

Table 1–7 SRS 2001 Environmental Restoration Activities

Page 1 of 2

Operable Unit	Activity Description
Fourmile Branch Watershed	
Burial Ground Complex Groundwater (also in Upper Three Runs Watershed)	Continued characterization
C-Area Burning/Rubble Pit	Continued interim remedial action
C-Area Reactor Seepage Basins	Continued remedial action
Central Shops Sludge Lagoon	Finalized remedy selection
F-Area Retention Basin (281–3F)	Completed remedial action
F-Area Seepage Basin Groundwater	Continued remediation system operation
Ford Building Seepage Basin	Issued ROD
H-Area Retention Basin (281–3H)	Issued remedy selection
H-Area Seepage Basin Groundwater	Continued remediation system operation
H-Area Groundwater	Continued characterization
Heavy Equipment Wash Basin and Central Shops Burning/Rubble Pit (631–5G)	Issued ROD
Old Radioactive Waste Burial Ground, including Solvent Tanks	Issued ROD
Lower Three Runs Watershed	
R-Area Reactor Seepage Basins	Initiated remedy selection
R-Area Acid/Caustic Basin	Initiated remedy selection
R-Area Bingham Pump Outage Pits	Initiated remedy selection
Pen Branch Watershed	
CMP Pits	Continued interim remedial action
K-Area Burning/Rubble Pit and Rubble Pile	Continued remedial action
K-Area Reactor Seepage Basin	Issued source unit remedy explanation of significant differences (plug-in ROD)
L-Area Burning/Rubble Pit, Rubble Pile, and Gas Cylinder Disposal Facility	Finalized remedy selection
Savannah River and Floodplain Swamp Watershed	
D-Area Expanded Operable Unit (Ash Basin, Coal Pile Run–off Basin, Waste Oil Facility, and Upgradient Sources)	Continued characterization
D-Area Oil Seepage Basin	Continued remedial action
Road A Chemical Basin	Finalized characterization
Savannah River and Floodplain Swamp IOU	Continued Phase I IOU characterization

Table 1–7 SRS 2001 Environmental Restoration Activities

Page 2 of 2

Operable Unit	Activity Description
Savannah River and Floodplain Swamp Watershed (cont.)	
TNX Operable Unit	Continued interim action and continued characterization
TNX Outfall Delta, Lower Discharge Gulley, and Swamp	Continued characterization
Steel Creek Watershed	
L-Area Hot Shop	Continued characterization
L-Area Oil and Chemical Basin	Completed remedial action
L-Area Reactor Seepage Basin	Finalized remedy selection
L-Area Southern Groundwater	Continued characterization
P-Area Reactor Seepage Basin	Initiated remedy selection
P-Area Burning/Rubble Pit	Initiated remedy selection
Upper Three Runs Watershed	
A-Area Burning/Rubble Pits and Rubble Pit	Continued interim action
A-Area Miscellaneous Rubble Pile	Finalized remedy selection
M-Area HWMF – A/M Groundwater	Continued remediation system operation
M-Area HWMF – Vadose Zone	Continued remediation system operation
Met Lab Basin/Carolina Bay	Continued remediation system operation
Miscellaneous Chemical Basin/Metals Burning Pit	Continued interim action
Mixed Waste Management Facility (including RCRA-regulated portions of LLRWDF)	Continued interim corrective action measures
Sanitary Landfill Groundwater	Continued interim-measure remediation system operation
SRL Seepage Basins	Completed remedial action

Editors' note: The "Environmental Compliance" chapter is unique in that its number of contributing authors is far greater than the number for any other chapter in this report. Space/layout constraints prevent us from listing all of them on the chapter's first page, so we list them here instead. Their contributions, along with those of the report's other authors, continue to play a critical role in helping us produce a quality document—and are very much appreciated.

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Chapter 2

Environmental Management

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Facilities Decontamination/ Decommissioning Program

To Read About . . . See Page . . .

ENVIRONMENTAL restoration, waste management, and facility disposition at the Savannah River Site (SRS) are part of the U.S. Department of Energy's (DOE) Environmental Management program, which was established in 1989 to address the environmental legacy of nuclear weapons production and other sources of potential pollutants, such as nuclear research. Progress continued in all three facets of the environmental management program during 2001. This chapter provides a brief overview of the high-level waste management and facility disposition activities and describes some of their major 2001 milestones. Details of environmental restoration and solid waste program activities can be found in the two divisions' annual reports, which also are accessible on this CD. These programs reflect the site's ongoing efforts to ensure the safety of its workers, the public, and the surrounding environment.

"Environmental restoration" involves 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 will not affect human health or the environment [DOE EM, 1991]. Determining the most environmentally sound methods of cleaning up waste units is a major focus of the SRS environmental restoration program.

"Waste management" refers 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.

"Facility disposition" encompasses the management of SRS excess facilities—from completion of operations shutdown through final disposition—in a way that minimizes facility life cycle costs without compromising health, safety, or environmental quality.

Regulatory Compliance

Applicable environmental management guidelines can be found in appendix A, "Applicable Guidelines, Standards, and Regulations."

High-Level Waste Management

"High-level waste" is highly radioactive liquid waste that results primarily from the reprocessing of spent nuclear fuel. This category includes liquid waste produced directly in reprocessing. The waste contains both transuranic waste and fission products in concentrations requiring permanent isolation from the environment.

SRS continues to manage approximately 38 million gallons of high-level liquid radioactive waste (about 400 million curies), which is stored in 49 large, shielded, and partially underground tanks grouped into two "tank farms." Twenty-nine tanks are located in the H-Area Tank Farm and 20 in the F-Area Tank Farm. All SRS tanks are built of carbon steel inside reinforced concrete containment vaults.

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

High-Level Waste Facilities

The F-Area and H-Area tank farms consist of large underground storage tanks that hold high-level liquid radioactive waste. Fresh waste received from the processing of the spent nuclear fuel separates into two parts, as follows:

- a sludge (which contains most of the radioactivity) that settles on the bottom of the tank
- a watery "supernate" that occupies the area above the sludge

The supernate is transferred to an evaporator system, where it is processed further. The evaporator system reduces this supernate to 30 percent of its original volume. The concentrated supernate that remains eventually will form a solid as it is cooled. This solid, commonly known as salt cake, generally resides in the evaporator concentrate tanks. The sludge layer remains in its original tank until a sludge processing campaign is executed.

Both F-Area and H-Area have their own evaporator systems. F-Area has one operating system (2F) while H-Area has two (2H and 3H). These evaporators reclaimed about 2.8 millions gallons of tank farm space in 2001.

SRS has successfully conducted this space reclamation operation in the tank farms since 1960, when the first evaporator facilities began operation. More than 100 million gallons of space have been reclaimed during this time. Without these evaporator systems, SRS would have required 86 additional waste storage tanks—at $50 million apiece—to store waste produced over the site's lifetime.

The Extended Sludge Processing Facility, one of two DWPF pretreatment operations in the High-Level Waste Division, washes sludge (settled insoluble waste) to reduce the concentration of sodium salts, which ensures glass quality when the sludge is processed at DWPF. In 2001, the facility finished processing the second of 10 sludge batches that will be required to vitrify all the high-level waste sludge, and continued preparation of the third sludge batch. Three million gallons of sludge must be pretreated in this manner.

The washed and decanted sludge is transferred to DWPF as part of "sludge only" operations. DWPF then processes the sludge from the original waste by combining it with glass frit. The mixture is heated until it melts, then is poured into stainless steel canisters to cool. The glass-like solid that forms contains the highly radioactive material and seals it off from the environment. Another word for this process is "vitrification." The sealed canisters will be stored at SRS until a federal repository is established.

The Salt Processing Facility, the second pretreatment operation for DWPF, was expected to process the salt cake and highly concentrated supernate waste (the result of the evaporation process) in tanks. However, work on salt processing was suspended in January 1998 because of technical issues with the system.

In October 2001, DOE approved a record of decision for the SRS Salt Processing Alternative Supplemental Environmental Impact Statement, identifying caustic side solvent extraction (CSSX) as the technology to be used for separation of radioactive cesium from SRS high-level waste salt.

In December 2001, a request for proposal was issued by DOE for a two-phased design/build process for design, construction and commissioning of a Salt Waste Processing Facility using CSSX technology. In parallel, DOE is evaluating the implementation of other salt processing alternatives for specific waste portions that would not need to be processed in the CSSX facility. The evaluation of alternatives and potential operations would be undertaken to maintain operational capacity and flexibility in the high-level waste system and to meet commitments for the closure of high-level waste tanks.

Accomplishments

SRS continued to manage its high-level waste facilities in support of the integrated high-level waste removal program in 2001.

Tank Farms

The tank farm evaporators recovered more than 2.8 million gallons of tank space in 2001 through evaporation of the watery supernate that resides atop the sludge in the tanks. The 2H evaporator system contributed 200,000 gallons to the recovery of space during 2001. The 3H evaporator system recovered more than 1.9 million gallons during the year, while the 2F evaporator system recovered more than 700,000 gallons. One of the keys to this achievement was an interarea line used to transfer waste from H-Area to F-Area via a 2-mile underground system. Approximately 1.6 million gallons of radioactive waste were transferred via the interarea line during 2001.

Modifications to the evaporator systems and tank farms ensured the continuation of safe operations in 2001—without affecting productivity. Also, Tank 49, which was out of service because it formerly was used in salt separation activities, has been returned to service, adding more than 1 million gallons of storage space to the tank farms.

DWPF

The successful processing of radioactive sludge continued in 2001. DWPF produced 195 canisters of immobilized high-level waste during the year, bringing the total to 1,220 canisters since radioactive processing began in March 1996.

DWPF will continue processing sludge until the "precipitate" from one of the salt processing alternatives is available. Approximately 220 canisters of glass are expected to be produced in 2002.

Facility Disposition

Deactivation and Decommissioning

With the reduced need for a large U.S. nuclear weapons stockpile, many SRS facilities no longer are required to produce or process nuclear materials. These inactive facilities must be placed in a safe, low-cost condition and properly maintained until they can be safely disposed.

SRS has approximately 126 inactive facilities, and many others are expected to be declared inactive within the next decade. These facilities range in size and complexity from large nuclear reactors to small storage buildings. Many site facilities have underground structures, storage tanks, and piping that require a large amount of excavation to access; some are more than 100 feet high. Many contain residual materials that could be hazardous to workers, the public, and the environment if improperly handled or stored. Others are located within the site's nuclear industrial areas—surrounded by buildings that are occupied or still being used—which makes their demolition extremely difficult. SRS faces a significant challenge in the safe maintenance, surveillance, cleanup, and disposition of these inactive facilities.

At SRS, Facilities Decontamination and Decommissioning program (FDD, formerly the Facilities Disposition Division) personnel manage the disposition phase of a surplus facility's life cycle in a manner that considers life cycle costs without compromising either (1) the health or safety of workers and the public or (2) the quality of the environment. The disposition phase begins upon completion of operations shutdown and extends through establishment of the facility's end state.

The facility disposition process consists of three activities, as follows:

- *Deactivation*, which places a facility in a known, safe, and stable configuration by removing hazardous chemical and radioactive materials, shutting down or mothballing the equipment, and mitigating other hazardous conditions.
- *Safe storage*, which is a dormant period involving only surveillance and maintenance (S&M) of the facility to ensure the continued safety of workers, the public, and the environment. S&M activities are performed during the entire disposition process to ensure that all structures, systems, and materials are monitored adequately and that a safe configuration is maintained.
- *Decommissioning*, which places the facility in its end state. This could involve decontamination, dismantlement, or some other activity to make the land available for either unrestricted use or limited applications. If not released for unrestricted use, institutional controls will be established and maintained under DOE's long-term stewardship program to ensure the safety of the public and the environment.

SRS has continued to manage the disposition of its surplus facilities safely through its Inactive-Facilities Risk Management Program. The immediate goal is to remove hazardous materials from surplus facilities and to place the facilities in a safe and stable condition. The site continues to seek opportunities to reuse these facilities for mission-related activities, as well as for other industrial uses. An S&M program is established and maintained to ensure that no facility deteriorates to the point that it becomes dangerous to workers or threatens the public and the environment with a release of hazardous materials.

Disposition Program Management

The WSRC Facility Disposition Procedure Manual, developed and issued in 1999, provides a consistent, disciplined process for facility disposition activities. The procedures are consistent with DOE's Life Cycle Asset Management System requirements and employ a graded approach to ensure cost effectiveness. FDD continues to provide management and direction to the WSRC Facilities and Assets Disposition Management Council, which coordinates the disposition processes across the site's operating divisions.

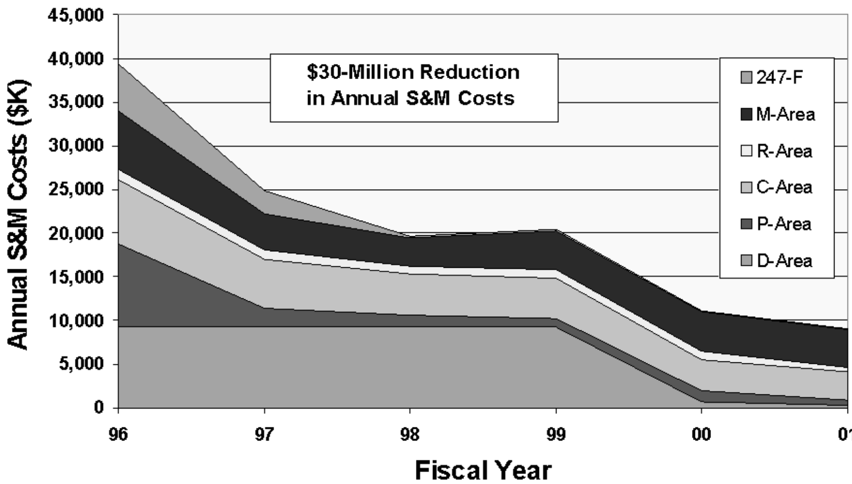
Facility Disposition Long-Range Planning

In 2000, FDD developed and implemented a standardized facility disposition long-range planning process integrated with DOE's long-term stewardship program. The process was developed to form a consistent basis for planning and estimating the cost of long-range facility disposition activities. The National Deactivation and Decommissioning Committee is pursuing use of this program to form the basis for a standardized facility disposition long-range planning process for DOE complexwide application.

Figure 2–1 Reduced Hazards with Reduced Costs

Facility shutdowns, risk reduction actions, and deactivation and decommissioning projects have combined to significantly reduce potential environmental hazards at SRS while cutting the annual cost of performing the surveillance and maintenance of FDD's inactive facilities to less than $10 million since 1996.

FDD Graphic (modified)



Accomplishments

Facility Transitions

FDD accepted custodial responsibility for an additional 12 facilities from other operating divisions during 2001. Ten of these were TNX facilities, with the custodial responsibility shifted as part of a 3-year program to transfer personnel out of T-Area. The transfer of 19 additional TNX facilities, planned for 2002, will complete the multiyear transfer program.

During the past 5 years, the cost to provide S&M for facilities in C-Area, D-Area, M-Area, P-Area, and R-Area has been reduced from more than $39 million to less than $10 million through similar shutdown and deactivation activities (figure 2–1).

Inactive-Facilities Risk Management Program

The WSRC Inactive-Facilities Risk Management Program augments the more traditional approach of conducting complete facility deactivation projects with a program that ensures that the limited funding available is directed toward reducing the greatest hazards, regardless of the facility in which the hazards are located.

Forty-one risk reduction actions were accomplished at 19 different facilities in 2001. These actions have reduced the risk assessment score for these facilities by more than 50 percent (figure 2–2).

As part of the annual program process, FDD personnel

- performed 81 detailed facility assessments
- updated the Inactive-Facilities Risk Ranked Priority List
- developed corrective action plans for the significant hazards identified
- planned 28 risk reduction actions for 2002

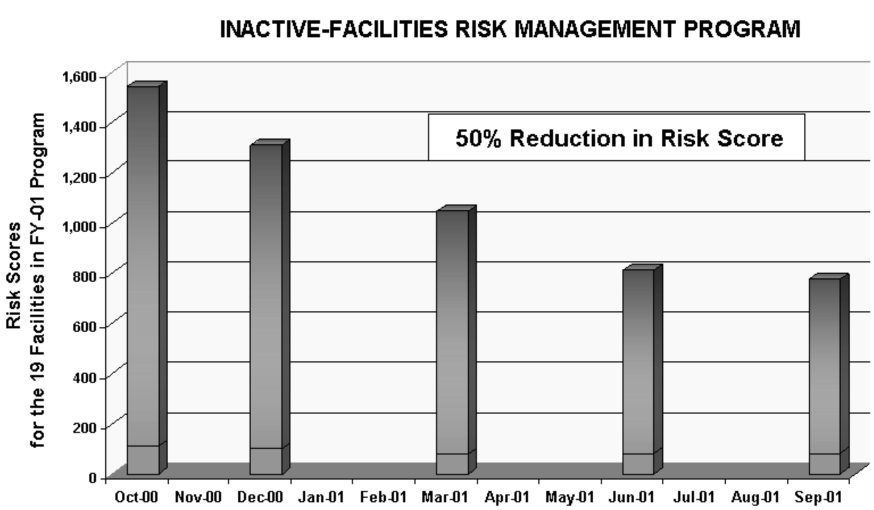


Figure 2–2 Facility Risk Management

The site's Inactive-Facilities Risk Management Program involved 19 SRS facilities in FY–01. Forty-one risk reduction actions were accomplished in these facilities; the completed actions reduced the total risk assessment score for the 19 facilities by approximately 50 percent (1543 to 776).

FDD Graphic (modified)

Disposition of Inactive Facilities

Major facility disposition activities conducted at SRS during 2001 included substantial progress on the 321–M Fuel Fabrication Facility, the 341–8M Vendor Treatment Facility, the R-Area Reactor Disassembly Basin, and the 284–F Powerhouse. A brief summary of the status of each of these facilities follows.

321-M Fuel Fabrication Facility

Highly enriched uranium was removed from the 321–M Fuel Fabrication Facility beginning in 2000 to the extent necessary to eliminate any potential for criticality and to allow reclassification of the facility from "radiological" to "other industrial." This removal project was completed in 2001, and subsequent deactivation actions are proceeding.

Vendor Treatment Facility

The goal to deinventory and decontaminate the Vendor Treatment Facility and place it in a passively safe condition was met in 2001. Deactivation activities included flushing and draining the melter, process lines, and tanks. All residual chemicals, samples, materials, tools, and miscellaneous equipment were removed from the facility.

The completed work required no significant decontamination or fixing of radioactive contamination. Pathways were sealed to prevent the migration of contamination out of the facility, and the remaining equipment in the facility was abandoned in place without the need for additional decontamination. All utilities were turned off or disconnected, placing the facility into a cold, dark, and secure condition, with only an annual building entry required.

R-Area Reactor Disassembly Basin

The demonstration of two parallel selective ion-exchange process systems to remove cesium and strontium from the R-Area Reactor Disassembly Basin was conducted in 2001. The demonstration showed that the systems were capable of reducing concentrations of cesium and strontium below DOE release limits.

This basin contains a large volume of water contaminated with fission products (cesium, strontium, and tritium). The ion-exchange process systems had been initiated in 2000 under a federally funded demonstration to remove a large part of the cesium and strontium. The systems were deployed under an Accelerated Site Technology Deployment project sponsored by DOE's Environmental Management Office of Science and Technology. The water was processed through the systems and returned to the basin. At the conclusion of the 2001 demonstration, the systems proved successful in removing approximately 80 percent of the cesium and strontium in a relatively brief time period, and in showing that the isotope levels could be reduced to near or below U.S. Environmental Protection Agency drinking water standards, which would be sufficient to allow release to normal surface streams. However, a decision since has been made not to release the basin water to surface waters regardless of radioisotope concentrations.

An interim deactivation project was begun in 2001 at the R-Area Reactor Disassembly Basin to stabilize hazards and reduce the potential for leakage. The project also is designed to reduce stewardship costs and to place the facility into a long-term, passively safe condition.

Removal of 284–F Powerhouse

WSRC placed a contract in May 2000 to dismantle and remove the 284–F Powerhouse—one of the highest-risk-ranked inactive facilities at SRS. Completed in 2001, the contract employed an assets-for-services approach that applied surplus government assets from the K-Area Cooling Tower and the 247–F Naval Fuels Manufacturing Facility to partially offset the cost of removing the powerhouse.

The contract was placed for less than $600,000, and the work was completed for less than $800,000—a savings of about $2.5 million over the estimated cost of $3.3 million to remove the powerhouse and other surplus equipment using site personnel.

During the past 4 years, FDD personnel have successfully used the assets-for-services approach to accomplish approximately $11.1 million in disposition services for an expenditure of about $1.1 million. This program has reduced surplus facilities at SRS by about 71,000 square feet.

Decontamination Facility Operations

FDD operates the Decontamination Facility to provide cost-effective decontamination and equipment size-reduction services for all WSRC divisions. These operations provide a valuable service for the SRS recycling and waste minimization programs.

The Decontamination Facility had its most productive year in 2001, with cost savings approaching $7.6 million. The savings were generated by

- processing more than 13,600 cubic feet of contaminated equipment and materials, including two trackhoes and two bulldozers
- rolling back more than 38,000 square feet of contaminated areas, including five waste tanks at the SRS Tank Farms, to radiologically controlled or buffered areas
- minimizing waste primarily through a 5-month project to repackage small solid waste boxes into larger drums prior to storage and disposal

New Decontamination Facility Technologies

FDD works closely with DOE's Environmental Management Office of Science and Technology, the National Energy Technology Laboratory, and the Savannah River Technology Center to review and deploy technologies that can lower costs, increase employee efficiency and safety, help eliminate waste production, and promote pollution prevention. Two of these technologies involve a remote-operations size-reduction system and a remotely controlled hydraulic shears machine.

Size Reduction SRS has identified a need for size-reduction capabilities to dispose of a growing quantity of large, contaminated equipment, to provide improved second-sort capabilities, and to size-reduce newly generated waste. A system (the remote-operations size-reduction system, also known as "ROSRS") was designed and constructed at a cost of approximately $9.5 million for use at the Rocky Flats Environmental Test Site Closure Project to size-reduce a variety of plutonium-contaminated gloveboxes. With deployment of the system cancelled primarily because of mission changes at Rocky Flats, SRS requested and was awarded the system in 2001 for use at the site's Decontamination Facility. The system has remotely operated size-reduction and material handling capabilities in a fully contained and ventilated environment.

Hydraulic Shears The Decontamination Facility also obtained a remotely controlled, tracked vehicle in 2001 that can be fitted with hydraulic shears. This configuration allows large components to be segmented while the operator remains in a safe location. The equipment was used to size-reduce contaminated large equipment during 2001, and although it can be taken anywhere on site, its primary use will be for various size-reduction tasks at the Decontamination Facility.

Chapter 3

Radiological Effluent Monitoring

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To Read About . . . See Page . . .

THIS chapter describes the Savannah River Site (SRS) radiological effluent monitoring program and summarizes the 2001 effluent monitoring data results.

Radiological effluent monitoring results are a major component in determining compliance with applicable dose standards, which can be found in chapter 5, "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 and to onsite workers 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. Each operating facility maintains ownership of and is responsible for its radiological effluents. Safety and Health Operations (S&HO) and the Environmental Protection Department's Environmental Monitoring Section (EMS) perform most of the radiological effluent monitoring functions. S&HO 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 and analyze most of the airborne effluent samples. Results of these analyses are compiled and reported in monthly radioactive releases reports.

Approximately 4,000 radiological effluent samples were collected at 61 points of discharge and analyzed during 2001.

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, 2001). A summary of data results is presented in this chapter; more detailed data can be found in *SRS Environmental Data for 2001* (WSRC–TR–2001–00475).

Airborne Emissions

Process area stacks that release or have the potential to release radioactive materials are monitored continuously by applicable online monitoring and/or sampling systems [SRS EM Program, 2001]. Filter paper samples, used to collect radioactive particles, generally are gathered daily and screened initially for radioactivity by S&HO personnel. Charcoal canisters, used to collect radioiodines, are gathered weekly at some locations and monthly at locations with lower potential for release. S&HO personnel routinely transfer the filter paper samples and charcoal canisters weekly 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 S&HO 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, S&HO 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 2001:

- Air effluent sampling at the 321–M stacks was discontinued at the end of October, following the completion of deactivation work.
- Air effluent sampling at the portable $C0_2$ blaster decon exhaust was discontinued in June because of a lack of work.

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 molecular sieve.

Laboratory Analysis

EMS provides most of the radioanalytical laboratory services required to conduct the site airborne effluent monitoring program. However, tritium in airborne effluents is measured at each applicable operating facility. Also, specific low-level analyses for iodine-129 were performed by an onsite laboratory during 2001.

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

Estimates of radionuclide releases from unmonitored diffuse and fugitive sources also are 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.

Diffuse and fugitive releases are calculated using the U.S. Environmental Protection Agency's (EPA's) recommended methods. The methods produce conservative estimates of release levels having a large uncertainty associated with them. However, for consistency with other reported data, the estimates are reported to three significant figures.

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.

The unmonitored radionuclides are fission product tritium, carbon-14, and krypton-85. These radionuclides cannot be measured readily in the effluent streams; therefore, the values are calculated on an annual basis and are based on production levels in the separations areas.

Because of increased operations in H-Canyon, the amount of krypton-85 estimated to have been released by the site increased 19 percent—from 52,800 Ci in 2000 to 64,700 Ci in 2001. This accounts for 58 percent of the total radioactivity released to the atmosphere from SRS operations. However, because krypton is a noble (chemically inert) gas, it is not readily absorbed by the human body and thus results in only a small amount of dose, even though the released amount is relatively high.

The data in table 3–1 on page 37 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 5, as is a comparison of these offsite doses to EPA and the U.S. Department of Energy (DOE) dose standards.

Beta- and Alpha-Emitting Radionuclides

Unspecified alpha and beta emissions have become large contributors (on a percentage basis) to offsite doses, especially for the airborne pathway from diffuse and fugitive releases. Because some (if not most) of these emissions are from naturally occurring

Diffuse and Fugitive Sources

Emissions from DOE facilities include those from point sources (stacks or vents) and those from diffuse and fugitive sources. A diffuse source is defined as an area source. Examples of diffuse sources include resuspension of contaminants deposited on open fields and evaporation from holding ponds and basins. A fugitive source is defined as an undesigned localized source. Process leaks that discharge to the atmosphere by a path other than a stack or vent are fugitive releases. Unmonitored evaporation releases from open tanks and drums also are considered fugitive releases.

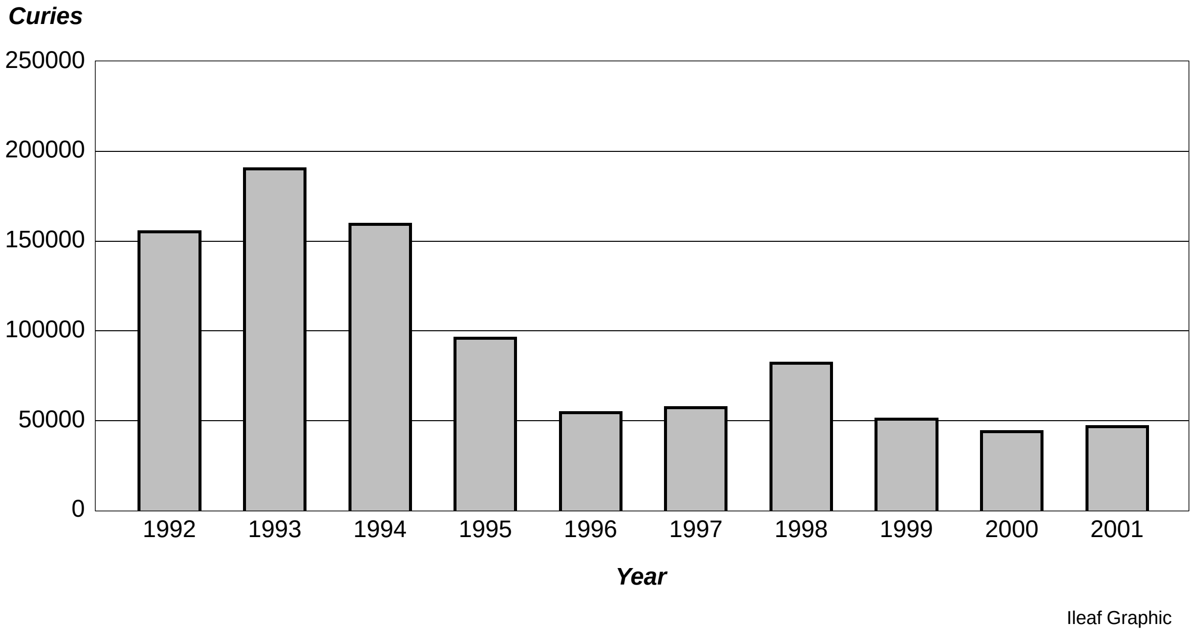

Figure 3–1 Ten-Year History of SRS Annual Atmospheric Tritium Releases

radionuclides, these emissions are accounted for separately from actual strontium-90 and plutonium-239 emissions.

Therefore, releases of unspecified alpha emissions and nonvolatile beta emissions are listed separately in the source term. Prior to 2000, these emissions were included in plutonium-239 and strontium-89,90 releases.

For dose calculations, the unspecified alpha releases were assigned the plutonium-239 dose factor, and the unspecified nonvolatile beta releases were assigned the strontium-90 dose factor (chapter 5).

Tritium

Tritium in elemental and oxide forms accounts for 42 percent of the total radioactivity released to the atmosphere from SRS operations. As an isotope of hydrogen, tritium acts the same as hydrogen chemically and physically and thus is extremely difficult to remove selectively from air effluent streams. During 2001, about 47,400 Ci of tritium were released from SRS, compared to about 44,800 Ci in 2000.

Because of improvements in facilities, processes, and operations and because of changes in the site's mission, the amount of tritium (and other atmospheric radionuclides) released has been reduced throughout the history of SRS. During the early years at SRS, large quantities of tritium were discharged to the atmosphere. The maximum yearly release of 2.4 million Ci of tritium occurred during 1958. In recent years, because of the changes in the site's missions and the existence of the Replacement Tritium Facility, the total amount of tritium released has fluctuated but has remained less than 100,000 Ci per year (figure 3–1).

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) in DOE Order 5400.5, "Radiation Protection of the Public and the Environment."

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 undiluted 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 5), this scenario is highly 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. The 2001 atmospheric 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 2001*.

Most of the SRS radiological stacks/facilities release small quantities of radionuclides at concentrations below the DOE DCGs. However, certain radionuclides—tritium (in the oxide form) from the reactor facilities and the tritium facilities and americium-241 and plutonium-239 in F-Area from the 6.1 and 6.4 dissolvers—were emitted at concentration levels above the DCGs. Because of the extreme difficulty involved in removing tritium and because of current facility designs, site missions, and operational considerations, this situation is unavoidable. The offsite dose consequences from all atmospheric releases during 2001, however, remained well below the DOE and EPA annual atmospheric pathway dose standard of 10 mrem (0.1 mSv) (chapter 5).

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, 2001]. The radiological liquid effluent sampling locations at SRS are shown, along with the surface water surveillance sampling locations, in chapter 4, “Radiological Environmental Surveillance” (page 48, figure 4–4).

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 by automatic samplers at, or very near, their points of discharge to the receiving streams. EMS personnel normally collect the liquid effluent samples weekly and transport them to the EMS laboratory for analysis.

Continuous Monitoring Systems

Depending on the processes involved, liquid effluents also may be monitored by area operations and/or S&HO personnel with real-time instrumentation to ensure that instantaneous releases stay within established limits. Because the instruments have limited detection sensitivity, online monitoring systems are not used to quantify liquid radioactive releases from SRS.

Laboratory Analysis

EMS provides most of the radioanalytical laboratory services required to conduct the site liquid effluent monitoring program.

Flow Rate Measurements

Liquid effluent flows generally are determined by one of two methods: U.S. Geological Survey flow stations or commercial flow meters. 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 migration release estimates to quantify the total radioactive material released to the Savannah River from SRS operations. SRS liquid radioactive releases for 2001 are shown by source in table 3–2, page 40.

The data 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 5, as is a comparison of these offsite doses to EPA and DOE dose standards.

Beta- and Alpha-Emitting Radionuclides

Unspecified alpha and beta emissions have become large contributors (on a percentage basis) to offsite doses, especially for the liquid pathway from diffuse and fugitive releases. Because some (if not most) of these emissions are from naturally occurring radionuclides, these emissions are accounted for separately from actual strontium-90 and plutonium-239 emissions.

Releases of unspecified alpha emissions and nonvolatile beta emissions are listed separately in the source term. Prior to 2000, these emissions were included in plutonium-239 and strontium-89,90 releases.

For dose calculations, the unspecified alpha releases were assigned the plutonium-239 dose factor, and the unspecified nonvolatile beta releases were assigned the strontium-90 dose factor (chapter 5).

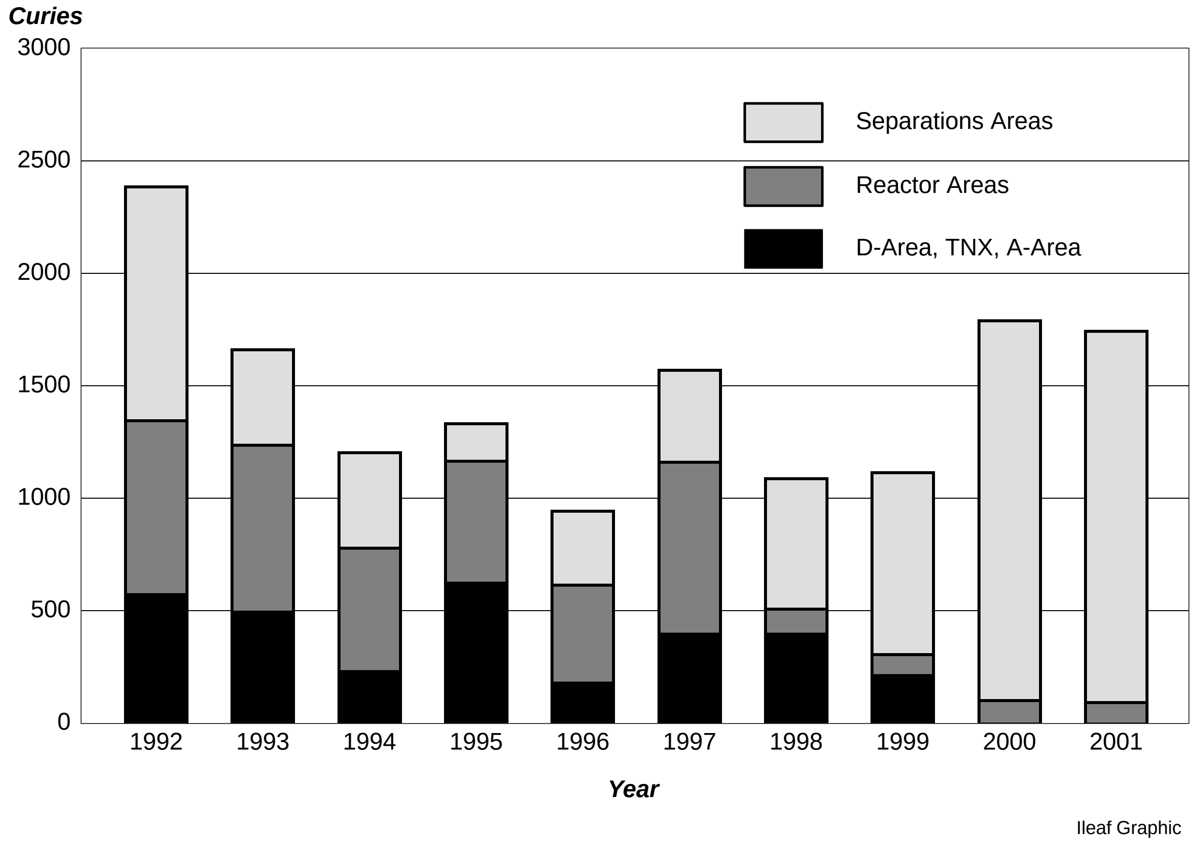

Figure 3–2 Direct Releases of Tritium to SRS Streams, 1992–2001

Operations at D-Area and TNX were discontinued in 2000 and 2001, respectively. Releases from A-Area and the reactor areas currently represent only a small percentage of the total direct releases of tritium to site streams.

Direct Discharges of Liquid Effluents

Direct discharges of liquid effluents are quantified at the point-of-release to the receiving stream, prior to dilution by the stream. The release totals are based on measured concentrations and flow rates.

Tritium accounts for nearly all of the radioactivity discharged in SRS liquid effluents. The total amount of tritium released directly from process areas (i.e., reactor, separations, Effluent Treatment Facility) to site streams during 2001 was 1,748 Ci**,** which was slightly less than the 2000 total of 1,795 Ci.

Direct releases of tritium to site streams for the years 1992–2001 are shown in figure 3–2, where it can be seen that the total amount of tritium released has fluctuated but has remained less than 2,000 Ci per year in recent years.

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 releases. These considerations are applicable to direct discharges but not to seepage basin and Solid Waste Disposal Facility 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 highly 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 2001 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 2001*.

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 2001. 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 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 during 2001.

Table 3–1 Radioactive Atmospheric Releases by Source

Page 1 of 3

Radionuclide	Curies[a] Reactors	Separa-tions[b]	Reactor Materials	SRTC[c]	Diffuse and Fugitive[d]	Total
Note: Blank spaces indicate no quantifiable activity.						
GASES AND VAPORS						
H-3(oxide)	2.41E+03	3.00E+04			6.07E+02	3.30E+04
H-3(elem.)		1.44E+04				1.44E+04
H-3 Total	2.41E+03	4.44E+04			6.07E+02	4.74E+04
C-14		1.70E–01			8.76E–05	1.70E–01
Kr-85		6.47E+04				6.47E+04
Xe-133		4.82E–06				4.82E–06
Xe-135		7.57E–02				7.57E–02
I-129		1.29E–02			1.29E–06	1.29E–02
I-131		2.05E–06		6.13E–06		8.18E–06
I-133				4.26E–04		4.26E–04
PARTICULATES						
Ac-228					4.07E–06	4.07E–06
Am-241		1.52E–04	5.72E–09		1.15E–04	2.67E–04
Am-243					9.90E–07	9.90E–07
Bi-214					1.29E–06	1.29E–06
Ce-141					4.16E–05	4.16E–05
Ce-144					1.43E–04	1.43E–04
Cm-242					1.43E–08	1.43E–08
Cm-244		3.90E–06	2.23E–09		4.76E–05	5.15E–05
Cm-245					4.18E–07	4.18E–07
Cm-246					1.01E–06	1.01E–06
Co-58					1.27E–04	1.27E–04
Co-60		4.40E–08		3.25E–07	8.59E–04	8.59E–04
Cr-51					1.21E–04	1.21E–04
Cs-134		1.94E–08			1.31E–04	1.31E–04
Cs-137		1.18E–03			2.22E–03	3.40E–03
Eu-152					4.15E–05	4.15E–05
Eu-154					1.53E–05	1.53E–05
Eu-155					7.85E–07	7.85E–07
Hg-203					2.29E–10	2.29E–10

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

Table 3–1 Radioactive Atmospheric Releases by Source

Page 2 of 3

	Curies[a]					
Radionuclide	**Reactors**	**Separa-tions[b]**	**Reactor Materials**	**SRTC[c]**	**Diffuse and Fugitive[d]**	**Total**
Mn-54					2.52E–08	2.52E–08
Na-22					2.09E–08	2.09E–08
Nb-94					4.56E–08	4.56E–08
Nb-95					1.13E–04	1.13E–04
Ni-63					4.38E–06	4.38E–06
Np-237					1.09E–08	1.09E–08
Np-239					1.24E–07	1.24E–07
Pa-233					2.29E–10	2.29E–10
Pa-234					1.76E–08	1.76E–08
Pb-212					2.74E–06	2.74E–06
Pb-214					6.58E–07	6.58E–07
Pm-147					1.34E–05	1.34E–05
Pu-236					1.22E–10	1.22E–10
Pu-238		9.15E–05	3.67E–09		3.99E–05	1.31E–04
Pu-239		2.62E–04	1.37E–08		1.94E–03	2.20E–03
Pu-240					8.51E–07	8.51E–07
Pu-241					6.70E–06	6.70E–06
Pu-242					2.09E–08	2.09E–08
Ra-226					5.25E–06	5.25E–06
Ra-228					4.16E–06	4.16E–06
Ru-103					4.23E–05	4.23E–05
Ru-106					9.92E–07	9.92E–07
Sb-124					8.09E–09	8.09E–09
Sb-125					5.37E–05	5.37E–05
Se-79					4.58E–09	4.58E–09
Sn-126					1.69E–07	1.69E–07
Sr-89					3.34E–07	3.34E–07
Sr-90		1.42E–04			3.57E–03	3.71E–03
Tc-99					1.89E–06	1.89E–06
Th-228					3.97E–06	3.97E–06
Th-230					2.71E–06	2.71E–06
Th-232					1.75E–06	1.75E–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

Table 3–1 Radioactive Atmospheric Releases by Source

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	Curies[a]					
Radionuclide	**Reactors**	**Separa-tions[b]**	**Reactor Materials**	**SRTC[c]**	**Diffuse and Fugitive[d]**	**Total**
Th-234					1.03E–04	1.03E–04
Tl-208					2.58E–06	2.58E–06
U-232					4.46E–11	4.46E–11
U-233					3.90E–08	3.90E–08
U-234		3.85E–05	3.43E–06		2.84E–04	3.26E–04
U-235		3.91E–06	5.16E–07		6.59E–06	1.10E–05
U-236					7.17E–10	7.17E–10
U-238		9.33E–05	4.93E–07		3.18E–04	4.12E–04
Zn-65					2.23E–05	2.23E–05
Zr-95					1.68E–05	1.68E–05
Alpha	5.49E–05	3.69E–05		1.49E–08	1.33E–03	1.42E–03
Beta-Gamma	3.81E–04	1.70E–04	1.10E–05		3.22E–02	3.28E–02

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

Table 3–2 Radioactive Liquid Releases by Source (Including Direct and Seepage Basin Migration Releases)

Page 1 of 1

	Curies[a]				
Radionuclide	**Reactors (C,K,L,P,R)**	**Separations[b] (F-Area, H-Area.**	**Reactor Materials (M-Area)**	**SRTC[c] (A-Area)**	**Total**
Note: Blank spaces indicate no quantifiable activity.					
H-3	1.28E+03	3.03E+03		7.94E–01	4.32E+03
Sr-90	5.92E–05	2.04E–02			2.05E–02
Tc-99		4.56E–02			4.56E–02
I-129		7.82E–02			7.82E–02
Cs-137	2.25E–02	5.80E–02			8.05E–02
U-234		2.09E–05	3.10E–05	4.28E–05	9.47E–05
U-235		9.05E–07		7.92E–07	1.70E–06
U-238		3.97E–05	3.55E–05	4.90E–05	1.24E–04
Pu-238		1.36E–05	2.85E–05	2.92E–06	4.50E–05
Pu-239		5.12E–06	2.31E–06		7.43E–06
Am-241		1.35E–06	5.72E–06		7.07E–06
Cm-244		1.22E–06	5.87E–06		7.09E–06
Alpha	3.26E–03	1.98E–02	2.59E–03	3.09E–03	2.87E–02
Beta-Gamma	2.56E–02	5.63E–02	1.73E–04	3.05E–03	8.51E–02

a One curie equals 3.7 E+10 Becquerels.
b Includes separations, waste management, and tritium facilities
c Savannah River Technology Center

Chapter 4

Radiological Environmental Surveillance

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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 2001 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 3, "Radiological Effluent Monitoring"), the radiological environmental surveillance 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 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 2001 results for groundwater can be found in chapter 8, "Groundwater."

Detailed analytical results for 2001—as well as representative minimum detectable concentrations (MDCs) for the types of analyses being performed on the various environmental surveillance media—appear in *SRS Environmental Data for 2001* (WSRC–TR–2001–00475). Data from earlier years can be found in previous SRS environmental reports and data publications.

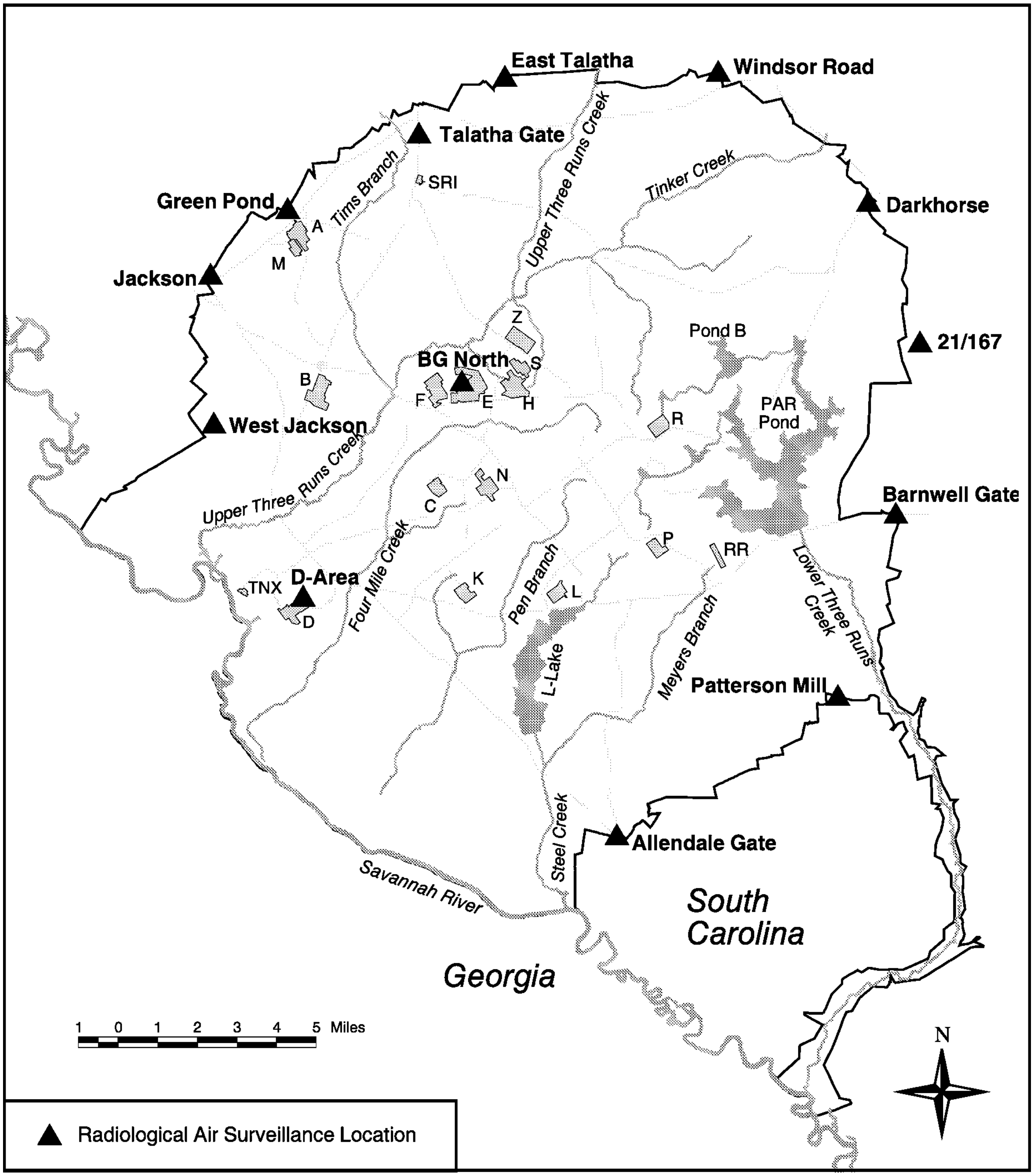
A complete description of the SRS radiological environmental surveillance program can be found in section 1105 of the *Savannah River Site Environmental Monitoring Section Plans and Procedures*, WSRC–3Q1–2, Volume 1 [SRS EM Program, 2001].

Air

Description of Surveillance Program

EMS maintains an extensive network of 17 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



EPD/GIS Map

Figure 4–1 Radiological Air Surveillance Sampling Locations

The SRS air surveillance program consists of 13 stations located on site or along the site perimeter, as well as (not shown) three stations approximately 25 miles from the site perimeter (located near the U.S. Highway 301 Bridge over the Savannah River; the New Savannah Bluff Lock and Dam, also known as the Augusta Lock and Dam; and the Aiken airport) and one about 100 miles from the site perimeter (near Savannah, Georgia).

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

Figure 4–1 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

Table 4–1
Average Gross Alpha and Gross Beta Measured in Air (pCi/m^3), 1997–2001

			Average Gross Alpha		
Locations	**1997**	**1998**	**1999**	**2000**	**2001**
On site	1.2E–03	1.1E–03	2.0E–03	1.6E–03	8.5E–04
Site perimeter	9.8E–04	1.4E–03	1.9E–03	1.7E–03	8.8E–04
25-mile radius	1.0E–03	1.5E–03	1.9E–03	1.7E–03	8.2E–04
100-mile radius	1.1E–03	a	2.1E–03	1.6E–03	9.0E–04
			Average Gross Beta		
Locations	**1997**	**1998**	**1999**	**2000**	**2001**
On site	1.7E–02	1.6E–02	1.9E–02	2.0E–02	1.8E–02
Site perimeter	1.5E–02	1.8E–02	1.9E–02	2.0E–02	1.8E–02
25-mile radius	1.6E–02	1.9E–02	1.9E–02	2.0E–02	1.7E–02
100-mile radius	1.1E–02	a	1.9E–02	1.8E–02	1.5E–02

a Could not be sampled in 1998

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 3 details the types and quantity of radioactive material released to the environment from SRS activities in 2001. Except for tritium, specific radionuclides were not routinely detectable at the site perimeter. Both onsite and 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 1997–2001 is presented in table 4–1. Average gross alpha and beta results were slightly lower in 2001 than in 1999 and 2000. However, they are consistent with historical results, which demonstrate a long-term variability.

As in previous years, no significant difference was seen between the average concentrations measured on site near the operating facilities and the average concentrations observed at the site perimeter.

Gamma-Emitting Radionuclides

Glass fiber filters and activated charcoal canisters are collected weekly. The glass fiber filters are analyzed weekly and the activated charcoal canisters are analyzed annually. No manmade gamma-emitting radionuclides were observed in 2001. These results are consistent with historical results, which indicate only 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 ensures that there will be information available to determine whether any potential health risk to the surrounding population is created.

As detailed in the *SRS Environmental Report for 2000* (WSRC–TR–2000–00328), an unanticipated change in silica gel in early 2000 resulted in significant increases in both the variability and the concentrations of the tritium-in-air analytical results.

Research by EMS identified the cause of these increases, as well as a solution, which eliminated the problems encountered in 2000. The variability of analytical results subsequently decreased, and tritium-in-air concentrations returned to levels observed in 1999.

The 2000 report also indicated that EMS identified and implemented a correction factor for tritium-in-air measurements using silica gel. The correction factor has been used since 1999; consequently, 2001 results appear higher than those of pre-1999 years, for which no corrections have been applied.

Tritium-in-air results for 2001 were similar to those observed in 1999 (the first year in which the correction factor was utilized). Comparison to 2000 results is not possible because of the analytical problems discussed earlier. As in previous years, the Burial Ground North location showed average and maximum concentrations significantly higher than those observed at other locations. This was expected because of its proximity to SRS's tritium facilities, which are near the center of the site. Consistent with the SRS source term, tritium concentrations generally decrease with increasing distance from the tritium facilities.

Alpha-Emitting Radionuclides

The analysis of glass fiber filter paper was expanded in 1999 to include uranium isotopes (uranium-234, uranium-235, uranium-238), americium-241, and curium-244—in addition to plutonium isotopes (plutonium-238, plutonium-239). These radionuclides are released in small quantities as part of routine site operations—primarily from the separations areas.

The analysis of glass fiber filter paper for alpha-emitting radionuclides is performed on one sample per year from each location. The analyses of samples from four of the 17 locations (Talatha Gate, Aiken Airport, the U.S. Highway 301 Bridge Area, and Savannah) were not completed because of analytical difficulties in the EMS laboratory. Detectable activity, primarily U-234 and U-238, was observed at six locations: Allendale Gate, D-Area, East Talatha, Patterson Mill Road, Windsor Road, and Augusta Lock and Dam. All isotopes at the remaining locations were below detection levels; generally, these concentrations were consistent with historical results.

Strontium

Strontium analysis is performed on one sample per year from each monitoring site. As observed in previous years, none of the samples showed strontium above the lower limit of detection (LLD).

Rainwater

SRS maintains a network of rainwater sampling sites as part of the air surveillance program. These stations are used to measure deposition of radioactive materials.

Description of Surveillance Program

Rainwater collection pans are located at each routine air surveillance station (figure 4–1). Ion-exchange resin columns are placed at seven of these locations. At each of the locations, rain passes through the column and into a collection bottle. Both the ion-exchange resin column and the collected liquid are returned to the laboratory for analysis. The column is analyzed weekly for gamma-emitting radionuclides, gross alpha, and gross beta and annually for plutonium-238, plutonium-239, and strontium-89,90; the rainwater is analyzed for tritium.

The rainwater collected from all other locations is analyzed for tritium only. Ion-exchange column sampling is performed monthly, while rainwater sampling is performed biweekly.

Surveillance Results

Gamma-Emitting Radionuclides

As in 2000, no detectable manmade gamma-emitting radionuclides were observed in rainwater samples during 2001.

Gross Alpha and Gross Beta

The gross alpha and gross beta results were consistent with those of 2000. Although the 2001 results generally were slightly higher than those of 2000, no long-term increasing or decreasing trend was evident. This implies that the observed values are natural background and does not indicate any contribution directly attributable to SRS.

Alpha-Emitting Radionuclides

The analysis of rain ion columns was expanded in 1999 to include uranium isotopes (uranium-234, uranium-235, uranium-238), americium-241, and curium-244—in addition to plutonium isotopes (plutonium-238 and plutonium-239). Except for U-234 and U-238 at BGN and U-234 at Savannah, all isotopes were below detection levels in 2001; generally, these concentrations were consistent with historical results.

Strontium

As in 2000, no detectable levels of strontium-89,90 were observed in rainwater samples during 2001.

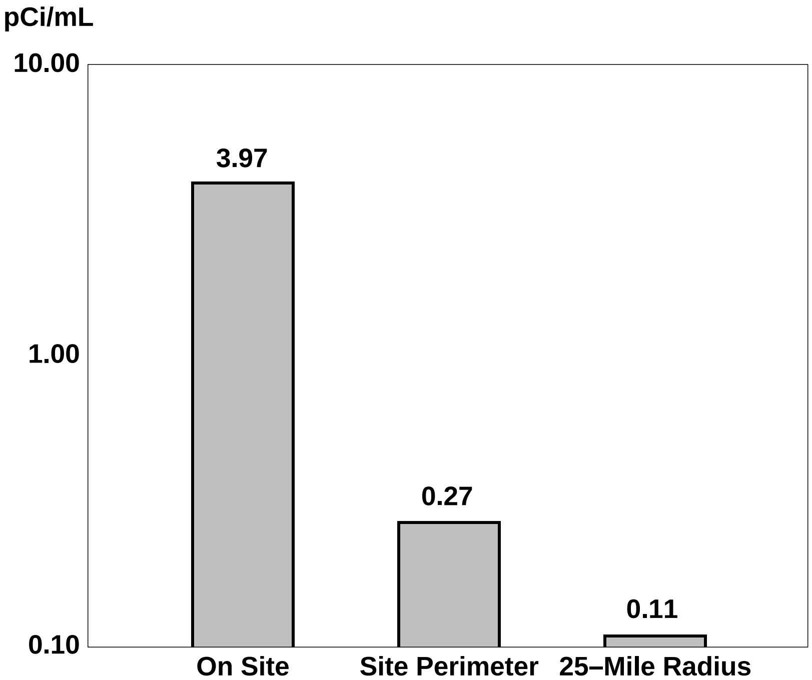


Figure 4–2 Average Concentration of Tritium in Rainwater, 2001

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

Ileaf Graphic

Tritium

As in previous years, tritium-in-rain values were highest near the center of the site. This is consistent with the H-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 4–2); 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

- 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 four subprograms, as follows: site perimeter stations, population centers, air surveillance stations, and Vogtle (stations that monitor potential exposures from Georgia Power’s Vogtle Electric Generating Plant). All TLDs are exchanged quarterly.

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.

Surveillance Results

In general, the 2001 ambient gamma radiation monitoring results indicated gamma exposure rates slightly lower than those observed at the same locations in 2000. However, these results generally are consistent with previously published historical results, as indicated in figure 4–3.

Exposures at all TLD monitoring locations show some variation based on normal site-to-site and year-to-year differences in the components of natural ambient gamma exposure levels. Generally, this

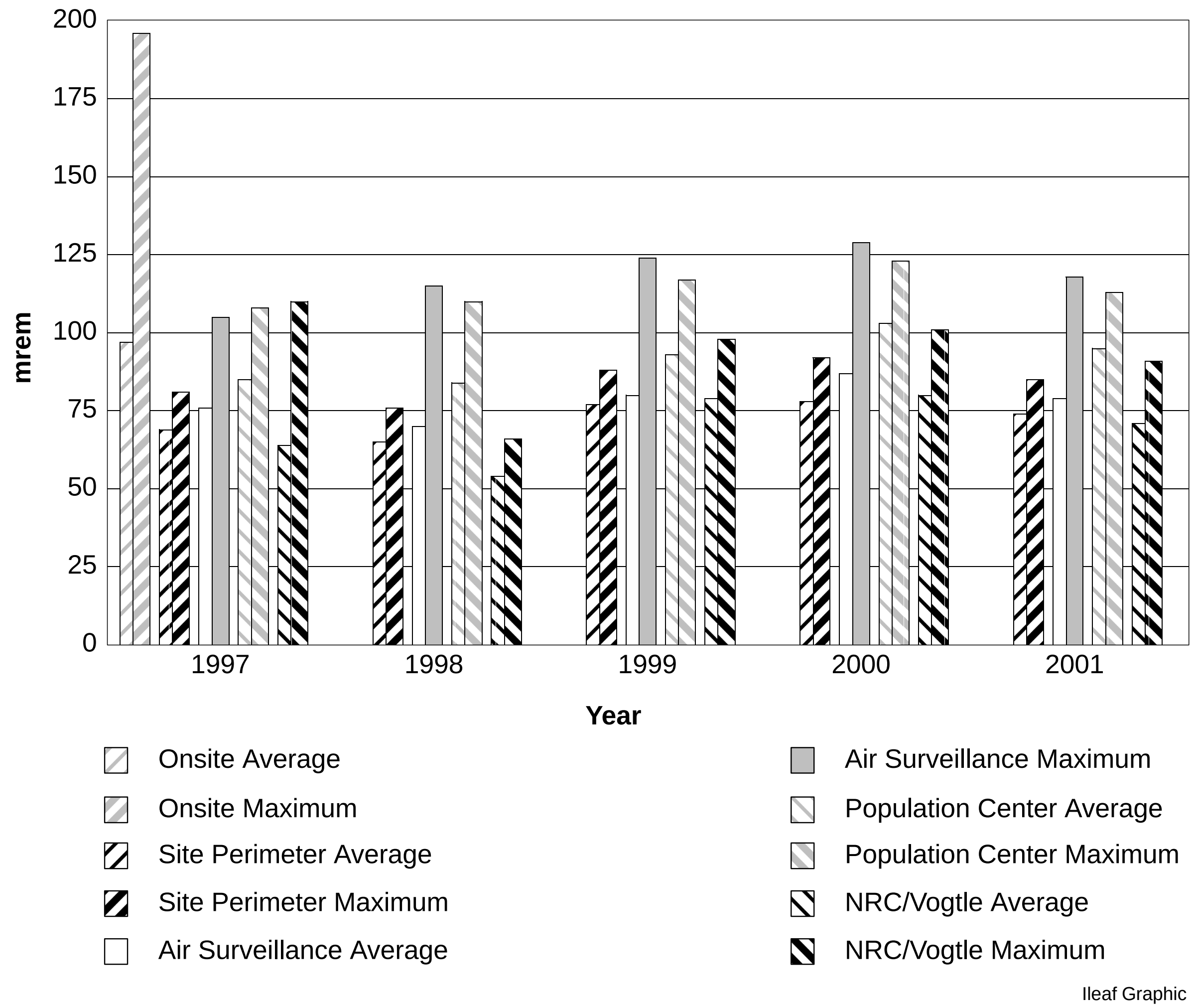


Figure 4–3 Annual Average/Maximum Gamma Exposure Grouped by Program Element, 1997–2001
Natural background gamma exposure levels remain fairly constant with time. With the exception of a few locations, onsite gamma exposure levels at SRS are similar to regional background levels.

Table 4–2
TLD Surveillance Results Summary for 2001

Monitoring Subprogram	Mean Exposure (mrem per year)	Maximum Exposure (mrem per year)	Maximum-Exposure Location
Site perimeter	74	85	Perimeter #65-D
Air surveillance	79	118	Burial Ground North
Population centers	95	113	Williston, SC
NRC/Vogtle	71	91	NRC #5

phenomena is observed at both onsite and offsite locations. Table 4–2 summarizes the 2001 surveillance results, which—except for the population center results—show no significant differences in average gamma exposure rates from one monitoring network to another. During the past 4 years, the highest exposure rate consistently has been at the burial ground.

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 seepage basins was discontinued in 1988, but stormwater accumulating in the basins 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, tritium, strontium, gamma-emitting radionuclides, and actinides. Analyses for specific radionuclides are determined by the makeup of previous releases to the basins.

Surveillance Results

Because of dry conditions, no samples were obtained from the E–06 location in 2001. Locations E–01, E–02, E–04, and E–05 were sampled monthly, and E–03 was sampled once. Because there are no active discharges to site seepage basins, the primary contributor to seepage basin water is from rainwater. As a result, there has been little variation in seepage basin results in recent years. In 2001, the highest mean tritium concentration, (6.66 ± 3.57)E+05 pCi/L, was found in E–02. This represents an increase from the highest 2000 mean concentration, (7.54 ± 1.08)E+03 pCi/L, found at E–02. The high mean tritium concentration at E–05 is the result of three tritium spikes that were caused by equipment failure and resulting drainage from the nearby Four Mile Creek phytoremediation project. The sampler at E–05 was relocated in late 2001, which should eliminate the possibility of concentration influence from the phytoremediation project. Mean cobalt-60, cesium-137, and gross alpha concentrations all were below their representative MDCs for rainwater.

Site Streams

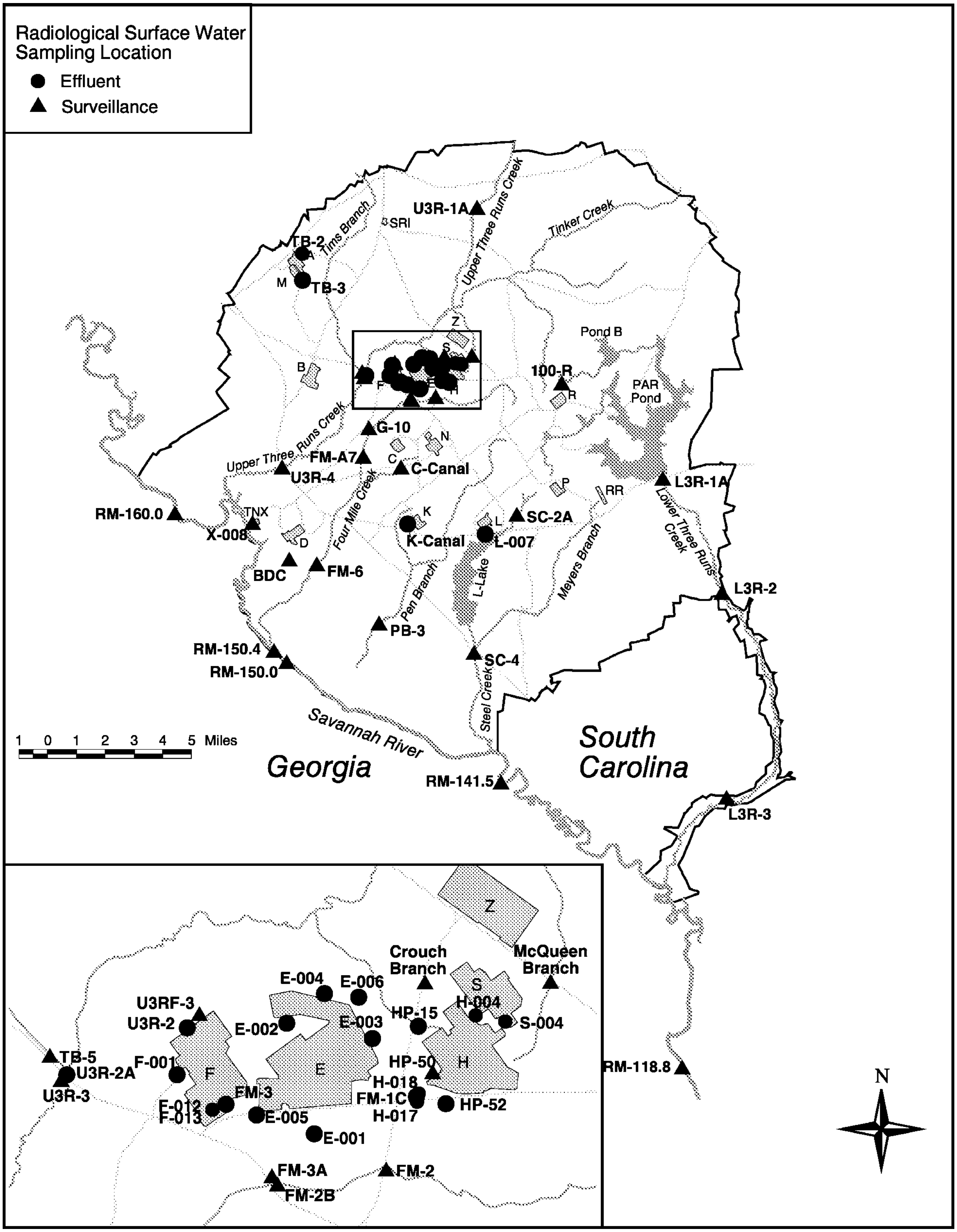
Continuous surveillance is used on several SRS streams (figure 4–4), including Tims Branch, Upper Three Runs, Four Mile Creek (also known as Fourmile Branch), Pen Branch, Steel Creek, and Lower Three Runs. Stream water sampling locations that monitor below process areas serve to detect and quantify levels of radioactivity in liquid effluents that are being transported to the Savannah River. In 2001, 23 such locations on SRS streams served as environmental surveillance points.

Description of Surveillance Program

The site's stream surveillance program monitors six streams—Tims Branch, Upper Three Runs, Four Mile Creek, Pen Branch, Steel Creek, and Lower Three Runs.

- Tims Branch is a tributary of Upper Three Runs, receiving effluents from M-Area and SRTC and stormwater runoff from A-Area and M-Area. The surveillance point on Tims Branch, TB–5, is located downstream of all release points and before entry into Upper Three Runs.
- Upper Three Runs receives discharges from the Effluent Treatment Facility (ETF) and S-Area; flow from Tims Branch; stormwater runoff from F-Area, H-Area, Z-Area, and S-Area; and water that has migrated from E-Area and is outcropping into the stream. Tritium, the predominant radionuclide detected in Upper Three Runs, is discharged primarily from the ETF.
- Four Mile Creek receives effluents from F-Area, H-Area, and the Central Sanitary Wastewater Treatment Facility (CSWTF); stormwater runoff from E-Area, C-Area, F-Area, and H-Area; and water that has migrated from seepage basins and E-Area and is outcropping into the stream.
- Pen Branch receives discharges and stormwater runoff from K-Area. Because K-Reactor has not operated since 1992, tritium detected in Pen Branch is attributed to groundwater seepage. PB–3 monitoring location tritium migration sources include the K-Area percolation field and seepage basins.
- Lower Three Runs receives overflow from PAR Pond, a manmade pond that receives seepage from R-Area basins and stormwater runoff from P-Area and R-Area.
- Steel Creek receives releases from L-Area effluents, tritium migration from P-Area seepage basins, and stormwater runoff from P-Area and L-Area.

For all locations except U3R–1A (the control location), which is sampled weekly, sampling for gross alpha and gross beta, tritium, and gamma is performed on a biweekly composite. Actinide analyses are performed annually on grab samples from all locations, while strontium-89,90 and—beginning in mid-2001—technetium-99 analyses are performed annually on grab samples from all except four locations on Four Mile Creek—FM–A7, FMC–2B, FMC–2, and FMC–3A. Strontium and technetium analyses at these locations are performed on biweekly composite samples. Outfall G–10, the discharge point for the CSWTF,



EPD/GIS Map

Figure 4–4 Radiological Surface Water Sampling Locations
Surveillance and effluent sampling points are at SRS seepage basins and streams and on the Savannah River.

establishes a baseline for monitoring radiological effluents to sanitary sewers. Sampling for gross alpha, gross beta, tritium, gamma, actinides, and strontium-89,90 is performed on a weekly composite at G–10. Outfall TNX–008 was added as a surveillance location in 2001 to monitor discharges from TNX-Area, which will be shut down in 2002.

Surveillance Results

The average gross alpha, gross beta, and tritium concentrations for 2001 at downstream locations near the creek mouths are presented in table 4–3. Figure 4–5 is a graph showing the average tritium concentration over a 10-year period in the five major site streams. 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 control location U3R–1A (above process effluents and runoff locations on Upper Three Runs) are listed for comparison purposes in table 4–3. Five-year trend charts showing gross alpha, gross beta, and cesium-137 concentrations for each major site stream appear in figure 4–6. The results in each chart are from the monitoring point nearest the stream's discharge to the Savannah River.

The gross alpha mean concentration at the control location (U3R–1A) doubled in 2001—from (4.04 ± 0.28)E+00 to (8.41 ± 0.85)E+00. A laboratory process investigation indicated no systematic errors. It is believed that this increase was the result of offsite activities; an investigation will be conducted in 2002.

The highest gross alpha mean concentration in 2001, found at TB–5, was (2.97 ± 0.62)E+00 pCi/L.

Mean gross beta concentrations were consistent with historical data. Strontium-89,90 and cesium-137 are contributors to gross beta activity. The newly initiated A Tc-99 measurement program begun in 2001 is still in the development stages in terms of establishing historical Tc-99 levels. During 2001, Tc-99 was detected at FM–2, FM–2B, and FM–A7.

Mean tritium concentrations at downstream locations were consistent with historical values.

Seepage Basin and Solid Waste Disposal Facility Radionuclide Migration

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 Solid Waste Disposal Facility (SWDF) as part of its stream surveillance program. During 2001, tritium, strontium-89,90, and cesium-137 were detected in migration releases. As noted in chapter 3 ("Radiological Effluent Monitoring"), measured iodine-129 results were not available from EMS and the value measured in 1996 was used for dose calculation. This value is reported in table 3–2 in chapter 3.

Figure 4–7 is a graphical representation of releases of tritium via migration to site streams for the years

Table 4–3
Average 2001 Concentration of Radioactivity in SRS Streams (pCi/L)

Location[a]	Gross Alpha	Gross Beta	Tritium
Onsite Downstream Locations			
Tims Branch (TB–5)	(2.97 ± 0.62)E+00	(1.38 ± 0.25)E+00	(6.46 ± 0.90)E+02
Lower Three Runs (L3R–3)	(2.01 ± 0.46)E+00	(1.90 ± 0.28)E+00	(1.36 ± 0.11)E+03
Steel Creek (SC–4)	(5.10 ± 1.02)E–01	(1.00 ± 0.11)E+00	(6.54 ± 0.40)E+03
Pen Branch (PB–3)	(4.09 ± 0.78)E–01	(9.85 ± 1.69)E–01	(1.06 ± 0.05)E+05
Four Mile Creek (FM–6)	(1.03 ± 0.19)E+00	(4.93 ± 0.67)E+00	(7.74 ± 0.23)E+04
Upper Three Runs (U3R–4)	(1.43 ± 0.17)E+00	(9.02 ± 1.28)E–01	(1.47 ± 0.16)E+04
Onsite Control Location (for comparison purposes)			
Upper Three Runs (U3R–1A)	(8.41 ± 0.85)E+00	(4.09 ± 0.44)E+00	(2.31 ± 0.53)E+02

a Site surveillance locations are near mouths of streams.

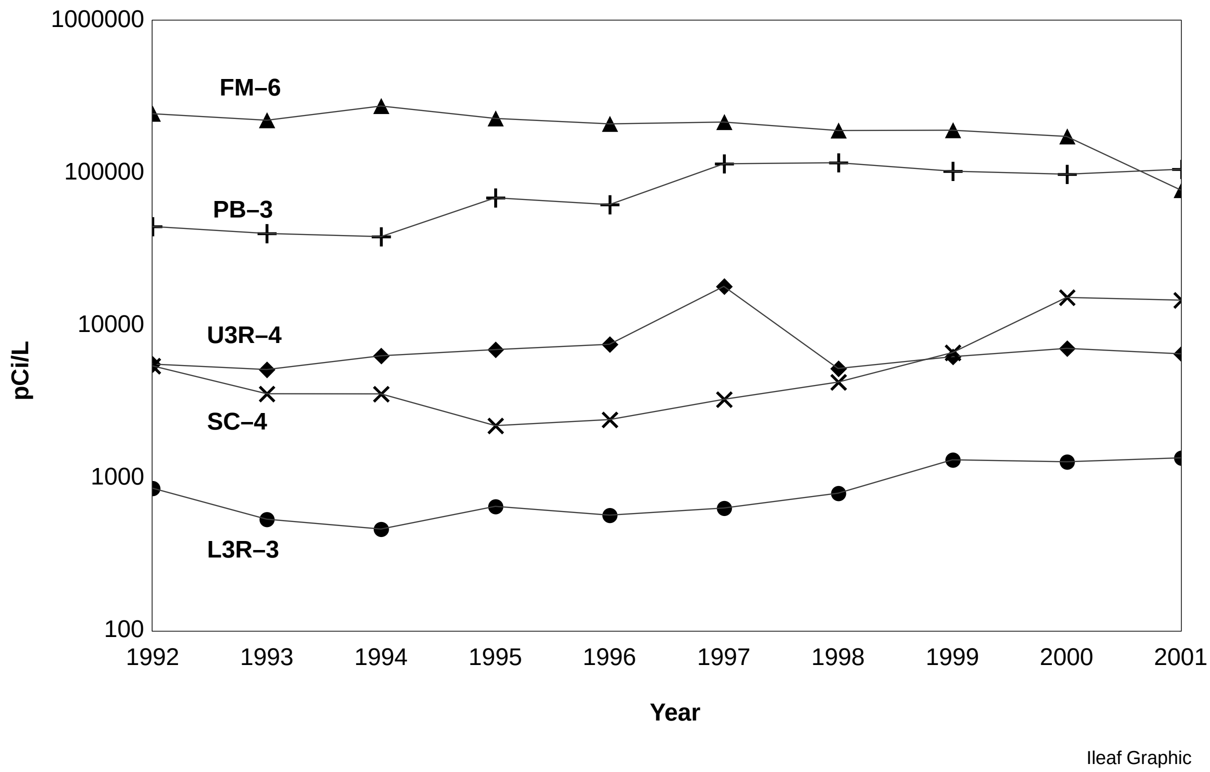


Figure 4–5 Average Tritium Concentrations in Major SRS Streams, 1992–2001

1992–2001. During 2001, the total quantity of tritium migrating from the seepage basins and SWDF was about 2,675 Ci, compared to 4,200 Ci in 2000. The decline is attributed to (1) the success of the Four Mile Creek phytoremediation project, which began in late 2000 with the installation of a dam on the creek, and (2) the subsequent startup in early 2001 of the project's irrigation system.

The total combined tritium releases in 2001 (direct discharges and migration from seepage basins and SWDF) were 4,423 Ci, compared to 5,995 Ci in 2000. Figure 4–8 shows 1992–2001 total combined tritium releases.

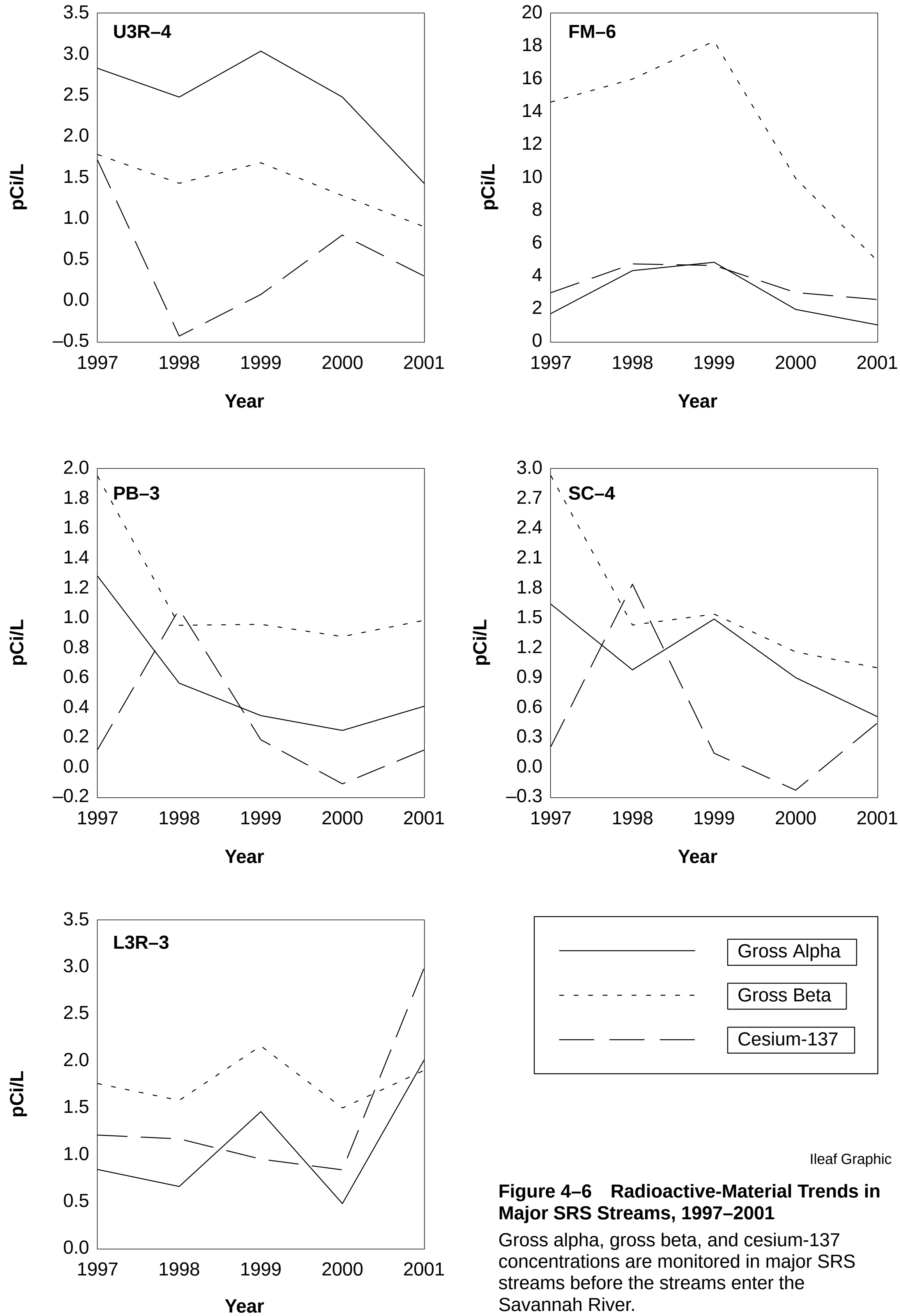
F-Area and H-Area Seepage Basins and SWDF

Radioactivity previously deposited in the F-Area and H-Area seepage basins and SWDF continues to migrate via the groundwater and to outcrop into Four Mile Creek and into Upper Three Runs.

Groundwater migration from the F-Area seepage basins enters Four Mile Creek between sampling locations FM–3A, FM–2B, and FM–A7. 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 part of 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. Four Mile Creek sampling locations are shown in figure 4–4.

Measured migration of tritium from F-Area seepage basins was 284 Ci in 2001. This is a 20-percent decrease from the 2000 total of 353 Ci. The measured migration from H-Area seepage basin 4 and SWDF was 411 Ci, a 400-percent decrease from the 2000 total of 1,920 Ci. Most of the decrease is believed to be attributable to the Four Mile Creek phytoremediation project. The measured migration from H-Area seepage basins 1, 2, and 3 was 161 Ci, a 16-percent increase from the 2000 total of 139 Ci. Figure 4–9 shows 1992–2001 tritium migration releases from the F-Area and H-Area seepage basins and from the SWDF.

Generally, 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 [Looney, 1993]. Tritium migration from SWDF has fluctuated between 2,000 and 5,000 Ci during the past 9 years. Based on recent assessments of the operational history of SWDF and the geology and hydrology of the site, it is anticipated that, with



Ileaf Graphic

Figure 4–6 Radioactive-Material Trends in Major SRS Streams, 1997–2001

Gross alpha, gross beta, and cesium-137 concentrations are monitored in major SRS streams before the streams enter the Savannah River.

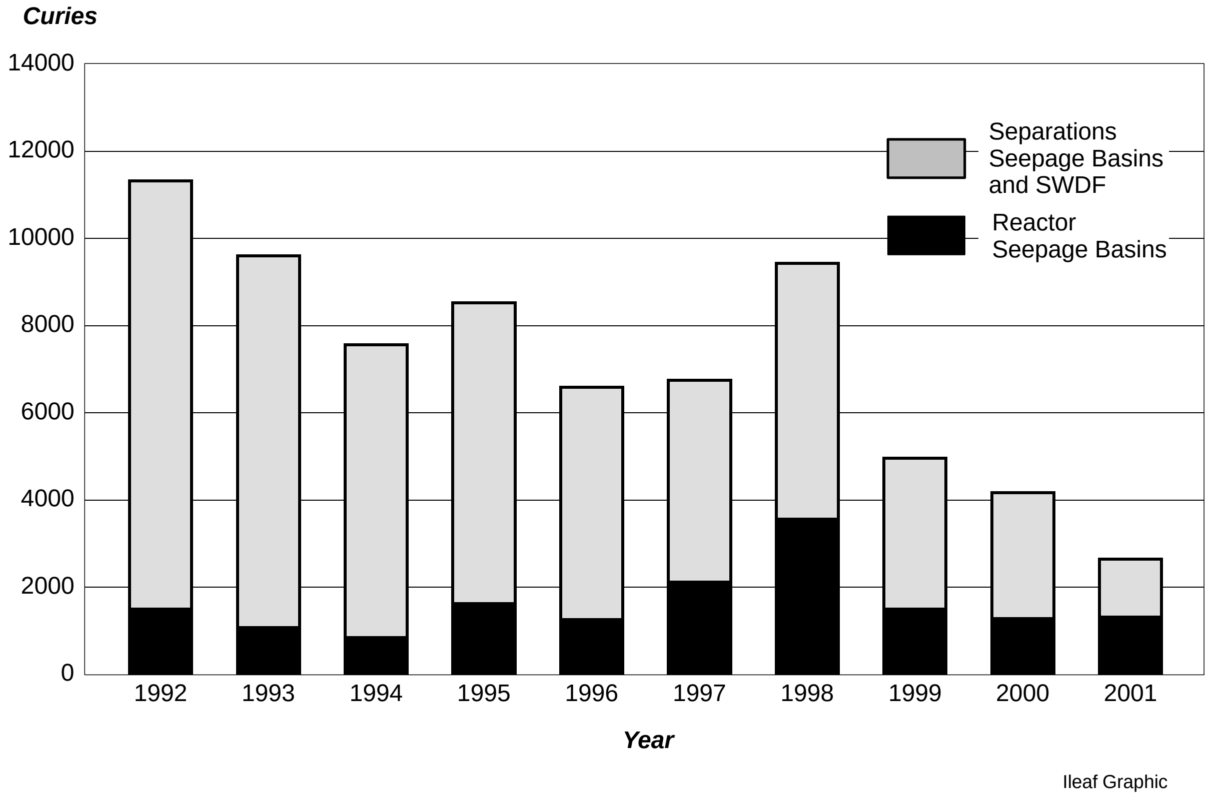


Figure 4–7 Tritium Migration from Seepage Basins and SWDF to SRS Streams, 1992–2001

no corrective actions, SWDF tritium migration into Four Mile Creek will continue, but slowly decrease for the next 20 to 25 years [Flach, 1996]. However, implementation of the Four Mile Creek phytoremediation project should accelerate this decrease.

The measured migration from the north side of SWDF and the General Separations Area (GSA) into Upper Three Runs in 2001 was 470 Ci, a 3-percent decrease from the 2000 total of 483 Ci. (The GSA is in the central part of SRS and contains all waste disposal facilities, chemical separations facilities, associated high-level waste storage facilities, and numerous other sources of radioactive material.)

A 10-year history of tritium migration releases into Upper Three Runs is shown in figure 4–10.Tritium migration into Upper Three Runs has remained between 150 and 500 Ci per year. A computer-modeled groundwater migration study predicts increased tritium migration to Upper Three Runs during the next 20 years [Cook, 1997]. This analysis assumes all current and future tritium inventories will migrate relatively fast without considering past migration releases or potential corrective actions; these assumptions are considered to be conservative. A complete and thorough assessment of tritium migration into Upper Three Runs that is based on measured groundwater concentrations and movement has not yet been performed.

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 2001. 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 (such as the Four Mile Creek phytoremediation project) are under consideration, or are currently being implemented, as components of SWDF remediation. Remediation is discussed in chapter 2, “Environmental Management.”

The total amount of strontium-89,90 entering Four Mile Creek from the GSA seepage basins and SWDF during 2001 was estimated to be 20 mCi. This was a 62-percent decrease from the 2000 level of 53 mCi. The decrease was attributed to the success of the Four Mile Creek phytoremediation project (figure 4–6).

In addition, a total of 37.5 mCi of cesium-137 was estimated to have migrated from the GSA seepage basins and SWDF in 2001. As discussed previously, iodine-129 was not measured in Four Mile Creek water samples during 2001. It was assumed that 78.2 mCi migrated from the GSA seepage basins in 2001. This was the amount last measured (during 1996).

A total of 45.6 mCi of technetium-99 was estimated to have migrated from the F-Area and H-Area seepage basins from the beginning of this analysis in mid-2001 until the end of the year.

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. From 1960 until 1992, purges from the K-Area disassembly basin were discharged to a percolation field below the K-Area retention basin. Tritium migration from the seepage basin and the percolation field is measured in Pen Branch. The 2001 migration total of 1,040 Ci represents no change from the 1,040 Ci recorded in 2000.

P-Area, C-Area, and L-Area Seepage Basins

Liquid purges from the P-Area, L-Area, and C-Area disassembly basins were released periodically to their respective seepage basins from the 1950s until 1970. Purge water was released to the reactor seepage basins to allow a significant part of the tritium to decay before the water outcropped to surface streams and flowed into the Savannah River. The delaying action of the basins reduced the dose that users of water from downriver water treatment plants received from SRS tritium releases. Between 1970 and 1978, disassembly basin purge water was released directly to SRS streams. However, the earlier experience with seepage basins indicated that the extent of radioactive decay during the holdup was sufficient to recommend that the basins be used again in C-Area, L-Area, and P-Area, and the periodic release of liquid purges to the seepage basins was resumed. The operation of the C-Area, L-Area, and P-Area seepage basins was terminated in 1988 because of mission changes at the site.

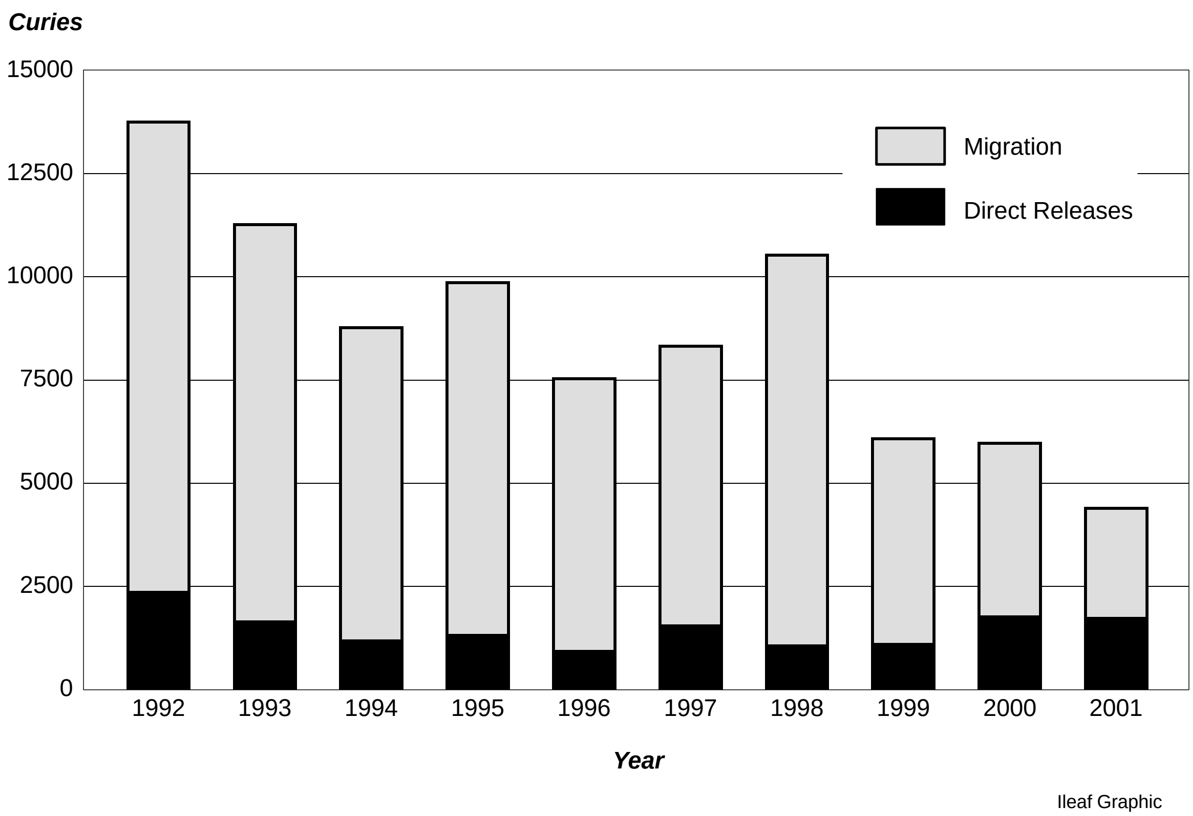


Figure 4–8 Total Tritium Releases to SRS Streams (Direct Discharges and Migration), 1992–2001, Based on Point-of-Release Concentrations and Flow Rates

No radionuclide migration was attributed to the C-Area seepage basin in 2001. 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 309 Ci of tritium migrated from the P-Area seepage basin during 2001, 17 percent more than the 265 Ci of tritium in 2000. 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 analytical method for actinides 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. Uranium was in most stream samples at approximately natural uranium-234/uranium-238 ratios. Plutonium-238, plutonium-239, americium-241, and curium-244 were found at low concentrations at HP–50. A few other samples had some of these radionuclides at barely detectable levels. Because the levels remained relatively low from 1996 through 1999, analysis of biweekly samples from these four locations was discontinued in 2000. Uranium, plutonium, americium, and curium now are analyzed on an annual grab sample from each stream location. Values for 2001 were consistent with historical data.

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.

Description of Surveillance Program

Five locations along the river continued to serve as environmental surveillance points in 2001. River sampling locations are shown in figure 4–4. Composite samples are collected weekly at the five river locations and analyzed for gross alpha, gross beta, tritium, and gamma-emitting radionuclides. An annual grab sample is obtained at each location and analyzed for strontium-89,90 and actinides. Grab samples are obtained annually—and analyzed for

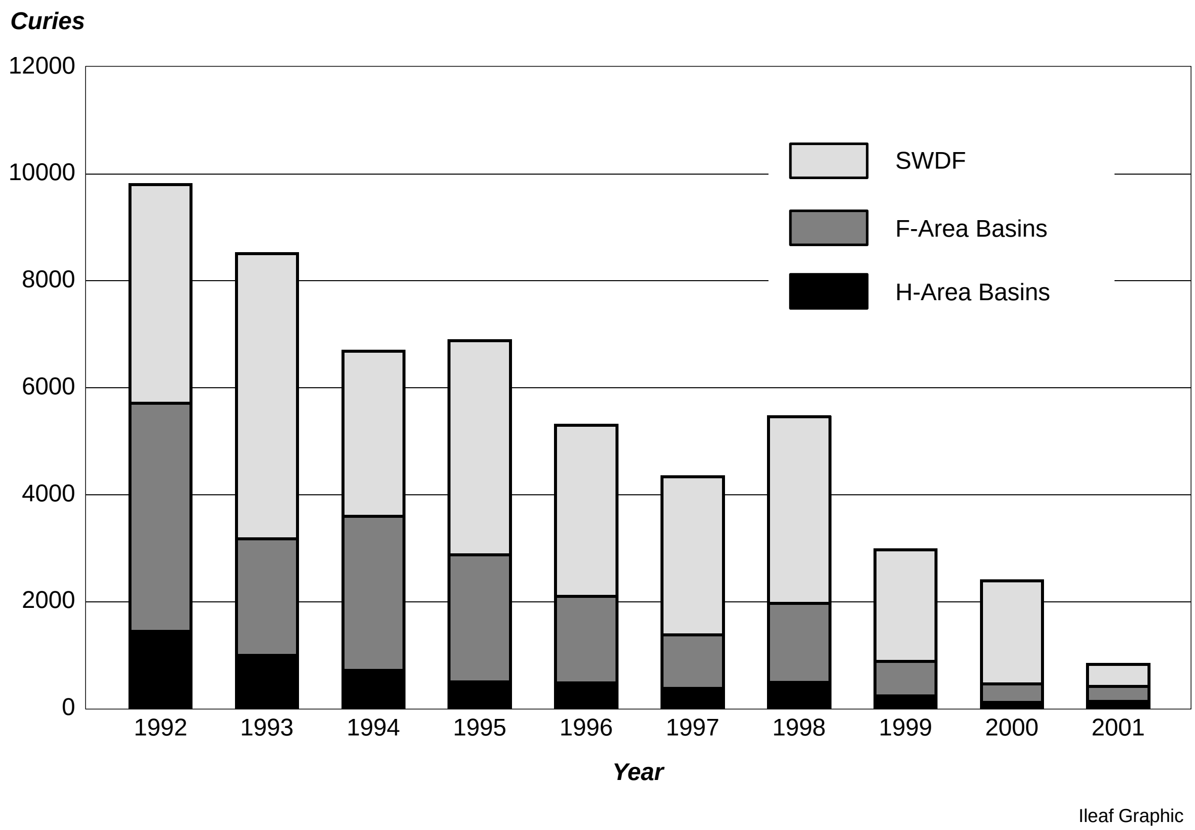


Figure 4–9 Tritium Migration Releases to Four Mile Creek from the F-Area and H-Area Seepage Basins and SWDF, 1992–2001

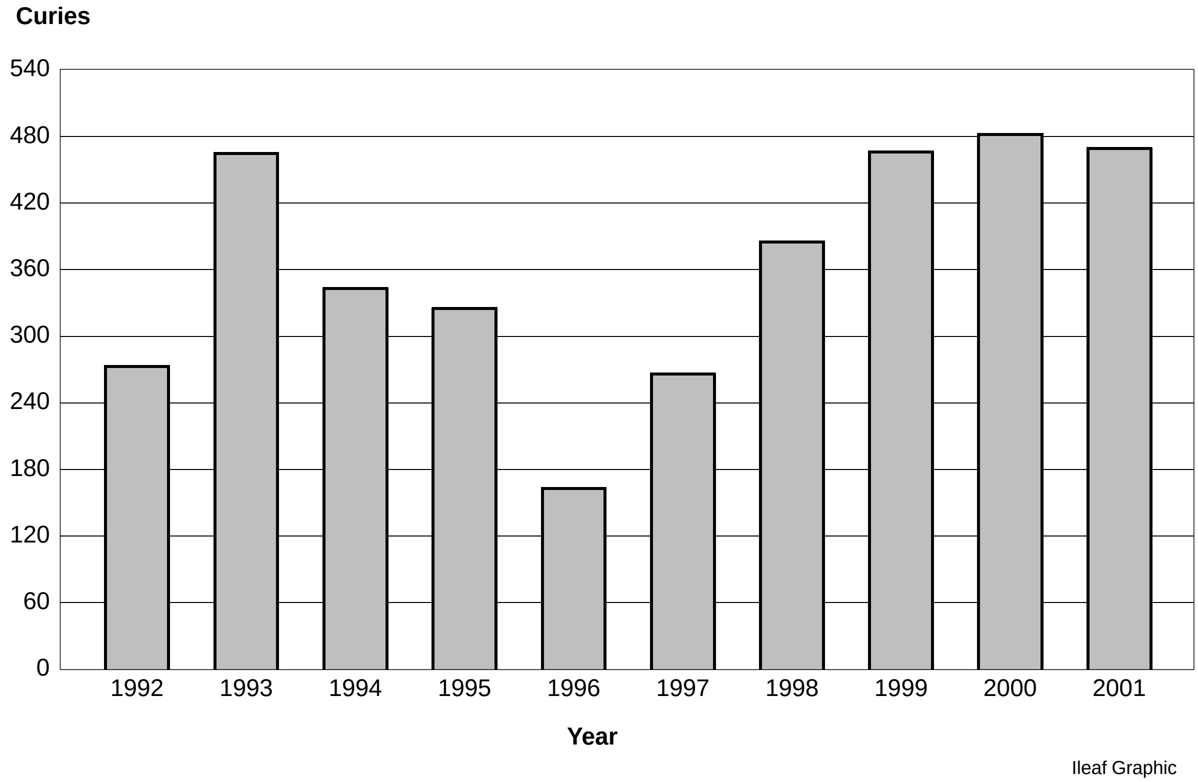


Figure 4–10 Tritium Migration Releases to Upper Three Runs from the General Separations Area and SWDF, 1992–2001

technetium-99—at each location except river mile (RM)–160.0.

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 4–4. The order of the locations begins at RM–160.0, above the site, and ends at RM–118.8, after all site streams enter the Savannah River. Samplers situated between RM–160.0 and RM–118.8 are located at regular intervals along the SRS boundary and where Plant Vogtle's discharges feed into the river (RM–150.4). RM–118.8 is the location of the site's hypothetical maximally exposed individual (chapter 5, "Potential Radiation Doses").

Tritium is the predominant radionuclide detected above background levels in the Savannah River. The annual mean tritium concentration at RM–118.8 was (1.02 ± 0.06)E+03 pCi/L, which is about 5 percent of the drinking water standard.

The average alpha concentration at each river location was slightly above the representative MDC in 2001. The average alpha activity level at RM–118.8 was about the same as the level at

Table 4–4
Average 2001 Concentration of Radioactivity in the Savannah River (pCi/L)

Location	Gross Alpha	Gross Beta	Tritium
RM–160.0	(1.77 ± 0.40)E–01	(1.23 ± 0.11)E+00	(8.23 ± 2.88)E+01
RM–150.4	(7.12 ± 1.05)E–01	(1.76 ± 0.17)E+00	(2.28 ± 0.33)E+03
RM–150.0	(2.24 ± 0.46)E–01	(1.36 ± 0.12)E+00	(1.23 ± 0.04)E+03
RM–141.5	(2.10 ± 0.51)E–01	(1.24 ± 0.12)E+00	(1.22 ± 0.07)E+03
RM–118.8	(2.28 ± 0.54)E–01	(1.29 ± 0.13)E+00	(1.02 ± 0.06)E+03

RM–160.0, which is the sampling location upstream of all SRS discharge points.

Gross beta activities at all locations were slightly above the representative MDC for the analysis in 2001. Mean and maximum concentrations were similar at all locations, indicating that there was no significant release of beta-emitting nuclides attributable to SRS discharges.

Cesium-137, Cobalt-60, Strontium-89,90, and Actinides

The mean concentrations for cesium-137 and cobalt-60 were below their representative MDCs for analysis in 2001 at all Savannah River locations. The maximum concentration of cesium-137 at RM–118.8 was slightly above the representative MDC; no cobalt was detected. Activity levels for strontium-89,90 and for all actinides—including isotopes of uranium and plutonium—fluctuated around their respective representative MDCs.

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)

During 2001, the total tritium transport in SRS streams decreased by approximately 28 percent (from 5,960 Ci in 2000 to 4,320 Ci in 2001). The 2001 measured tritium transport in the Savannah River (4,815 Ci) was more than the stream transport total. Some of this increase is attributed to Plant Vogtle's 2001 tritium releases, which totaled 1,492 Ci.

SRS tritium transport data for 1960–2001 are depicted in figure 4–11, which shows summaries of the past 42 years of direct releases, stream transport, and river transport determined by EMS.

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 the determination of water flow rates and of varying transport times.

In calculating doses from tritium, the stream transport value is used instead of the the river transport value or the direct-plus-migration value (chapter 3). This is because the stream transport value—measured in site streams just prior to their discharge to the Savannah River—most accurately reflects the actual amount of aqueous tritium leaving the site (chapter 5).

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 does not exceed EPA drinking water standards for radionuclides.

Description of Surveillance Program

Onsite sampling consists of quarterly grab samples at large treatment plants in A-Area, D-Area, and K-Area and annual grab samples at wells and small systems. Collected monthly off site are composite samples from

- 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

At all the offsite facilities, raw and finished water samples are collected daily and composited for analysis by EMS. All drinking water samples are screened for alpha, beta, and gamma emitters and analyzed specifically for tritium. The onsite samples also are analyzed once a year for actinides and strontium-89,90.

Surveillance Results

Gross Alpha and Gross Beta

All drinking water samples collected by EMS are screened for gross alpha and gross beta

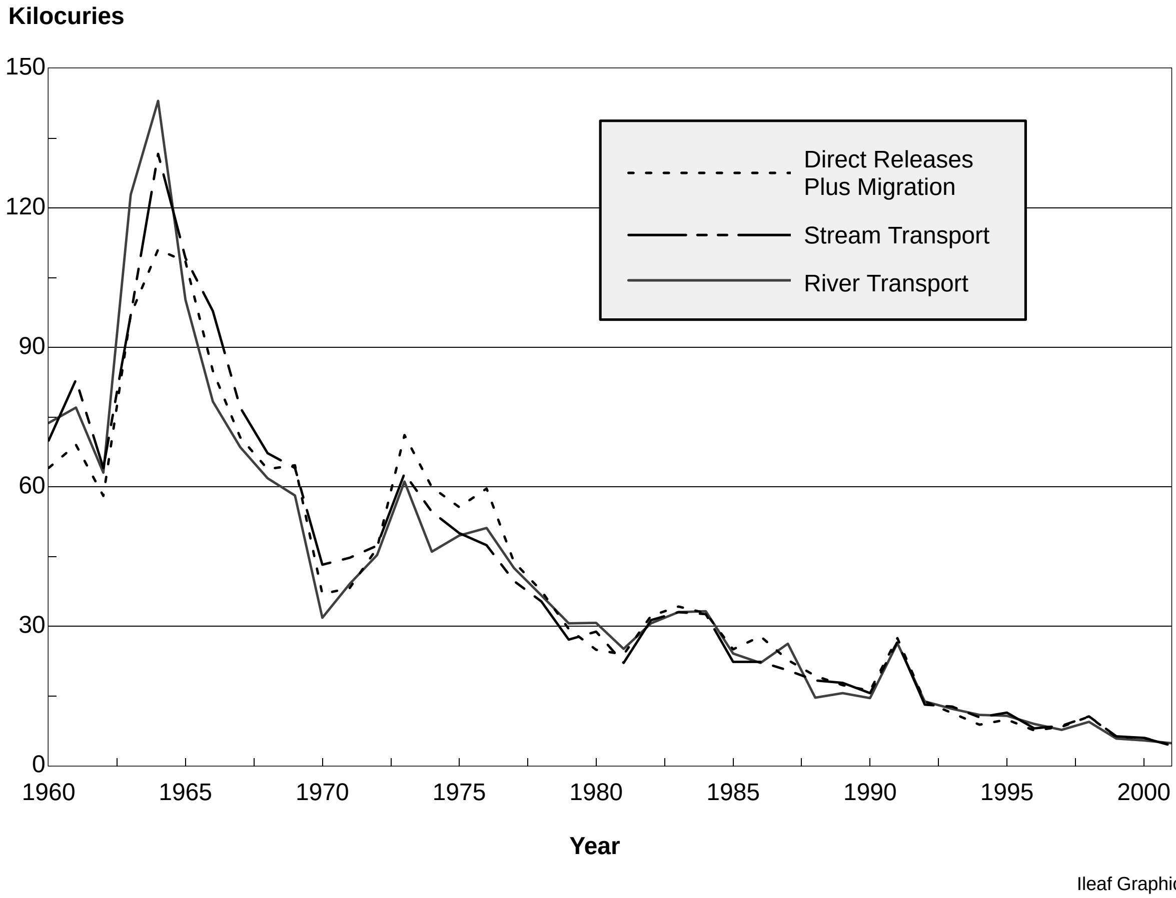


Figure 4–11 SRS Tritium Transport Summary, 1960–2001

SRS has maintained a tritium balance of direct releases plus migration, 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 because (1) the site's tritium production has stopped, (2) effluent controls have been developed, and (3) the tritium, which has a 12.3-year half-life, continues to decay at a rate of about 5 percent a year.

concentrations to determine if activity levels warrant further analysis. No samples collected in 2001 exceeded EPA's 1.50E+01-pCi/L alpha activity limit or 5.00E+01-pCi/L beta activity limit. In 2001, the highest alpha concentration in SRS drinking water was (3.06 ± 0.61)E+00-pCi/L—at the PAR Pond Laboratory (735–7G). No samples have exceeded 8.00E+00 pCi/L of beta activity—the EPA limit for strontium-90, which is the most restrictive beta-emitting radionuclide.

Tritium

No onsite or offsite drinking water samples collected and analyzed by EMS in 2001 exceeded the 2.00E+04-pCi/L EPA tritium limit. The highest level observed was (7.62 ± 1.30)E+02 pCi/L—at 661–G (Firing Range Pumphouse). 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 and Plant Vogtle operations into the Savannah River. The average tritium concentration in finished water at Beaufort-Jasper in 2001, (9.68 ± 2.64)E+02 pCi/L, was 4.84 percent of the EPA drinking water limit. The average tritium concentration at Port Wentworth, (8.67 ± 2.63)E+02 pCi/L, was 4.34 percent of the EPA drinking water limit. The levels of tritium at both treatment facilities were not significantly different than those measured in 2000.

Strontium

No drinking water samples collected and analyzed by EMS for strontium 89,90 in 2001 exceeded the 1.40E+00-pCi/L representative MDC.

Other Radionuclides

No cobalt-60, cesium-137, plutonium-238, or plutonium-239 were detected in any drinking water samples collected during 2001. Samples from some locations showed detectable levels of uranium isotopes and/or americium-241 and curium-244.

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 SRS, approximately 9 miles (15 km) beyond its perimeter, into four quadrants: northeast, southeast, southwest, and northwest. Samples of food—including meat (beef), fruit (melons or peaches), and a green vegetable (collards)—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.

Food samples are analyzed for the presence of gamma-emitting radionuclides, tritium, strontium-89,90, plutonium-238, and plutonium 239.

Milk

During 2001, 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 collected monthly to be analyzed for the presence of tritium and gamma-emitting radionuclides, primarily cesium-137 and iodine-131. Additional samples are collected quarterly to be analyzed for the presence of strontium-89,90.

Surveillance Results

The 15 samples of milk collected during three quarters were analyzed for strontium-90, rather than strontium-89,90, in 2001 because of a laboratory error.

Gamma-Emitting Radionuclides

The only manmade gamma-emitting radionuclide detected in food products other than milk was cobalt-60, which was found in a beef sample from the 0–10-mile northwest quadrant; the concentration was (2.17 ± 0.64)E–02 pCi/g. Generally, concentrations of cesium-137 in indicator samples were similar to those measured at the control location, and 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 2001. Measured maximum concentrations ranged from a high of (5.08 ± 1.76)E+00 pCi/L at the Waynesboro, Georgia, location to lows below the representative MDC at several locations. The mean concentrations measured in 2001 were similar to those measured in 2000.

Iodine-131 was not detected in any 2001 milk samples. Because of its short physical half-life (8 days), iodine-131 generally is not detected, except

- shortly after tests of nuclear weapons
- in the wake of events such as the Chernobyl incident
- during reactor operations
- when processing fresh fuel
- when the isotope is used medically, industrially, or for research.

Tritium

Tritium in milk and other samples is attributed primarily to releases from SRS. Tritium concentrations in food products other than milk ranged from a high of (2.45 ± 0.34)E–01 pCi/g, measured in greens from the 0–10-mile northwest quadrant, to lows below the representative MDC in several samples. The concentrations were similar to those measured in 2001.

No tritium was detected above the representative MDC in any milk samples collected during 2001. The tritium concentrations measured in milk during 2001 were slightly lower than in 2000 and generally reflected atmospheric releases from the site.

Strontium

The highest strontium-89,90 concentration detected in food products other than milk during 2001 was

(7.03 ± 0.92)E–01 pCi/g—found in greens from the northeast quadrant; the lowest was below the representative MDC at one location. Strontium-89,90 levels generally were within the ranges observed during past years.

The 2001 results from the analysis of milk for strontium-89,90 and strontium-90 showed concentrations ranging from a maximum of (4.14 ± 0.95)E+00 pCi/L in a sample from locally produced inventories of a major distributor to minimums below their representative MDCs.

Plutonium

Only one terrestrial food product sample contained a detectable concentration of plutonium-238 in 2001—greens from the 0–10-mile southwest qudrant, at (2.87 ± 0.92)E–01 pCi/g. No plutonium-239 was detected in food products other than milk in 2001.

Aquatic Food Products

Description of Surveillance Program

The aquatic food product surveillance program includes fish (freshwater and saltwater) and shellfish. To determine the potential dose and risk to the public from consumption, both types are sampled.

Nine surveillance points for the collection of freshwater fish are located on the Savannah River (figure 4–12). These points are at

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

Nine surveillance points for freshwater fish collection also are located within the SRS boundary. These points are at PAR Pond, L-Lake, Pond B, Lower Three Runs, Upper Three Runs, Beaver Dam Creek, Pen Branch, Steel Creek, and Four Mile Creek. Freshwater fish are grouped into one of three categories: bass, panfish (bream), or catfish.

Saltwater fish are collected downstream from the U.S. Highway 17 Bridge Area and include composites of sea trout, red drum (spottail bass), and mullet. The fish are selected for sampling 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 GDNR's 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 and skin only) and nonedible (scales, head, fins, viscera, bone) portions; however, catfish are skinned and the skin becomes part of the nonedible composite. Analyses are conducted for gross alpha and gross beta on edible portions for all locations and on nonedible portions for all offsite locations except those at Stokes Bluff Landing and at the U.S. Highway 17 Bridge Area. Freshwater fish collected from the New Savannah Bluff Lock and Dam location downstream through the U.S. Highway 301 Bridge Area also are analyzed for strontium-89,90; plutonium-238 and plutonium-239 and tritium (edible portions only); and gamma-emitting radionuclides. Freshwater fish (edible portions only) from river locations at Stokes Bluff Landing and the U.S. Highway 17 Bridge Area and from onsite streams and ponds are analyzed for gross alpha, gross beta, and gamma-emitting radionuclides.

Saltwater fish (edible portions only) also are analyzed for gross alpha, gross beta, and gamma-emitting radionuclides.

In the shellfish surveillance program, samples of oysters and crabs are collected on the coast near Savannah. 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 5.

Surveillance Results

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

Freshwater Fish

Savannah River All categories of freshwater fish from all nine Savannah River locations were collected during 2001.

Gross alpha activity in Savannah River edible and nonedible composites was below the MDCs at all nine sampling locations.

Gross beta activity in Savannah River edible composites was detectable at all nine locations and was attributed primarily to the naturally occurring radionuclide potassium-40. The values ranged from a high of (3.24 ± 0.43)E+00 pCi/g in bass from the mouth of Beaver Dam Creek to lows below the

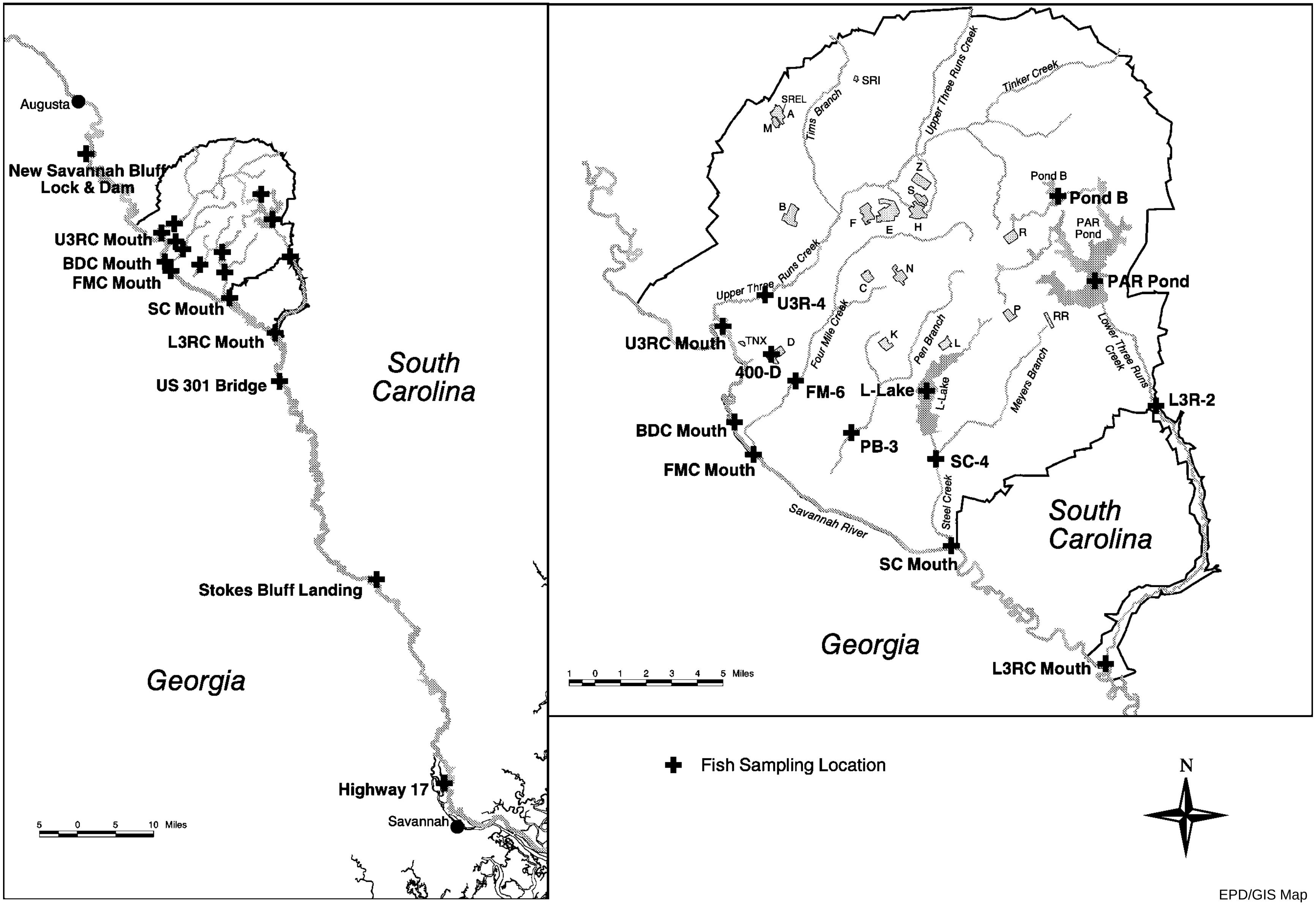


Figure 4–12 SRS Fish Sampling Locations
SRS collects fish (for both radiological and nonradiological analyses) from the Savannah River above, adjacent to, and below the site, as well as at Stokes Bluff Landing and near Savannah, Georgia.

MDCs in several composites. Gross beta activity in river nonedible composites was detected at four locations, ranging from a high of (4.00 ± 1.17)E+00 pCi/g in bass from the mouth of Beaver Dam Creek to lows below the MDCs in several composites.

Cesium-137 was the only manmade, gamma-emitting radionuclide detected in 2001 fish composites. Cesium-137 activity in Savannah River edible composites was detectable at all sampling locations, ranging from a high of (1.48 ± 0.03)E+00 pCi/g in bass from the mouth of Beaver Dam Creek to lows below the MDCs in several composites. Cesium-137 activity in river nonedible composites was detected at six of seven sampling locations, ranging from a high of (1.13 ± 0.28)E–01 pCi/g in bass from the mouth of Upper Three Runs to lows below the MDCs in several composites.

Strontium-89,90 activity in Savannah River edible fish in 2001 was detectable at four sampling locations, ranging from a high of (2.04 ± 0.50)E–02 pCi/g in bream from Upper Three Runs mouth to lows below the MDCs in several composites. Strontium-89,90 in river nonedible composites was detectable at six of seven sampling locations, ranging from a high of (2.18 ± 0.31)E–01 pCi/g in bass from Augusta Lock and Dam to a lows below the MDCs in several composites.

Tritium activity in Savannah River edible composites in 2001 was detectable at six of the seven sampling locations and ranged from a high of (7.92 ± 0.58)E–01 pCi/g in bream from Four Mile Creek mouth to lows below the MDCs in several composites.

Onsite Streams and Ponds Not enough fish of appropriate size could be collected from onsite streams and ponds in 2001 for any composite samples (five from the same category per location) from Four Mile Creek, Pen Branch, Steel Creek, Beaver Dam Creek, or Upper Three Runs.

Gross alpha activity in fish composites (edible portions only) from onsite streams and ponds was below detection at three of the four sampled locations. Gross alpha activity was observed in two Pond B samples, with a maximum concentration of (7.09 ± 0.33)E–01 pCi/g in bream. Gross beta activity, on the other hand, was detected at all of these locations and ranged from a high of (4.87 ± 0.12)E+01 pCi/g in bass from Pond B to below the MDC in bass from L-Lake.

Cesium-137—the only manmade, gamma-emitting radionuclide found in 2001 fish composites from onsite streams and ponds—was detectable at all four sampled locations. The activity ranged from a high of (8.85 ± 0.44)E+01 pCi/g in bass from Pond B to a low of (3.26 ± 0.42)E–01 pCi/g in bream from L-Lake.

Saltwater Fish

In the saltwater fish category, red drum (spottail bass) sea trout, and mullet were collected in 2001 from the U.S. Highway 17 Bridge Area. All gross alpha concentrations measured in saltwater fish composites during 2001 were below the MDC. Gross beta concentrations were detectable in all nine composites analyzed and ranged from a high of (2.55 ± 0.36)E+00 pCi/g in spottail bass to a low of (1.16 ± 0.30)E+00 pCi/g in sea trout. No manmade gamma-emitting radionuclides were detected in any saltwater fish sample.

Shellfish

A sample of oysters and a sample of crabs—both from near the mouth of the Savannah River—were collected in 2001. No manmade radionuclides above the MDCs were detected in these 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 dose resulting from consumption is calculated for each animal, and each hunter's cumulative total is tracked to ensure compliance with the U.S. Department of Energy (DOE) dose limit for the general public. 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

A total of 79 deer and 102 feral hogs were taken from the site as part of a special animal control program in 2001. This compares with 294 deer and 38 feral hogs taken during 2000. After 14 hunts in 2000, the 2001 program included only four days of animal control activities—targeting specific high-density areas—because of security concerns in the wake of the terrorist attacks of September 11. The increase in the number of hogs taken is attributable to special hunts held in early 2001 for additional control of the growing hog population on site.

Gamma-Emitting Radionuclides

In 2001, the maximum field measurement of cesium-137 in deer muscle was approximately 2 pCi/g (compared with 57 pCi/g in 2000), while the mean cesium-137 concentration was approximately 1 pCi/g. The large decrease in the maximum is believed to be attributable to the limited scope of the hunts in 2001. In feral hogs, the maximum field measurement of cesium-137 in muscle was approximately 6 pCi/g, while the mean concentration was approximately 1 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 it is estimated will result in a hunter's annual dose exceeding 25 mrem (approximately 25 percent of the DOE limit)—either alone or in combination with previous animals killed by the hunter. In 2001, eight samples from eight animals were collected and analyzed for gamma-emitting radionuclides.

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 from all animals ranged from approximately 1 pCi/g to 6 pCi/g, while lab measurements ranged from approximately 1 pCi/g to 8 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.

Because of the reduced size of the daily harvest in 2001, no bone or muscle samples were collected for strontium 89,90 analysis.

Turkeys

Description of Surveillance Program

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

Surveillance Results

EMS monitored only 12 turkeys in 2001 because of reduced program needs. Concentrations of cesium-137 generally were similar to those measured in the past, with all results 4.0 pCi/g or less. This compares to maximum concentrations of 5.0 pCi/g in 2000, of 4.0 pCi/g in 1999, of 5.0 pCi/g in 1998, and of 6.0 pCi/g in 1997. All concentrations below the LLD are assigned a value of 1.0 pCi/g.

Beavers

Description of Surveillance Program

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

Surveillance Results

No beavers were monitored at SRS in 2001 because of programmatic difficulties. The highest concentrations of cesium-137 found in beavers during previous years were 47 pCi/g in 2000, less than 1.0 pCi/g in all 11 beavers monitored in 1998 (none were monitored in 1999), and 12.5 pCi/g in 1997.

Soil

The SRS soil monitoring program provides

- data for long-term trending of radioactivity deposited from the atmosphere (both wet and dry deposition)
- 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 2001 (as shown in figure 4–13) from

- four uncultivated and undisturbed onsite locations—in E-Area (burial ground), F-Area, H-Area, and Z-Area

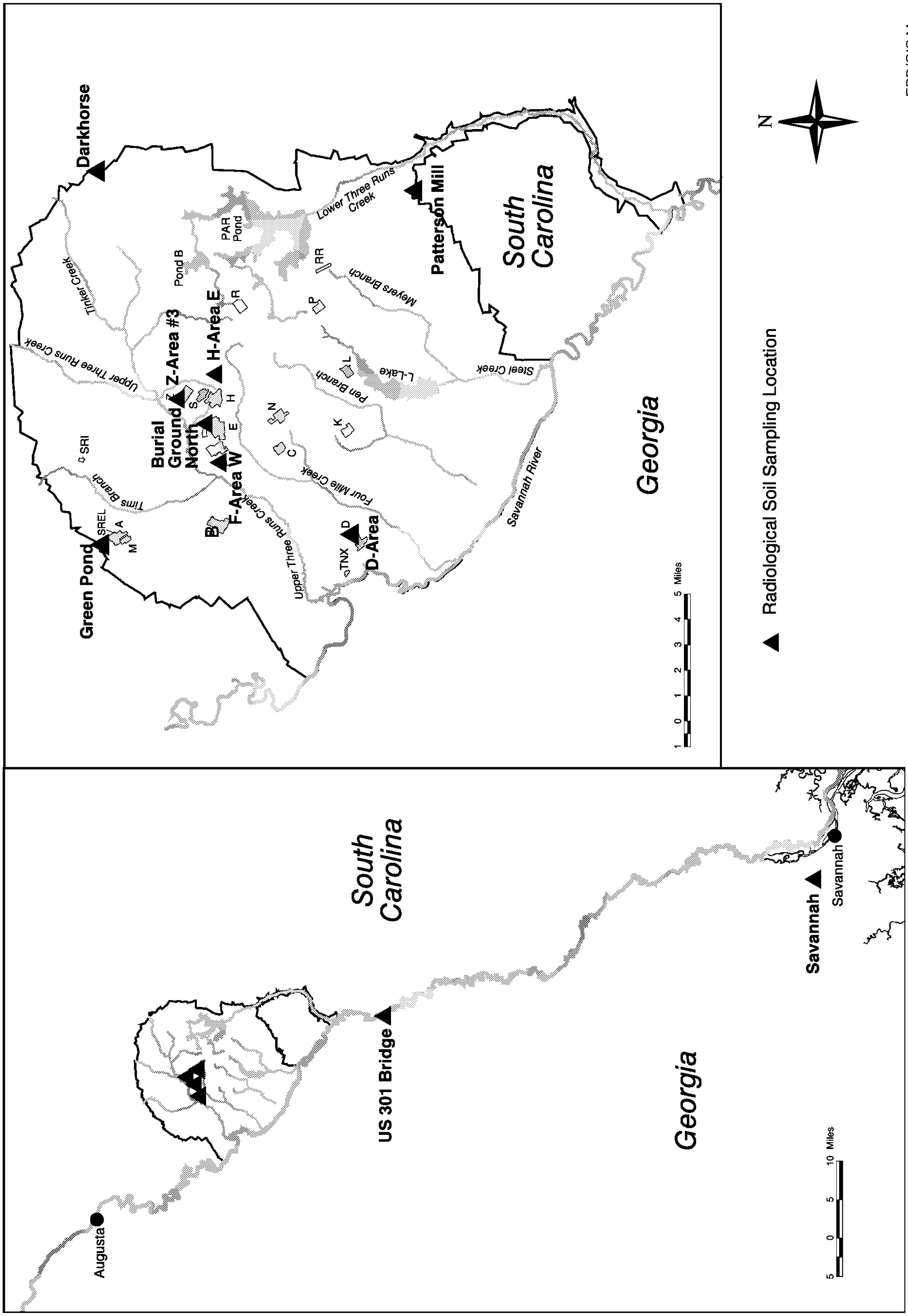


Figure 4–13 Radiological Soil Sampling Locations
SRS collected soil samples in 2001 from four onsite locations, four site perimeter locations, and two offsite locations—one near the U.S. Highway 301 Bridge over the Savannah River and one near Savannah, Georgia.

- four site perimeter locations (on Darkhorse Road, Green Pond Road, and Patterson Mill Road—and in D-Area)
- one offsite control location near the U.S. Highway 301 Bridge over the Savannah River
- another offsite location approximately 100 miles from SRS, near Savannah

One sample was collected from each of the 10 locations.

Hand augers or other similar devices are used in sample collection to a depth of 3 inches. 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 representative MDC in 2001 at three onsite, all four perimeter, and one offsite location. The highest onsite concentration detected, (5.94 ± 0.49)E–01 pCi/g, was in a sample taken from H-Area, and the lowest was below the representative MDC. The highest perimeter concentration, (4.19 ± 0.36)E–01 pCi/g, was detected at the Darkhorse at Williston Gate location. The highest offsite concentration was (2.71 ± 0.36)E–01 pCi/g, at the 100-mile-radius location near Savannah.

Plutonium

Two of the four onsite soil sampling locations showed concentrations of plutonium-238 above the representative MDC in 2001. The highest concentration, (4.63 ± 0.72)E–02 pCi/g, was in F-Area. Two of the onsite locations also had concentrations of plutonium-239 above the representative MDC—F-Area, at (4.60 ± 0.73)E–02 pCi/g, and H-Area, at (9.51 ± 0.87)E–02 pCi/g.

None of the four perimeter locations had a concentration of plutonium-238 above the representative MDC, while three of four perimeter locations had concentrations of plutonium-239 above the representative MDC—with the highest at D-Area, (8.34 ± 1.52)E–03.

One offsite location, the 100-mile-radius location near Savannah, had concentrations above the representative MDCs, as follows: plutonium-238, (1.38 ± 0.28)E–02 pCi/g, and plutonium-239, (3.53 ± 0.46)E–02 pCi/g.

Strontium

Soil samples from all 10 locations were analyzed for strontium-89,90 in 2001, and the results of none of the 10 showed concentrations above the representative MDC.

Settleable Solids

Description of Surveillance Program

Settleable-solids monitoring in effluent water is required to ensure—in conjunction with routine sediment monitoring—that a long-term buildup of radioactive materials does not occur in stream systems.

DOE limits on radioactivity levels in settleable solids are 5 pCi/g above background for alpha-emitting radionuclides and 50 pCi/g above background for beta/gamma-emitting radionuclides.

Low total suspended solids (TSS) levels result in a small amount of settleable solids, so an accurate measurement of radioactivity levels in settleable solids is impossible. Based on this, an interpretation of the radioactivity-levels-in-settleable-solids requirement was provided to Westinghouse Savannah River Company (WSRC) by DOE in 1995. The interpretation indicated that TSS levels below 40 parts per million (ppm) were considered to be in *de-facto* compliance with the DOE limits.

To determine compliance with these limits, EMS uses TSS results—gathered as part of the routine National Pollutant Discharge Elimination System monitoring program—from outfalls co-located at or near radiological effluent points. If an outfall shows that TSS levels regularly are greater than 40 ppm, a radioactivity-levels-in-settleable-solids program and an increase in sediment monitoring would be implemented.

Surveillance Results

During 2001, only two TSS samples exceeded 40 ppm—one from outfall A–11 (101 ppm) and the other from outfall X–08 (43 ppm). Outfall A–11 is not associated with radiological discharges.

An investigation into the cause of the X–08 concentration determined that maintenance activities in a weir box upstream of the outfall resulted in the visible disturbance and transport of detritus. An examination of the 2001 X–08 TSS results indicated that

- the annual mean—including the 43-ppm value—was 5 ppm, considerably lower than the 40-ppm compliance limit

- if the 43-ppm value is discounted, the highest TSS level at X–08 is 4 ppm.

Based on these facts, it was determined that the monitoring of radioactivity levels in settleable solids was not required at X–08.

Overall, the TSS results indicate that SRS is in compliance with the DOE radioactivity-levels-in-settleable-solids requirement.

Sediment

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

Description of Surveillance Program

Sediment samples (annual) were collected at 21 locations in 2001—eight in the Savannah River and 13 in site streams (figure 4–14). Samples are obtained with a Ponar dredge or an Emery pipe dredge and 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 2001 were similar to those of past years.

Gamma-Emitting Radionuclides

Cesium-137 and Cobalt-60 were the only manmade gamma-emitting radionuclides observed in river and stream sediments during 2001.

The highest cesium-137 concentration in streams, (1.76 ± 0.09)E+02 pCi/g, was detected in sediment from R-Area Downstream of R–1; the lowest concentrations were below the representative MDC at Tims Branch 5 near Road C and at U3R–1A. The highest level found on the river, (2.49 ± 0.33)E–01 pCi/g, was at the mouth of Lower Three Runs; the lowest levels were below the representative MDC at several locations. Generally, cesium-137 concentrations were 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 beds or at the streams' entrances to the swamp areas along the river.

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

- Four Mile Creek Swamp Discharge
- Four Mile A–7A
- R-Area Downstream of R–1

The highest Cobalt-60 concentration, (4.79 ± 0.48)E–01 pCi/g, was measured at R-Area Downstream of R–1; concentrations at the other sediment sampling locations were below the representative MDC.

Plutonium/Uranium

Concentrations of plutonium-238 in sediment during 2001 ranged from a high of (1.21 ± 0.07)E+00 pCi/g at the Four Mile 2 at Road 4 location to lows below the representative MDC at several locations. Concentrations of plutonium-239 ranged from a high of (3.53 ± 0.23)E–01 pCi/g—at the Four Mile A–7A location—to lows below the representative MDC at several locations. Uranium-235—at (1.02 ± 0.32)E–01 pCi/g—was detected in sediment from River Mile 150.2 below Four Mile Creek.

As expected, concentrations of these isotopes in streams generally were higher than concentrations in the river. Differences observed when these data are compared to those of previous years probably are attributable to the effects of resuspension and deposition, which occur constantly in sediment media.

Strontium

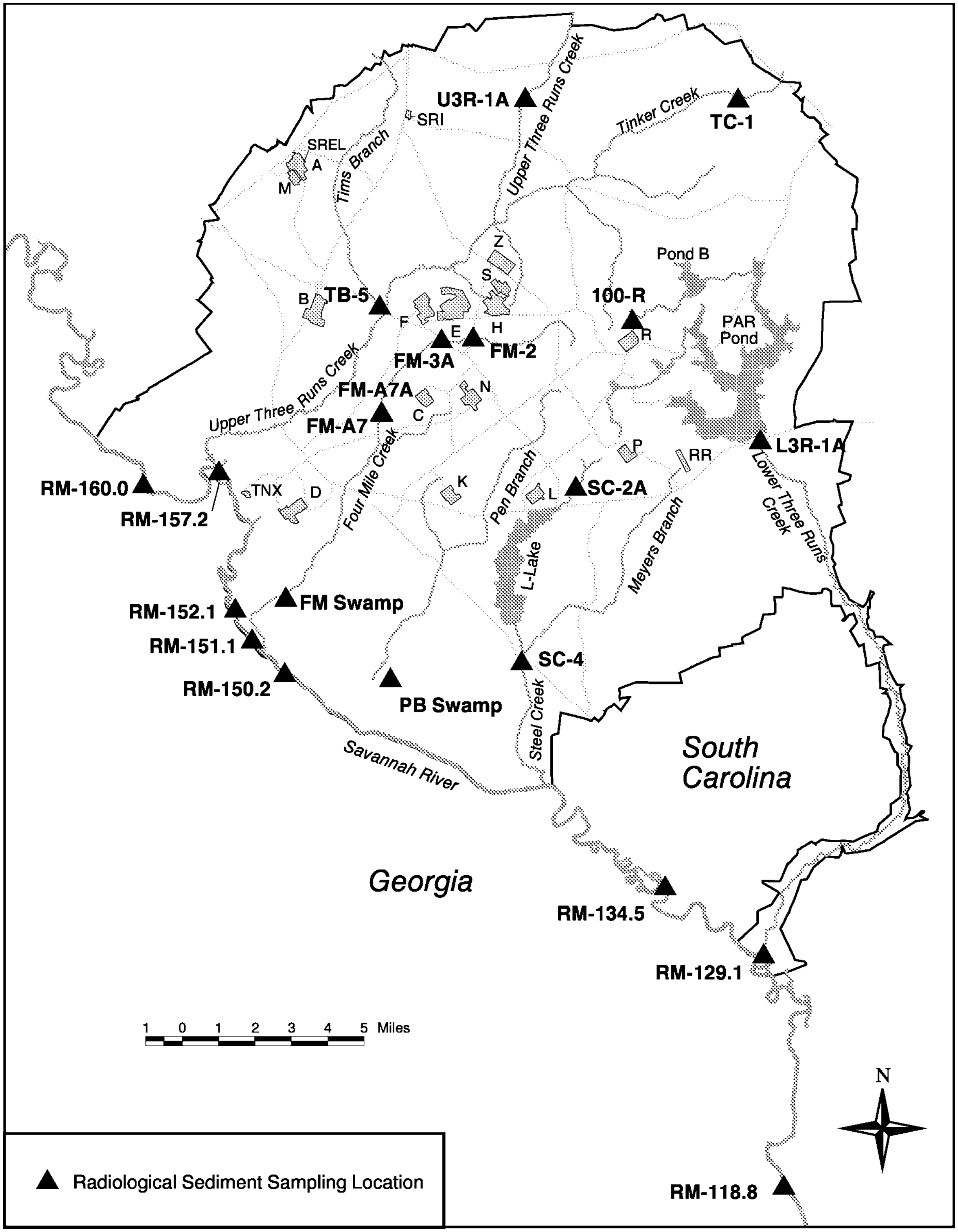
Concentrations of strontium-89,90 in sediment ranged from a high of (3.78 ± 0.56)E–01 pCi/g at the FM–A7 location to lows below the representative MDC at all eight river locations and 11 of the 13 site stream locations.

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.

The program also provides information that can be used to determine the effects, if any, of various radioactive material operations on the surrounding vegetation.

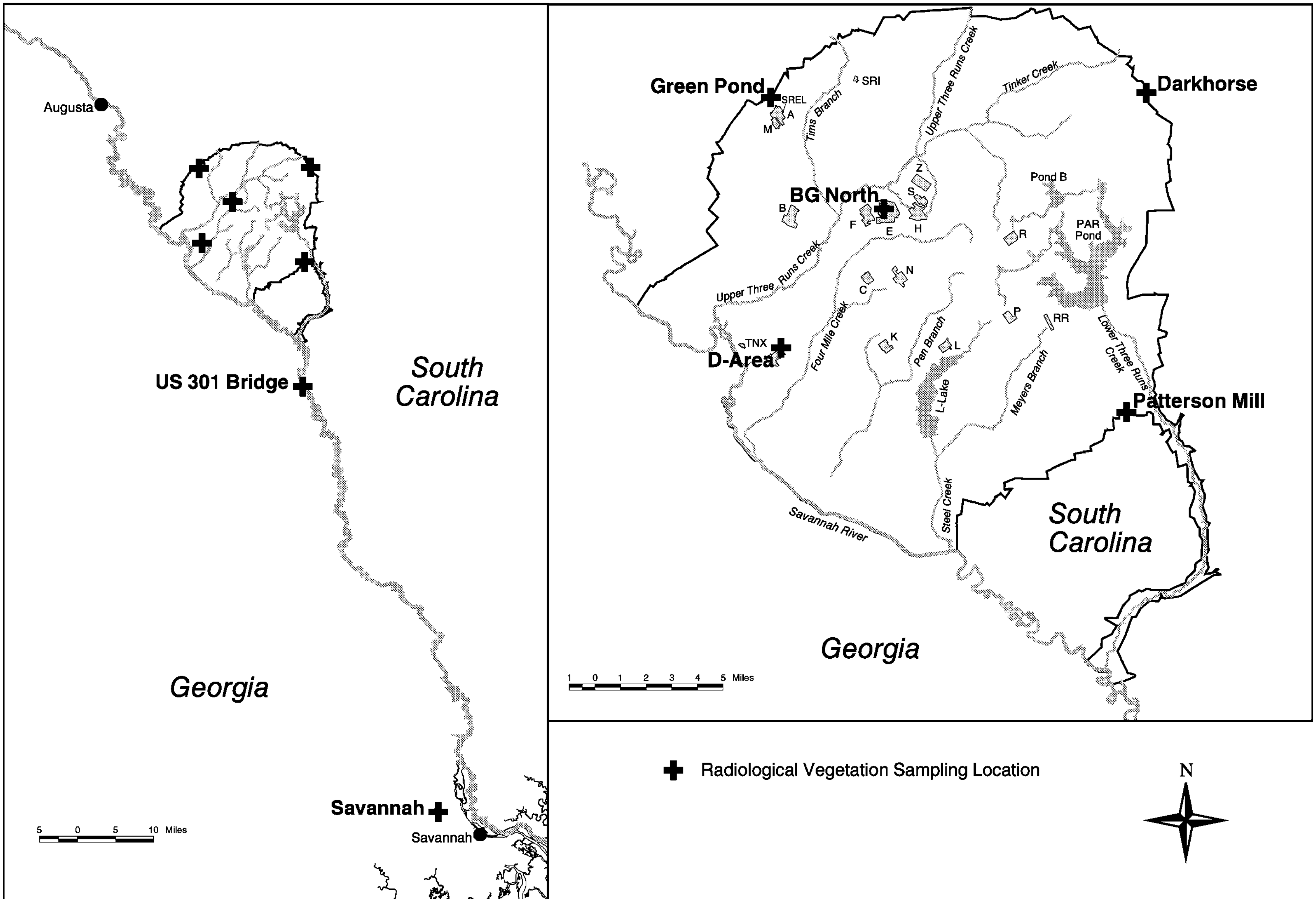
Typically, grasses are collected for vegetation because of their year-round availability. Bermuda



EPD/GIS Map

Figure 4–14 Radiological Sediment Sampling Locations

Sediment samples were collected in 2001 at eight Savannah River locations—upriver of, adjacent to, and downriver of the site—and 13 site stream locations.



EPD/GIS Map

Figure 4–15 SRS Vegetation Sampling Locations

Vegetation samples were collected for radiological analysis in 2001 from five locations on site and two off site (near Savannah, Georgia, and at the U.S. Highway 301 Bridge over the Savannah River).

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

An onsite location is near the geographical center of the site, and four perimeter locations are situated near air monitoring stations that provide sampling within each 30-degree sector around the site boundary. Two offsite locations—selected as control sites—are in the vicinity of the environmental air monitoring stations at the U.S. Highway 301 Bridge over the Savannah River and near the city of Savannah. All the vegetation locations, which continue to be sampled annually, are shown in figure 4–15.

In addition to actinides, vegetation samples are analyzed for gross alpha and gross beta, gamma-emitting radionuclides, tritium, plutonium, and strontium. 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 vegetation surveillance program makes no attempt to differentiate between contributions of the external and internal contaminations, contributions can be approximated when 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

All surveillance results are based on dry weight. The 2001 grassy vegetation analysis results showed tritium, cesium, strontium, plutonium, and actinide activity near minimum detectable concentrations at several locations. Gross beta activity was detected at all seven locations but was attributed primarily to the naturally occurring radionuclide potassium-40. Plutonium and actinide results for the U.S. Highway 301 Bridge Area had to be discarded because of laboratory error.

Georgia Well Sampling

Contamination of groundwater has been detected at several locations within SRS. Concern has been raised by State of Georgia officials that groundwater contaminated with tritium might migrate through aquifers underlying the Savannah River into Georgia by what is sometimes referred to as trans-river flow.

DOE and the State of Georgia jointly selected a panel of experts to review available information and previous studies regarding tritium migration to determine if additional studies are needed. The Tritium Migration Independent Scientific Peer Review Panel convened January 30, 2001; the results of its review are expected in January 2002.

Previous Studies

The U.S. Geological Survey (USGS), in cooperation with DOE and GDNR, began a study (the Trans-River Flow Project) in 1988 to describe groundwater flow and quality near the Savannah River and to determine the potential for movement beneath the river. The study area was bounded by the fall line, which is about 20 miles northwest of SRS, and extended to about 20 miles south of the site.

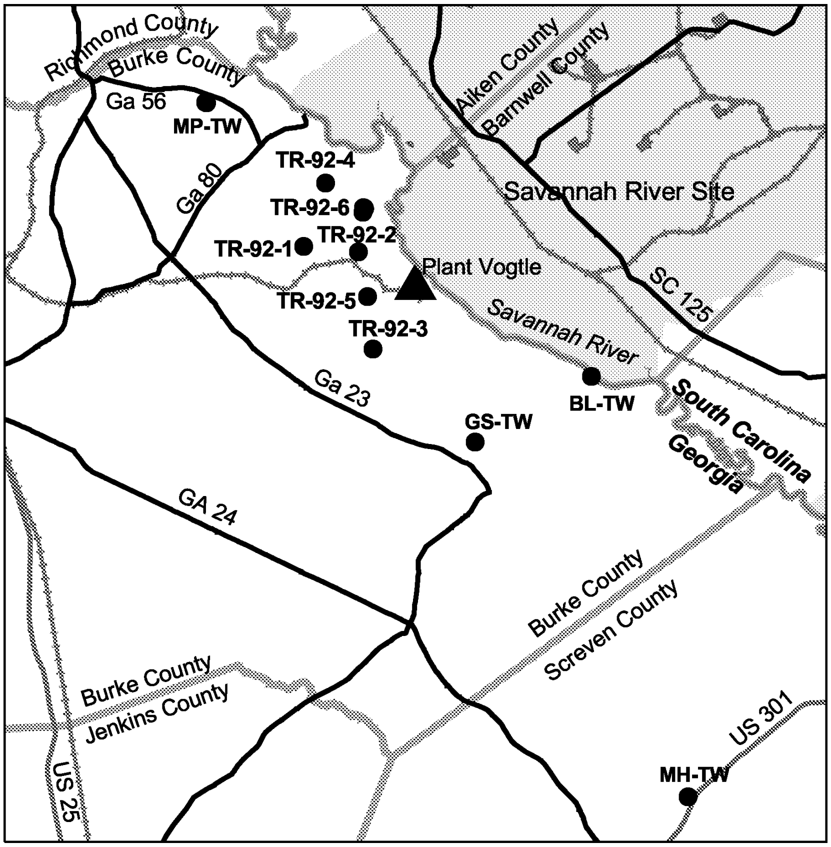
Summaries of the Trans-River Flow Project results may be found in 1992–1996 SRS environmental reports, which concluded that there was no potential for groundwater with tritium contamination to flow under the river, and that the low levels of tritium found in Burke County came from rainfall.

SRS acquired and performed pump maintenance on 14 USGS wells in Burke and Screven counties in 2000. The addition of these wells to the 30 monitoring wells SRS acquired from GDNR in 1999 brought the total number of Georgia wells available for sampling to 44. Figure 4–16 shows the location of the 10 well clusters in the study.

Current Study and Results

EMS personnel sampled 41 of the 44 wells during 2001, when joint sampling was conducted by GDNR for the first time. The overall trend of the data showed a continued gradual decline in tritium levels.

The highest value reported in 2000 came from well TR92–2A, a well screened in the water table. The value was 1,260 pCi/L, which is about 6 percent of the EPA drinking water standard of 20,000 pCi/L. The highest values in 2001—from wells TR92–1H and TR–92–2A—were 1,070 pCi/L and 1,060 pCi/L, respectively; these values are about 5 percent of the drinking water standard and are consistent with conclusions from the earlier studies that the tritium



EPD/GIS Map

Figure 4–16
Burke/Screven County Well Locations

Groundwater samples were collected for tritium analysis in 2001 from nine well clusters in Burke County, Georgia, and one in Screven County. Forty-one samples were collected from the 44 total wells.

comes from rainfall. Well TR92–2A was not sampled in 1997–1999, but its tritium values from 1994, 1995, and 1996 were 1,500 pCi/L, 1,300 pCi/L, and 1,700 pCi/L, respectively.

Well TR92–5B, located at DeLaigle Trailer Park, showed tritium levels slightly above the minimum detection limit. This location will be resampled and reanalyzed to verify the result.

SRS and GDNR will jointly sample the Burke and Screven County wells for tritium again in February 2002.

Chapter 5

Potential Radiation Doses

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THIS chapter presents the potential doses to offsite individuals and the surrounding population from 2001 Savannah River Site (SRS) atmospheric and liquid radioactive releases. Additionally, potential doses from special-case exposure scenarios—such as the consumption of deer meat, creek mouth fish, goat milk, and crops irrigated with Savannah River water—are documented.

Unless otherwise noted, the generic term "dose" used in this report includes both the committed effective dose equivalent (50-year committed dose) from internal deposition of radionuclides and the effective dose equivalent attributable to sources external to the body. Use of the effective dose equivalent allows doses from different types of radiation and to different parts of the body to be expressed on the same relative basis.

Many parameters—such as radioactive release quantities, population distribution, meteorological conditions, radionuclide dose factors, human consumption rates of food and water, and environmental dispersion—are considered in the dose models used to estimate offsite doses at SRS. Descriptions of the effluent monitoring and environmental surveillance programs discussed in this chapter can be found in chapter 3, "Radiological Effluent Monitoring," and chapter 4, "Radiological Environmental Surveillance." A complete description of how potential doses are calculated can be found in section 1108 of the *Savannah River Site Environmental Monitoring Section Plans and Procedures*, WSRC–3Q1–2, Volume 1 [SRS EM Program, 2001]. Tables containing all potential dose calculation results are presented in *SRS Environmental Data for 2001* (WSRC–TR–2001–00475).

Applicable dose regulations can be found in appendix A, "Applicable Guidelines, Standards, and Regulations," of this document.

Calculating Dose

Potential offsite doses from SRS effluent releases of radioactive materials (atmospheric and liquid) are calculated for the following scenarios:

- hypothetical maximally exposed individual
- 80-km (50-mile) population

Because the U.S. Department of Energy (DOE) has adopted dose factors only for adults, SRS calculates

Dose to the Hypothetical Maximally Exposed Individual

When calculating radiation doses to the public, SRS uses the concept of the maximally exposed individual; however, because of the conservative lifestyle assumptions used in the dose models, no such person is known to exist. The parameters used for the dose calculations are

For airborne releases: Someone who lives at the SRS boundary 365 days per year and consumes large amounts of milk, meat, and vegetables produced at that location

For liquid releases: Someone who lives downriver of SRS (near River Mile 118.8) 365 days per year, drinks 2 liters of untreated water per day from the Savannah River, consumes a large amount of Savannah River fish, and spends the majority of time on or near the river

To demonstrate compliance with the DOE Order 5400.5 all-pathway dose standard of 100 mrem per year, SRS conservatively combines the airborne pathway and liquid pathway dose estimates, even though the two doses are calculated for hypothetical individuals residing at different geographic locations.

maximally exposed individual and collective doses as if the entire 80-km population consisted of adults [DOE, 1988]. For the radioisotopes that constitute most of SRS's radioactive releases (i.e., tritium and cesium-137), the dose to infants would be approximately two to three times more than to adults. The dose to older children becomes progressively closer to the adult dose.

When DOE formally adopts age-specific dose factors and models, SRS will calculate doses for the various age groups.

SRS also uses adult consumption rates for food and drinking water and adult usage parameters to estimate intakes of radionuclides. These intake values and parameters were developed specifically for SRS based on an intensive regional survey [Hamby, 1991]. The survey includes data on agricultural production, consumption rates for food products, and use of the Savannah River for drinking water and recreational purposes.

Dose Calculation Models

To calculate annual offsite doses, SRS uses transport and dose models developed for the commercial nuclear industry [NRC, 1977]. The models are implemented at SRS in the following computer programs [SRS EM Program, 2001]:

- MAXDOSE–SR: calculates maximum and average doses to offsite individuals from atmospheric releases.
- POPDOSE–SR: calculates collective doses from atmospheric releases.
- LADTAP XL©: calculates maximum and average doses to offsite individuals and the population from liquid releases.
- CAP88: calculates doses to offsite individuals from atmospheric releases to demonstrate compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP) under the Clean Air Act.

The CAP88 computer code is required under the Clean Air Act to calculate offsite doses from atmospheric releases from existing and proposed facilities. SRS uses the CAP88 dose estimates to show NESHAP compliance, but not for routine dose calculations.

Meteorological Database

Meteorological data are used as input for the atmospheric transport and dose models.

For 2001, all potential offsite doses from releases of radioactivity to the atmosphere were calculated with quality-assured meteorological data for A-Area (used for A-Area and M-Area releases) and H-Area (used for releases from all other areas). The meteorological databases used were for the years 1992–1996, reflecting the most recent 5-year compilation period. Five-year average databases are used instead of the actual annual data because of the difficulty of compiling, inputting, and validating all the data in time to be used for the current-year dose calculations.

The wind rose developed from the 1992–1996 H-Area database shows that there is no prevailing wind at SRS, which is typical for the lower midlands of South Carolina. The maximum frequency that the wind blew in any one direction was 9.7 percent of the time, which occurred toward the southwest direction.

The meteorological measurements include all dispersion conditions observed during the 5-year period, ranging from unstable (considerable turbulence, which leads to rapid dispersion) to very stable (very little turbulence, which produces a narrow, undispersed plume). The data for 1992–1996 indicate that the SRS area experiences stable conditions (atmospheric stability classes E, F, G) about 18.4 percent of the time.

Population Database and Distribution

Collective, or population, doses from atmospheric releases are calculated for the population within a 80-km radius of SRS.

For 2001 dose calculations, the 2000 population database prepared by the Savannah River Technology Center (SRTC) was used. This database uses the U.S. Census Bureau population data for 2000 and distributes the population into a grid of cells one-second latitude by one-second longitude. The database is transformed by the POPDOSE–SR Code into polar coordinates of 16 compass sectors and varying radial distances out to 80 km. The POPDOSE–SR Code can prepare a polar coordinate database for any release point put into the code in polar coordinates. A separate, fixed-polar-coordinate database was prepared for use with the CAP88 Code, which does not have the capability of transforming the grid into polar coordinates. The population database generated by the POPDOSE–SR Code is centered on the geographical center of SRS.

Within the 80-km radius, the total population for 2000 was 713,500, compared to 620,100 for 1990, a 15-percent population growth in 10 years.

Some of the collective doses resulting from SRS liquid releases are calculated for the populations served by the City of Savannah Industrial and Domestic Water Supply Plant, near Port Wentworth, Georgia, and by the Beaufort-Jasper Water Treatment Plant, near Beaufort, South Carolina. According to the treatment plant operators, the population served by the Port Wentworth facility during 2001 was approximately 11,000 persons, while the population served by the Beaufort-Jasper facility (including some residents of Hilton Head Island) was approximately 97,000 persons.

River Flow Rate Data

Offsite dose from liquid effluents varies each year with the amount of radioactivity released and the amount of dilution (flow rate) in the Savannah River. Although flow rates are recorded at U.S. Geological Survey (USGS) gauging stations at the SRS boat dock and near River Mile 118.8 (U.S. Highway 301 bridge), these data are not used directly in dose calculations. This is because weekly river flow rates fluctuate widely (i.e., short-term dilution varies from week to week). Used instead are “effective” flow rates, which are based on measured concentrations of tritium in Savannah River water and measured concentrations in water used at the downstream water treatment plants. However, the USGS-measured flow rates are used for comparison to these calculated values.

For 2001, the River Mile 118.8 calculated (effective) flow rate of 4,743 cubic feet per second was used in determining doses to maximally exposed individuals, population doses from recreation and fish consumption, and potential doses from crops irrigated with river water. This flow rate was about 16 percent less than the 2000 effective flow rate of 5,640 cubic feet per second. For comparison, during 2001, the USGS-measured flow rate at River Mile 118.8 was 5,804 cubic feet per second.

The 2001 calculated (effective) flow rate for the Beaufort-Jasper facility was 5,411 cubic feet per second, which was about 19 percent less than the 2000 flow rate.

The 2001 calculated (effective) flow rate for the Port Wentworth facility was 6,047 cubic feet per second, which was about 14 percent less than the 2000 flow rate.

The 2001 calculated Savannah River estuary flow rate (6,384 cubic feet per second) was used only for calculation of dose from consumption of salt water invertebrates.

In figure 5–1, the annual average Savannah River flow rates, measured by the USGS at River Mile 118.8, are provided for the years of SRS operations (1954 to 2001). The 2001 rate of 5,804 cubic feet per second was the third lowest measured during this 48-year period.

Uncertainty in Dose Calculations

Radiation doses are calculated using the best available data. If adequate data are unavailable, then site-specific parameters are selected that would result in a conservative estimate of the maximum dose.

All radiation data and input parameters have an uncertainty associated with them, which causes uncertainty in the dose determinations. For example, there is uncertainty in the assumed maximum meat consumption rate of 81 kg (179 pounds) per year for an individual. Some people will eat more than 81 kg, but most probably will eat less. Uncertainties can be combined mathematically to create a distribution of doses rather than a single number. While the concept is simple, the calculation is quite difficult. A detailed technical discussion of the method of estimating uncertainty at SRS was published in the July 1993 issue of *Health Physics* [Hamby, 1993].

Dose Calculation Results

Liquid and air pathway doses are calculated for the maximally exposed individual and for the surrounding population. In addition, a sportsman dose is calculated separately for consumption of fish, deer, and feral hogs, which are nontypical exposure pathways. Finally, a dose is calculated for the aquatic biota found in SRS streams.

Liquid Pathway

This section contains information on liquid release quantities used as source terms in SRS dose calculations, including a discussion about radionuclide concentrations in Savannah River fish. The calculated dose to the maximally exposed individual, the calculated collective (population) dose, and the potential dose from agricultural irrigation are presented.

Liquid Release Source Terms

The 2001 radioactive liquid release quantities used as source terms in SRS dose calculations are presented in chapter 3 and summarized by radionuclide in table 5–1.

As discussed in chapters 3 and 4, SRS measures tritium releases to the Savannah River using three methods. In calculating doses from tritium, the stream transport value is used instead of the the river transport value or the direct-plus-migration value

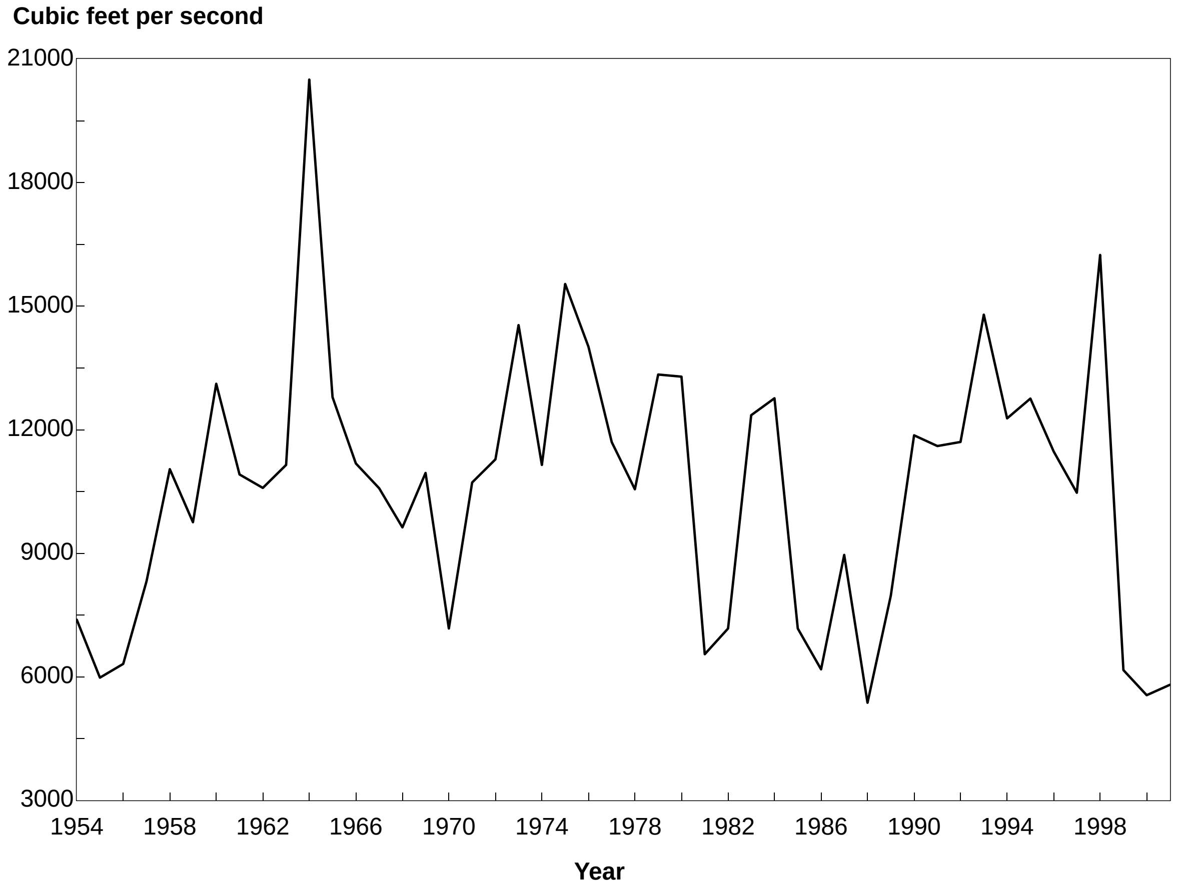

Figure 5–1 Savannah River Mile 118.8 Annual Average Flow Rates, 1954–2001

The 2001 River Mile 118.8 flow rate of 5,804 cubic feet per second was the third lowest measured during the 48-year operating history of SRS. River Mile 118.8 flow rates were not measured for the years 1971–1981; mean flow rates for those years are based on rates measured near Augusta, Georgia.

(chapter 4). This is because the stream transport value—measured in site streams just prior to their discharge to the Savannah River—most accurately reflects the actual amount of aqueous tritium leaving the site. During 2001, the total tritium transport in SRS streams decreased by approximately 28 percent (from 5,960 Ci in 2000 to 4,320 Ci in 2001). Most of this decrease is attributed to the Four Mile Creek phytoremediation project.

Releases of unspecified alpha emitters and nonvolatile beta emitters are listed separately in the source term. Prior to 1999, these alpha and beta emitters were included in plutonium-239 and strontium-89,90 releases, respectively.

For dose calculations, unspecified alpha releases were assigned the plutonium-239 dose factor, and unspecified nonvolatile beta releases were assigned the strontium-90 factor. Accounting for the alpha and beta emitters in this way generates an overestimated dose attributed to releases from SRS because

- plutonium-239 and strontium-90 have the highest dose factors among the common alpha- and beta-emitting radionuclides
- a part of the unidentified activity probably is not from SRS operations but from naturally occurring radionuclides, such as potassium-40 and radon progeny

Radionuclide Concentrations in Savannah River Water and Fish

For use in dose determinations and model comparisons, the concentrations of tritium in Savannah River water and cesium-137 in Savannah River fish are measured at several locations along the river. The amounts of all other radionuclides released from SRS are so small that they usually cannot be detected in the Savannah River using standard analytical techniques.

Radionuclide Concentrations in River Water and Treated Drinking Water The measured concentrations of tritium in the Savannah River near River Mile 118.8 and at the Beaufort-Jasper and Port Wentworth water treatment facilities are shown in table 5–1, as are the LADTAP XL©-determined concentrations for the other released radionuclides.

The 12-month average tritium concentrations measured in the Savannah River near River Mile 118.8 (1.02 pCi/mL), and at the Beaufort-Jasper (0.894 pCi/mL) and Port Wentworth (0.800 pCi/mL) water treatment plants, remained below the U.S. Environmental Protection Agency (EPA) maximum contaminant level (MCL) of 20 pCi/mL.

The 2001 River Mile 118.8 concentration was slightly less than the 2000 concentration of 1.18 pCi/mL.

Annual average tritium concentrations measured during the period 1992–2001 at River Mile 118.8 and at the Beaufort-Jasper and Port Wentworth facilities are compared to the EPA MCL in figure 5–2. The data for Beaufort-Jasper and Port Wentworth are the tritium concentrations measured in the finished drinking water at each facility.

Compliance With EPA's Maximum Contaminant Levels for Radionuclides in Drinking Water

In 2001, the EPA promulgated 40 CFR, Parts 9, 141, and 142, "National Primary Drinking Water Regulations; Radionuclides; Final Rule." This rule, applicable only to community drinking water systems, finalized maximum contaminant levels for radionuclides, including uranium [EPA, 2000].

The MCL for each radionuclide released from SRS during 2001 is provided in table 5–1. The table indicates that all individual radionuclide concentrations at the two downriver community drinking water systems, as well as at River Mile 118.8, were below the MCLs.

Because more than one radionuclide is released from SRS, the sum of the ratios of the observed concentration of each radionuclide to its corresponding MCL must not exceed 1.0.

As shown in table 5–1, the sum of the ratios was 0.0574 at the Port Wentworth facility and 0.0641 at

Table 5–1
2001 Radioactive Liquid Release Source Term and 12-Month Average Downriver Radionuclide Concentrations Compared to EPA's Drinking Water Maximum Contaminant Levels (MCLs)

		12-Month Average Concentration (pCi/mL)			
Nuclide	**Curies Released**	**Below SRS[a]**	**Beaufort-Jasper[b]**	**Port Wentworth[c]**	**EPA MCL**
H-3[d]	4.32E+03	1.02E+00	8.94E–01	8.00E–01	2.00E+01
Sr-90	2.05E–02	4.84E–06	4.24E–06	3.80E–06	8.00E–03
Tc-99	4.56E–02	1.08E–05	9.44E–06	8.44E–06	9.00E–01
I-129	7.82E–02	1.85E–05	1.62E–05	1.45E–05	1.00E–03
Cs-137[e]	6.58E–02	1.55E–05	1.36E–05	1.22E–05	2.00E–01
U-234	9.47E–05	2.24E–08	1.96E–08	1.75E–08	1.87E+02
U-235	1.70E–06	4.01E–10	3.52E–10	3.15E–10	6.48E–01
U-238	1.24E–04	2.93E–08	2.57E–08	2.30E–08	1.01E–02
Pu-238	4.50E–05	1.06E–08	9.31E–09	8.33E–09	1.50E–02
Pu-239	7.43E–06	1.75E–09	1.54E–09	1.38E–09	1.50E–02
Am-241	7.07E–06	1.67E–09	1.46E–09	1.31E–09	1.50E–02
Cm-244	7.09E–06	1.67E–09	1.47E–09	1.31E–09	1.50E–02
Alpha	2.87E–02	6.78E–06	5.94E–06	5.31E–06	1.50E–02
Nonvolatile Beta	8.51E–02	2.01E–05	1.76E–05	1.58E–05	8.00E–03
Sum of the Ratios =		7.32E–02	6.41E–02	5.74E–02	

a Near Savannah River Mile 118.8, downriver of SRS at the U.S. Highway 301 bridge
b Beaufort-Jasper, South Carolina, drinking water
c Port Wentworth, Georgia, drinking water
d Measured concentrations; all other concentrations calculated using models verified with tritium measurements
e Curies released based on measured cesium-137 levels in Savannah River fish

the Beaufort-Jasper facility. These are below the 1.0 requirement.

For 2001, the sum of the ratios at the River Mile 118.8 location was 0.0732. This is provided here only for comparison because River Mile 118.8 is not a community water system location.

Radionuclide Concentrations in River Fish At SRS, an important dose pathway for the maximally exposed individual is from the consumption of fish.

Fish exhibit a high degree of bioaccumulation for certain elements. For the element cesium (including radioactive isotopes of cesium), the bioaccumulation factor for Savannah River fish is approximately 3,000. That is, the concentration of cesium found in fish flesh is about 3,000 times more than the concentration of cesium found in the water in which the fish live.

Because of this high bioaccumulation factor, cesium-137 is more easily detected in fish flesh than in river water. Therefore, the fish pathway dose from cesium-137 is based directly on the radioanalysis of the fish collected near Savannah River Mile 118.8, which is the assumed location of the hypothetical maximally exposed individual. The fish pathway dose from all other radionuclides is based on the calculated concentrations determined by the LADTAP XL© code. A consumption rate of 19 kg (42 pounds) of fish per year is used in the maximally exposed individual dose calculation [Hamby, 1991]. Some fraction of this estimated dose is due to cesium-137 from worldwide fallout and from neighboring Vogtle Electric Generating Plant; however, that amount is difficult to determine and is not subtracted from the total.

The dose determinations are accomplished in the LADTAP XL© code by substituting a cesium-137 release value that would result in the measured concentration in river fish, assuming the site-specific bioaccumulation factor of 3,000. A weighted average concentration (based on the number of fish in each composite analyzed) of cesium-137 in River Mile 118.8 fish was used for maximally exposed individual and population dose determinations.

Dose to the Maximally Exposed Individual

The potential liquid pathway dose to the hypothetical maximally exposed individual living downriver of

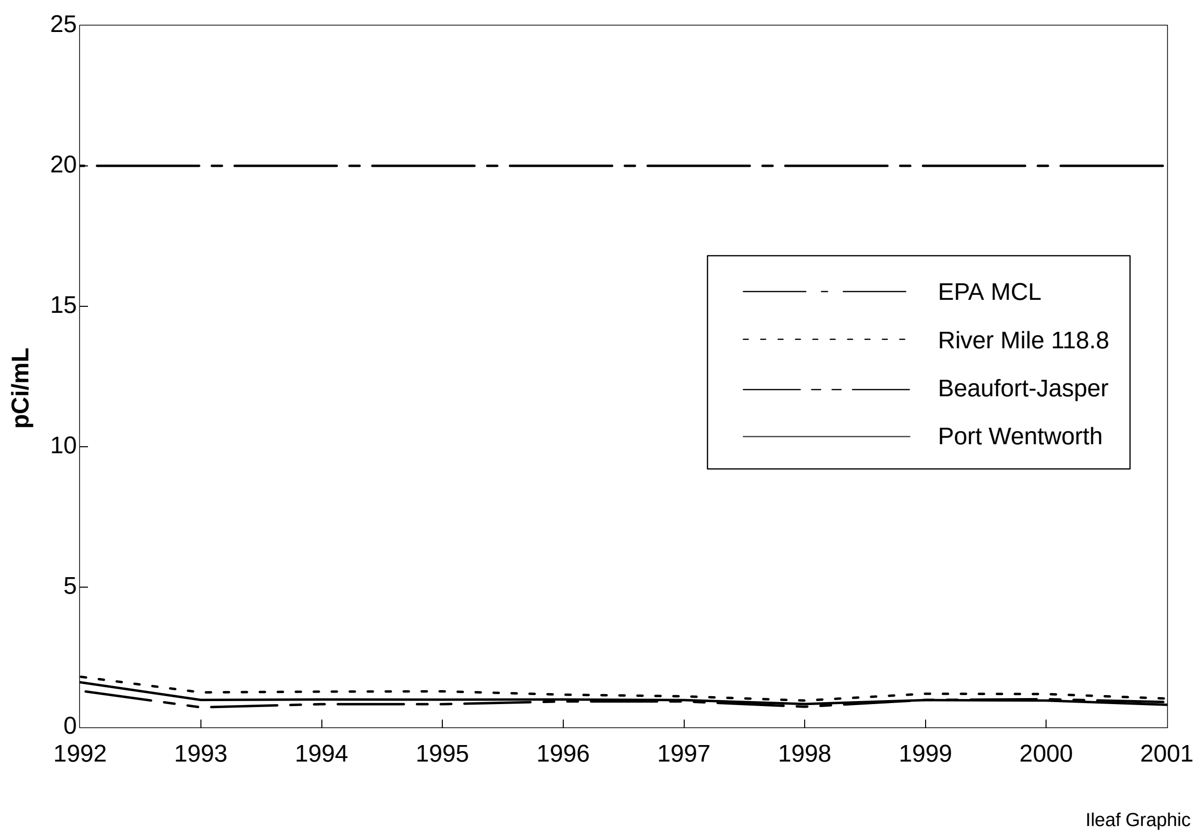

Figure 5–2 Annual Average Tritium Concentrations at River Mile 118.8, Beaufort-Jasper, and Port Wentworth (1992–2001) Compared to the EPA MCL for tritium of 20 pCi/mL.

Table 5–2
Potential Dose to the Maximally Exposed Individual from SRS Liquid Releases in 2001

	Committed Dose (mrem)	Applicable Standard (mrem)	Percent of Standard
Maximally Exposed Individual			
Near Site Boundary (all liquid pathways)	0.13	100[a]	0.13
At Port Wentworth (public water supply only)	0.06	4[b]	1.50
At Beaufort-Jasper (public water supply only)	0.07	4[b]	1.75

a All-pathway dose standard: 100 mrem per year (DOE Order 5400.5)
b Drinking water pathway standard: 4 mrem per year (DOE Order 5400.5)

SRS, near River Mile 118.8, was determined based on adult intake and usage parameters discussed earlier in this chapter and on other site-specific physical parameters.

As shown in table 5–2, the highest potential dose to the maximally exposed individual from liquid releases in 2001 was estimated at 0.13 mrem (0.0013 mSv). This dose is 0.13 percent of DOE’s 100-mrem all-pathway dose standard for annual exposure.

The 2001 potential maximally exposed individual dose was slightly less than the 2000 dose of 0.14 mrem (0.0022 mSv).

Approximately 36 percent of the dose to the maximally exposed individual resulted from the ingestion of cesium-137, mainly from the consumption of fish, and about 38 percent resulted from the ingestion (via drinking water) of tritium. About 18 percent of the liquid pathway maximally exposed individual dose was attributed to unspecified alpha emitters, which are conservatively assigned the dose factor for plutonium-239 in the dose calculations (chapter 3).

Drinking Water Pathway Persons downriver of SRS may receive a radiation dose by consuming drinking water that contains radioactivity as a result of liquid releases from the site. In 2001, tritium in downriver drinking water represented the majority of the dose (about 63 percent) received by persons at downriver water treatment plants.

The calculated doses to maximally exposed individuals whose entire daily intake of water is supplied by the Beaufort-Jasper and Port Wentworth water treatment facilities, located downriver of SRS, were determined for maximum (2 liters per day for a year) water consumption rates.

The maximum potential drinking water doses during 2001 were 0.07 mrem (0.0007 mSv) at the Beaufort-Jasper Water Treatment Plant and 0.06 mrem (0.0006 mSv) at the City of Savannah Industrial and Domestic Water Supply Plant (Port Wentworth).

As shown in table 5–2, the maximum dose of 0.07 mrem (0.0007 mSv) is 1.75 percent of the DOE standard of 4 mrem per year for public water supplies. The 2001 maximum potential drinking water dose was slightly more than the 2000 maximum dose of 0.06 mrem (0.0006 mSv).

The “Potential Dose” section of appendix A, “Applicable Guidelines, Standards, and Regulations,” explains the differences between the DOE and EPA drinking water standards.

Collective (Population) Dose

The collective drinking water consumption dose is calculated for the discrete population groups at Beaufort-Jasper and Port Wentworth. The collective dose from other pathways is calculated for a diffuse population that makes use of the Savannah River. However, this population cannot be described as being in a specific geographical location.

Potential collective doses were calculated, by pathway and radionuclide, using the LADTAP XL©

computer code. In 2001, the collective dose from SRS liquid releases was estimated at 4.3 person-rem (0.043 person-Sv). This was 10 percent more than the 2000 collective dose of 3.9 person-rem (0.039 person-Sv).

Potential Dose from Agricultural Irrigation

The 1990 update of land- and water-use parameters [Hamby, 1991] revealed that there is no known use of river water downstream of SRS for agricultural irrigation purposes. However, in response to public concerns, potential doses from this pathway are calculated for information purposes only and are not included in calculations of the official maximally exposed individual or collective doses.

For 2001, a potential offsite dose of 0.13 mrem (0.0013 mSv) to the maximally exposed individual and a collective dose of 8.9 person-rem (0.089 person-Sv) were estimated for this exposure pathway.

As in previous years, collective doses from agricultural irrigation were calculated for 1,000 acres of land devoted to each of four major food types—vegetation, leafy vegetation, milk, and meat. It is assumed that all the food produced on the 1,000-acre parcels is consumed by the 80-km population of 713,500.

Air Pathway

This section describes the atmospheric source term and concentrations used for dose determinations and presents the calculated dose to the maximally exposed individual, as well as the calculated collective (population) dose. Also included is a discussion about how SRS demonstrates NESHAP compliance.

Atmospheric Source Terms

The 2001 radioactive atmospheric release quantities used as the source term in SRS dose calculations are presented in chapter 3. Releases of unspecified alpha emitters and nonvolatile beta emitters were listed separately in the source term. Prior to 1999, these alpha and beta emitters were included in the plutonium-239 and strontium-89,90 releases, respectively.

For air pathway dose calculations—as in liquid dose calculations—unspecified alpha releases were assigned the plutonium-239 dose factor, and unspecified nonvolatile beta releases were assigned the strontium-90 dose factor.

In 2001, krypton-85 accounted for more than half of the radioactivity released to the atmosphere from SRS. Because krypton is an inert noble gas, which means it is chemically and biologically inactive, it is not readily assimilated or absorbed by the human body and it quickly disperses in the atmosphere. Therefore, it causes a relatively small amount of dose to humans (less than 1 percent of the maximally exposed individual dose in 2001).

Estimates of unmonitored diffuse and fugitive sources were considered, as required for demonstrating compliance with NESHAP regulations.

Airborne effluents are grouped by major release points for dose calculations. For the MAXDOSE–SR code, five release locations (center of site, H-Area, K-Area, M-Area, and SRTC) with specific release heights were used.

The CAP88 code can calculate doses from collocated release heights but cannot combine calculations for releases at different geographical locations. Therefore, for CAP88 calculations, airborne effluents were grouped for elevated releases (61 meters) and ground-level releases (0 meters), and the geographical center of the site was used as the release location for both.

Atmospheric Concentrations

The MAXDOSE–SR and CAP88 codes calculate average and maximum concentrations of all released radionuclides at the site perimeter. These calculated concentrations are used for dose determinations instead of measured concentrations. This is because most radionuclides released from SRS cannot be measured, using standard methods, in the air samples collected at the site perimeter and offsite locations. However, the concentrations of tritium oxide at the site perimeter locations usually can be measured and are compared with calculated concentrations as a verification of the dose models.

In table 5–3, the average 1992–2001 tritium oxide concentrations in air—measured near the center of the site and at locations along the site perimeter—are compared to the average concentrations calculated for the site perimeter, using the MAXDOSE–SR code.

These data show that the calculated site-perimeter tritium oxide concentrations have consistently and reasonably approximated the measured values and therefore are appropriate for use in dose determinations.

The average tritium-in-air concentration at the site boundary calculated using the MAXDOSE–SR code was 9 pCi/m^3. The maximum concentration was

Table 5–3
Ten-Year History of SRS Atmospheric Tritium and Tritium Oxide Releases and Average Measured Tritium Oxide Concentrations in Air Compared to Calculated Concentrations in Air

Year	Total Tritium Released (Ci)	Tritium Oxide Released[a] (Ci)	Average Tritium Oxide Concentrations in Air: Center of Site (measured) (pCi/m^3)	Site Perimeter (measured) (pCi/m^3)	Site Perimeter (calculated by dose model)[b] (pCi/m^3)
1992[c]	156,000	100,000	420	27	30
1993	191,000	133,000	450	30	37
1994[d]	160,000	107,000	350	23	30
1995	97,000	55,000	300	16	16
1996	55,300	40,100	123	11	11
1997	58,000	39,100	162	12	10
1998	82,700	58,600	147[e]	12[e]	15
1999	51,600	33,900	148[f]	14[f]	9
2000	44,800	32,400	[g]	[g]	8
2001	47,400	33,000	293	15	9

a Tritium oxide releases are included with elemental tritium releases in the “Total Tritium Released” column.

b MAXDOSE–SR

c During May 1992, the method for determining tritium oxide concentrations in air was changed to the use of measured humidity values (averaged biweekly) instead of a single generic value. The listed concentrations are for May to December 1992.

d During 1994, because of problems with measuring location-specific humidity values, a single generic value of 11.4 g/m^3 was used for absolute humidity.

e In 1998, the number of monitoring stations near the center of the site was reduced to one, and the number of monitoring stations at the site perimeter was reduced to 12.

f In 1999, the Environmental Monitoring Section changed the way that the tritium concentration in air is determined at SRS by incorporating a factor to correct for the dilution of tritium-in-air samples by intrinsic water in the silica gel sampling media.

g During 2000, because of problems with the analysis of silica gel sampling material, the uncertainty in the measured tritium-in-air concentrations was too high to allow a comparison.

calculated to be 18 pCi/m^3 in the north-northwest sector.

These concentrations compare favorably with the CAP88 code, which calculates an average concentration of 8 pCi/m^3 and a maximum site perimeter concentration of 12 pCi/m^3. This value is less than the MAXDOSE–SR code value because the CAP88 code assumes that all releases occurred from only one point, which is located at the center of the site.

Dose to the Maximally Exposed Individual

The potential air pathway dose to a hypothetical maximally exposed individual located at the site perimeter was determined using the MAXDOSE–SR computer code. The adult consumption and usage parameters used for the calculations were discussed earlier in this chapter.

In 2001, the estimated dose to the maximally exposed individual was 0.05 mrem (0.0005 mSv), which is 0.5 percent of the DOE Order 5400.5 (“Radiation Protection of the Public and the Environment”) standard of 10 mrem per year. This dose is slightly more than the 2000 dose of 0.04 mrem (0.0004 mSv); the change is attributed to increases in releases of tritium and iodine-129 from SRS (chapter 3). Table 5–4 compares the maximally exposed individual’s dose with the DOE standard.

Tritium oxide releases accounted for about 51 percent of the dose to the maximally exposed individual.

Iodine-129 and plutonium-239 emissions each accounted for about 16 percent of the maximally exposed individual dose. More than 90 percent of the plutonium-239 releases were estimated to be from diffuse and fugitive sources (chapter 3).

For 2001, the MAXDOSE–SR code determined that the north-northwest sector of the site was the location

Table 5–4
Potential Dose to the Maximally Exposed Individual from SRS Atmospheric Releases in 2001

	MAXDOSE–SR	CAP88 (NESHAP)
Calculated dose (mrem)	0.05	0.05
Applicable standard (mrem)	10[a]	10[b]
Percent of standard	0.5	0.5

a DOE: DOE Order 5400.5, February 8, 1990
b EPA: (NESHAP) 40 CFR 61 Subpart H, December 15, 1989

of the highest maximally exposed individual dose. Figure 5–3 shows the potential dose to the maximally exposed individual residing at the site boundary for each of the 16 major compass point directions around SRS.

The major pathways contributing to the dose to the maximally exposed individual from atmospheric releases were inhalation (43 percent) and the consumption of vegetation (44 percent), cow milk (9 percent), and meat (3 percent).

Additional calculations of the dose to the maximally exposed individual were performed substituting goat milk for the customary cow milk pathway. The potential dose using the goat milk pathway was estimated at 0.06 mrem (0.0006 mSv).

Collective (Population) Dose

Potential doses also were calculated, by pathway and radionuclide, using the POPDOSE–SR computer code for the population (713,500 people) residing within 80 km of the center of SRS.

In 2001, the collective dose was estimated at 2.9 person-rem (0.029 person-Sv)—less than 0.01 percent of the collective dose received from natural sources of radiation (about 214,000 person-rem).

Tritium oxide releases accounted for 59 percent of the collective dose. The 2001 collective dose was 26 percent more than the 2000 collective dose of 2.3 person-rem (0.023 person-Sv). The increase is attributed primarily to the use of the U.S. Census Bureau population data for 2000 (see earlier section, “Population Database and Distribution,” page 72).

NESHAP Compliance

To demonstrate compliance with NESHAP (Clean Air Act, 40 CFR 61, Subpart H) regulations, maximally exposed individual and collective doses were calculated, and a percentage of dose contribution from each radionuclide was determined using the CAP88 computer code.

The dose to the maximally exposed individual, calculated with CAP88, was estimated at 0.05 mrem (0.0005 mSv), which is 0.5 percent of the 10-mrem-per-year EPA standard, as shown in table 5–4. Tritium oxide releases accounted for about 85 percent of this dose.

The CAP88 collective dose was estimated at 5.6 person-rem (0.056 person-Sv). Tritium oxide releases accounted for about 86 percent of this dose.

The CAP88 code estimates a higher dose for tritium oxide than do the MAXDOSE–SR and POPDOSE–SR codes. Most of the differences occur in the tritium dose estimated from food consumption. The major cause of this difference is the CAP88 code’s use of 100-percent equilibrium between tritium in air moisture and tritium in food moisture, whereas the MAXDOSE–SR and POPDOSE–SR codes use 50-percent equilibrium values, as recommended by the Nuclear Regulatory Commission [NRC, 1977]. A site-specific study indicated that the 50-percent value is correct for the atmospheric conditions at SRS [Hamby and Bauer, 1994].

Because tritium oxide dominates the doses determined using the CAP88 code, and because the CAP88 code is limited to a single, center-of-site release location, other radionuclides (such as plutonium-239) are less important—on a percentage-of-dose basis—for the CAP88 doses than for the MAXDOSE–SR and POPDOSE–SR doses.

All-Pathway Dose

To demonstrate compliance with the DOE Order 5400.5 all-pathway dose standard of 100 mrem per year (1.0 mSv per year), SRS conservatively combines the maximally exposed individual airborne pathway and liquid pathway dose estimates, even

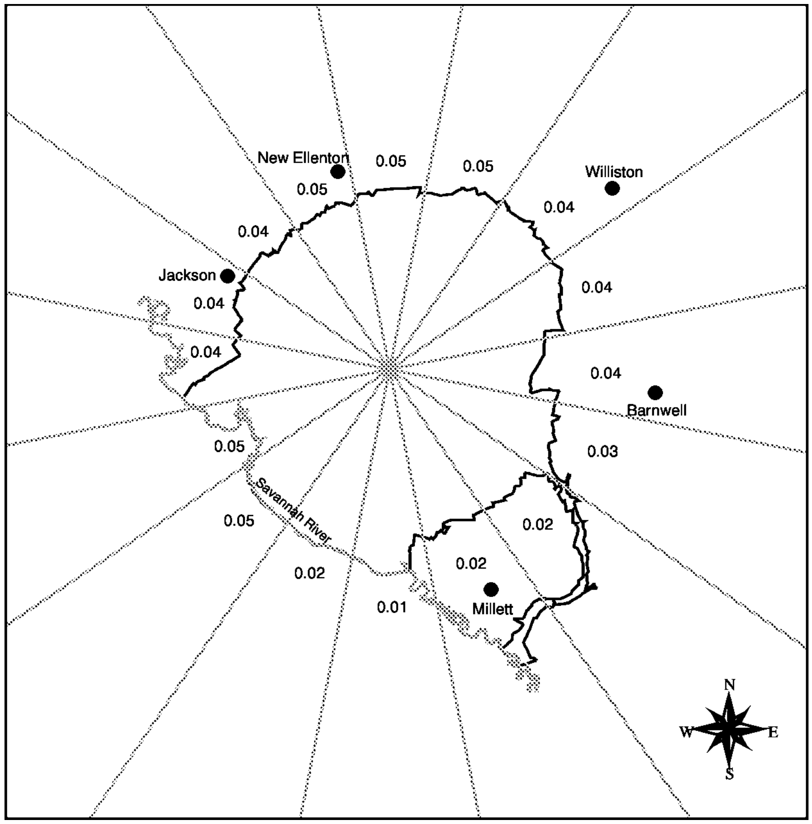

Figure 5–3 Sector-Specific Adult Maximally Exposed Individual Air Pathway Doses (in mrem) for 2001

Maximally exposed individual site boundary doses from airborne releases are shown for each of the 16 major compass point directions surrounding SRS. For 2001, five sectors (NNW, N, NNE, SW, WSW) had essentially the same maximally exposed individual dose of 0.05 mrem. However, when the third decimal point was considered, the NNW sector was slightly higher than the other four sectors.

EPD/GIS Map

though the two doses are calculated for hypothetical individuals residing at different geographic locations.

For 2001, the potential maximally exposed individual all-pathway dose was 0.18 mrem (0.0018 mSv)—0.05 mrem from airborne pathway plus 0.13 mrem from liquid pathway. This dose is the same as the 2000 all-pathway dose.

Figure 5–4 shows a 10-year history of SRS's all-pathway doses (airborne pathway plus liquid pathway doses to the maximally exposed individual).

As shown in table 5–5, the 2001 potential all-pathway dose of 0.18 mrem (0.0018 mSv) is 0.18 percent of the 100-mrem-per-year DOE dose standard.

Figure 5–5 shows a comparison of the 2001 maximum potential all-pathway dose attributable to SRS operations (0.18 mrem) with the average annual radiation dose received by a typical Central Savannah River Area (CSRA) resident from natural and manmade sources of radiation (360 mrem).

Sportsman Dose

DOE Order 5400.5 specifies radiation dose standards for individual members of the public. The dose standard of 100 mrem per year includes doses a person receives from routine DOE operations through all exposure pathways. Nontypical exposure pathways, not included in the standard calculations of the doses to the maximally exposed individual, are considered and quantified separately. This is because they apply to low-probability scenarios, such as consumption of fish caught exclusively from the mouths of SRS streams, or to unique scenarios, such as volunteer deer hunters.

For 2001, in addition to deer and fish consumption, the following exposure pathways were considered for an offsite hunter and an offsite fisherman—both on a privately owned portion of the Savannah River Swamp (Creek Plantation):

- External exposure to contaminated soil
- Incidental ingestion of contaminated soil
- Incidental inhalation of resuspended contaminated soil

The Creek Plantation, a privately owned land area located along the Savannah River, borders the southeast portion of SRS. The land is primarily undeveloped and agricultural; it is used in equestrian-related operations and as a recreational hunt club. A portion of Creek Plantation along the Savannah River includes part of the Savannah River

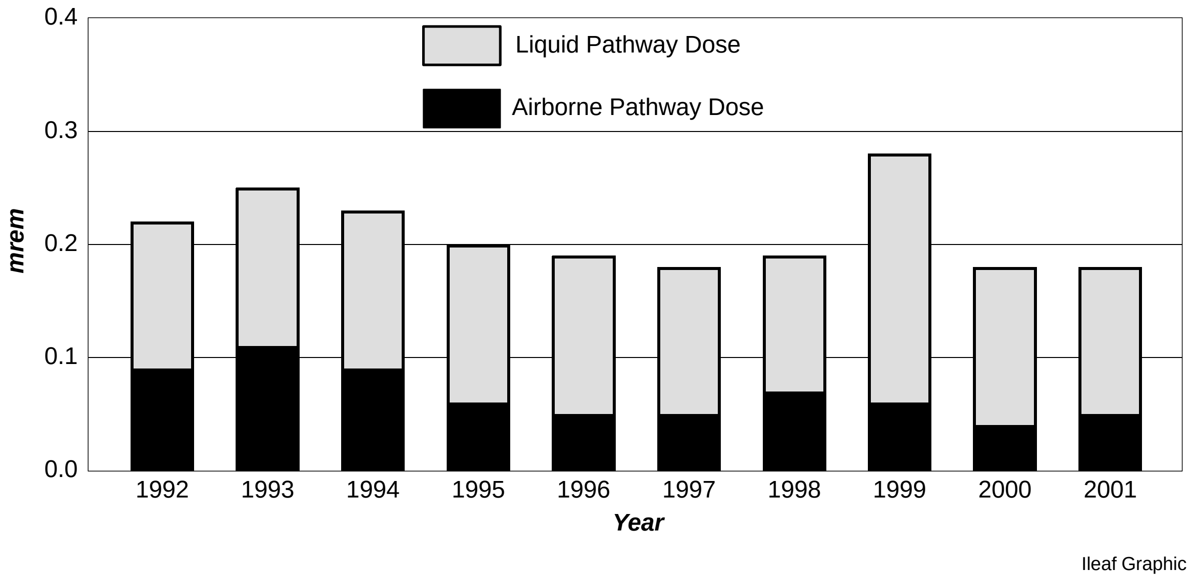

Figure 5–4 Ten-Year History of SRS Potential All-Pathway Doses to the Maximally Exposed Individual (Airborne plus Liquid Pathways)

Swamp, a low-lying swamp that is uninhabited and not easily accessible.

In the 1960s, an area of the Savannah River Swamp on Creek Plantation—specifically, the area between Steel Creek Landing and Little Hell Landing—was contaminated by SRS operations.

Comprehensive and cursory surveys of the swamp have been conducted periodically since 1974. These surveys measure radioactivity levels to determine changes in the amount and/or distribution of radioactivity in the swamp. The last comprehensive survey was conducted in 2000; a cursory survey was performed in 2001 (chapter 10, "Special Surveys and Projects").

Onsite Hunter Dose

Controlled hunts of deer and feral hogs are conducted at SRS every year for approximately 6 weeks. Hunt participants are volunteers. Before any harvested deer or hog is released to a hunter, SRS personnel perform a field analysis for cesium-137 on the animal at the hunt site, using a portable sodium iodide detector.

Because of heightened security concerns in the wake of the terrorist attacks of September 11, the number and locations of the hunts were restricted. As a result, the number of animals harvested in 2001 was greatly reduced.

Deer and Hog Consumption Pathway The estimated dose from consumption of the harvested deer or hog meat is determined for each onsite hunter. During 2001, the maximum potential dose that could have been received by an actual onsite hunter was estimated at 14 mrem (0.14 mSv), or 14 percent of DOE's 100-mrem all-pathway dose standard (table 5–5). This dose was determined for a prolific hunter who in fact harvested 11 hogs during the 2001 hunts.

The hunter-dose calculation is based on the conservative assumption that the hunter individually consumed the entire edible portion—approximately 279 kg (616 pounds)—of the hogs he harvested from SRS.

Offsite Hunter Dose

The potential doses to a hypothetical offsite hunter from deer consumption and contaminated soil exposure were calculated for 2001.

Deer Consumption Pathway The deer consumption pathway considered was for a hypothetical offsite individual whose entire intake of meat during the year was deer meat. It was assumed that this individual harvested deer that had resided on SRS, but then moved off site. The estimated dose was based on the assumed maximum annual meat consumption rate for an adult of 81 kg per year [Hamby, 1991].

Based on these low-probability assumptions and on the average concentration of cesium-137 (1.13 pCi/g) in deer harvested from SRS during 2001, the potential maximum dose from this pathway was estimated at 0.53 mrem (0.0053 mSv). A background cesium-137 concentration of 1 pCi/g is subtracted from the onsite average concentration before calculating the dose.

The background concentration is based on previous analyses of deer harvested 80 km from SRS (table 33, *SRS Environmental Data for 1994,* WSRC–TR–95–077).

Savannah River Swamp Hunter Soil Exposure Pathway The potential dose to a recreational hunter exposed to SRS legacy contamination in Savannah River Swamp soil on the privately owned Creek Plantation in 2001 was estimated using the RESRAD dosimetry code (DOE Order 5400.5). It was assumed that this recreational sportsman hunted for 120 hours during the year (8 hours per day for 15 days) at the location of maximum radionuclide contamination.

During the comprehensive survey of the Savannah River Swamp conducted in 2000, the location with the worst-case combination of cesium-137, cobalt-60, and strontium-90 concentrations was on trail 2, at a distance of 3,100 feet from the Savannah River (table 60, *SRS Environmental Data for 2000,* WSRC–TR–2000–00329).

Using these radionuclide concentrations, the potential dose to a hunter from a combination of 1) external exposure to the contaminated soil, 2) incidental ingestion of the soil, and 3) incidental inhalation of resuspended soil was estimated to be 4.4 mrem (0.044 mSv).

As shown in table 5–5, the offsite deer consumption pathway and the Savannah River Swamp hunter soil exposure pathway were conservatively added together to obtain a total offsite hunter dose of 4.93 mrem (0.0493 mSv). This potential dose is 4.9 percent of the DOE 100-mrem all-pathway dose standard.

Offsite Fisherman Dose

The potential doses to a hypothetical offsite fisherman from fish consumption and contaminated soil exposure were calculated for 2001.

Table 5–5
2001 Maximum Potential All-Pathway and Sportsman Doses Compared to the DOE All-Pathway Dose Standard

	Committed Dose (mrem)	Applicable Standard[a] (mrem)	Percent of Standard
Maximally Exposed Individual Dose			
All-Pathway (Liquid Plus Airborne Pathway)	0.18	100	0.18
Sportsman Doses			
Onsite Hunter	14	100	14
Creek Mouth Fisherman[b]	0.26	100	0.26
Savannah River Swamp Hunter			
Offsite Deer Consumption	0.53		
Soil Exposure[c]	4.4		
Total Offsite Hunter Dose	4.93	100	4.9
Savannah River Swamp Fisherman			
Steel Creek Fish Consumption	0.1		
Soil Exposure[d]	0.54		
Total Offsite Fisherman Dose	0.64	100	0.64

a All-pathway dose standard: 100 mrem per year (DOE Order 5400.5)

b In 2001, the maximum fisherman dose was caused by the consumption of bass from the mouth of Upper Three Runs.

c Includes the dose from a combination of external exposure to—and incidental ingestion and inhalation of—the worst-case Savannah River Swamp soil

d Includes the dose from a combination of external exposure to—and incidental ingestion and inhalation of—Savannah River Swamp soil near the mouth of Steel Creek

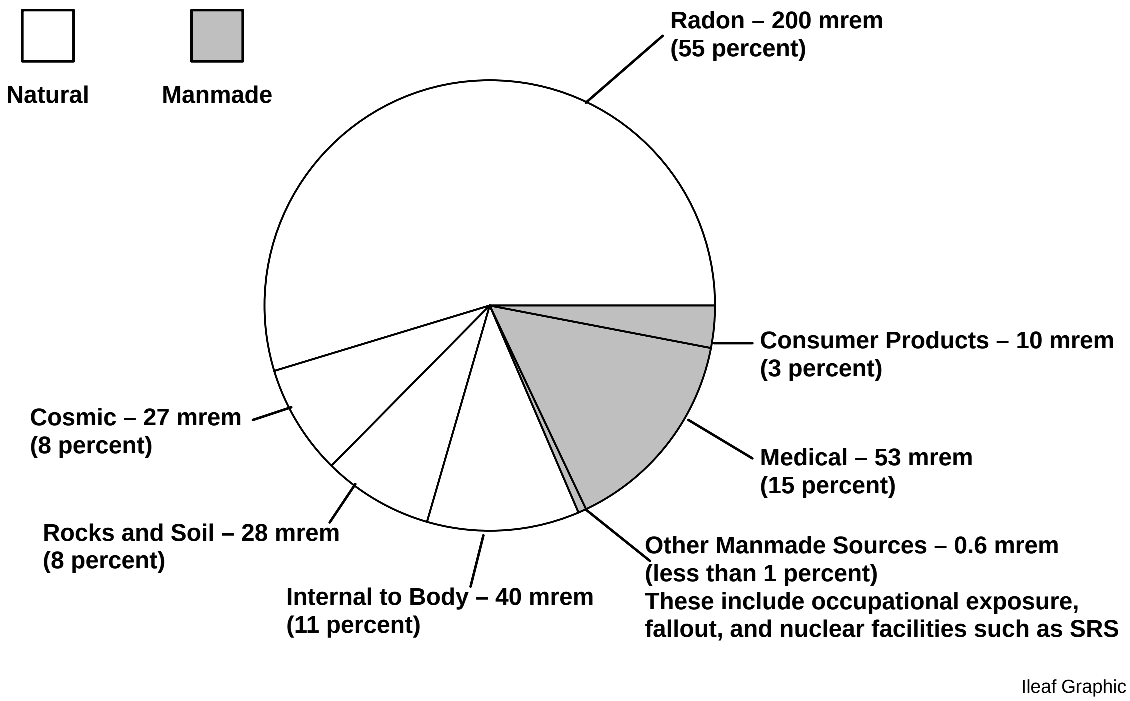

Figure 5–5 Contributions to the U.S. Average Individual Dose
The major contributor to the annual average individual dose in the United States, including residents of the CSRA, is naturally occurring radiation (about 300 mrem) [NCRP, 1987]. During 2001, SRS operations potentially contributed a maximum individual dose of 0.18 mrem, which is 0.05 percent of the 360-mrem total annual average dose (natural plus manmade sources of radiation).

Creek Mouth Fish Consumption Pathway For 2001, analyses were conducted of fish taken from the mouths of five SRS streams, and the subsequent estimated doses from the maximum consumption of 19 kg (42 pounds) per year [Hamby, 1991] of these fish were determined. Fish flesh was composited by species for each location and analyzed for tritium, strontium-89,90, cesium-137, plutonium-238, and plutonium-239.

As shown in table 5–5, the maximum potential dose from this pathway was estimated at 0.26 mrem (0.0026 mSv) from the consumption of bass collected at the mouth of Upper Three Runs. This hypothetical dose is based on the low-probability scenario that, during 2001, a fisherman consumed 19 kg of bass caught exclusively from the mouth of Upper Three Runs. About 74 percent of this potential dose was from strontium-90.

Savannah River Swamp Fisherman Soil Exposure Pathway The potential dose to a recreational fisherman exposed to SRS legacy contamination in Savannah River Swamp soil on the privately owned Creek Plantation in 2001 was estimated using the RESRAD dosimetry code (DOE Order 5400.5). It was assumed that this recreational sportsman fished on the South Carolina bank of the Savannah River near the mouth of Steel Creek for 250 hours during the year.

During the comprehensive survey of the Savannah River Swamp conducted in 2000, the location on Creek Plantation that was closest to the South Carolina bank of the Savannah River and the mouth of Steel Creek was on trail 1, at a distance of 0 feet from the Savannah River (table 60, *SRS Environmental Data for 2000*).

Using the radionuclide concentrations measured at this location, the potential dose to a fisherman from a combination of 1) external exposure to the contaminated soil, 2) incidental ingestion of the soil, and 3) incidental inhalation of resuspended soil was estimated to be 0.54 mrem (0.0054 mSv).

As shown in table 5–5, the Steel Creek mouth fish consumption dose (0.1 mrem) and the Savannah River Swamp fisherman soil exposure pathway were conservatively added together to obtain a total offsite creek mouth fisherman dose of 0.64 mrem (0.0064 mSv). This potential dose is 0.64 percent of the DOE 100-mrem all-pathway dose standard.

Potential Risk from Consumption of SRS Creek Mouth Fish

During 1991 and 1992, in response to a U.S. House of Representative Appropriations Committee request for a plan to evaluate risk to the public from fish collected from the Savannah River, SRS developed—in conjunction with EPA, the Georgia Department of Natural Resources (GDNR), and the South Carolina Department of Health and Environmental Control (SCDHEC)—the *Westinghouse Savannah River Company/Environmental Monitoring Section Fish Monitoring Plan*, which is summarized in SRS EM Program, 2001. Part of the reporting requirements of this plan are to perform an assessment of radiological risk from the consumption of Savannah River fish, and to summarize the results in the annual *SRS Environmental Report*. The following sections discuss the potential radiological risks from the consumption of Savannah River fish. Potential radiological risks are determined using both the ICRP–60 [ICRP, 1991] and the EPA [EPA, 1991] methods.

Exposure Scenario In EPA's risk assessment guidance document [EPA, 1991], two fish consumption pathways are considered—the recreational fisherman scenario and the subsistence fisherman scenario. Because of SRS's relatively remote location, the recreational fisherman scenario—as opposed to the subsistence fisherman scenario—is considered the more reasonable exposure scenario and is used in this assessment.

It is assumed that a recreational fisherman fishes for a single species of fish—either panfish, such as bream; predators, such as bass; or bottom dwellers, such as catfish—from the mouth of the worst-case SRS stream. Access to upstream portions of SRS streams is prohibited by postings, fencing (where possible), and periodic patrols.

Per EPA guidance [EPA, 1991], the maximum consumption rate that should be used for determining risk to the recreational fisherman is 19 kg (42 pounds) per year. This is the same as the consumption rate used by SRS for demonstrating maximally exposed individual dose compliance [Hamby, 1991].

The EPA guidance document requires that critical subpopulations and fish species be considered in risk assessments. Currently, there are no known sensitive subpopulations (e.g., Native Americans) in the immediate SRS region who are known to regularly consume whole fish (edible and nonedible portions) as part of their typical diet. Also, there are no known species of fish, such as smelt, in the SRS region of the Savannah River that are commonly eaten whole. Therefore, it is reasonably assumed that the recreational fisherman consumes only the edible (fillet only) portion of the fish caught.

Risk Factors For the EPA method, estimates of potential risk are calculated directly by multiplying the amount of each radionuclide ingested by the appropriate risk (slope) factors provided in EPA's *Health Effects Assessment Summary Tables* (HEAST) [EPA, 2001]. The HEAST ingestion slope factors are best estimates of potential, age-averaged, lifetime excess cancer incidence (fatal and nonfatal) risk per unit of activity ingested.

For the ICRP–60 method, estimates of potential risk are determined first by calculating a radiation dose attributable to the amount of radionuclides ingested and then multiplying that dose by the ICRP–60 coefficient of risk of severe detriment of 7.3E–07 per mrem [ICRP, 1991]. Stated another way, if 10,000,000 people each received a radiation dose of 1 mrem, there would theoretically be—during their collective lifetimes—7.3 additional severe detrimental incidences (fatal/nonfatal cancer or severe hereditary effects), which is small compared to the 2,000,000 or more expected fatal cancer incidences from other causes during their lifetimes [NRC, 1990].

The ICRP–60 risk coefficient includes factors for

- fatal cancers (5.0E–07 per mrem)
- nonfatal cancers (1.0E–07 per mrem)
- hereditary effects (1.3E–07 per mrem)

It should be noted that all radiological risk factors are based on observed and documented health effects to actual people who have received high doses (more than 10,000 mrem) of radiation, such as the Japanese atomic bomb survivors. Radiological risks at low doses (less than 10,000 mrem) are theoretical and are estimated by extrapolating the observed health effects at high doses to the low-dose region by using a linear, no-threshold model. However, cancer and other health effects have not been observed consistently at low radiation doses because the health risks either do not exist or are so low that they are undetectable by current scientific methods.

Exposure Duration According to EPA guidance, the upper bound value of 30 years can be used for exposure duration when calculating reasonable maximum residential exposures. This assessment compares the potential risks of exposure durations of 1 year, 30 years, and 50 years. The 30-year and 50-year exposure duration risks are simply 30 times and 50 times the 1-year exposure duration risk, respectively.

Risk Comparisons The maximum potential radiation doses and lifetime risks from the consumption of SRS creek mouth fish for 1-year, 30-year, and 50-year exposure durations are shown in table 5–6 and are compared to the radiation risks associated with the DOE Order 5400.5 all-pathway dose standard of 100 mrem (1.0 mSv) per year.

The maximum recreational fisherman dose was caused by the consumption of bass collected at the mouth of Upper Three Runs. About 74 percent of the dose was attributed to strontium-90, and about 26 percent was attributed to cesium-137.

Figure 5–6 shows a 9-year history of the annual potential radiation doses from consumption of Savannah River fish. No apparent trends can be discerned from these data. This is because there is large variability in the annual strontium-90 and cesium-137 concentrations measured in fish from the same location due to differences in

- the size of the fish collected each year
- their mobility and location within the stream mouth from which they are collected
- the time of year they are collected.

Also, it should be noted that most of the strontium-90 and cesium-137 that exists in SRS stream watersheds is legacy contamination left from relatively large releases that occurred during the early years of operations at SRS (1954–1963) and is not from current direct operational releases [Carlton et al., 1994]. Therefore, there is large annual variability in the amount of strontium-90 and cesium-137 available in the water and sediments at the site stream mouths; this is caused by annual changes in stream flow rates (turbulence) and water chemistry.

As indicated in figure 5–6, the 50-year maximum potential lifetime risks from consumption of SRS creek mouth fish range between 9.5E–06 and 6.2E–05, which are below the 50-year risk (3.2E–03) associated with the 100-mrem-per-year dose standard.

According to EPA practice, if a potential risk is calculated to be less than 1.0E–06 (i.e., one additional case of cancer over what would be expected in a group of 1,000,000 people), then the risk is considered minimal and the corresponding contaminant concentrations are considered negligible. If a calculated risk is more than 1.0E–04 (one additional case of cancer in a population of 10,000), then some form of corrective action or remediation usually is required. However, if a calculated risk falls between 1.0E–04 and 1.0E–06, which is the case with the maximum potential lifetime risks from the consumption of Savannah River fish, then the risks are considered acceptable if they are kept as low as reasonably achievable (ALARA).

At SRS, the following programs are in place to ensure that the potential risk from site radioactive liquid effluents (and, therefore, from consumption of Savannah River fish) are kept ALARA:

- radiological liquid effluent monitoring program (chapter 3)
- radiological environmental surveillance program (chapter 4)
- environmental ALARA program [SRS EM Program, 2001]

Table 5–6
Potential Lifetime Risks from the Consumption of Savannah River Fish Compared to Dose Standards

	Committed Dose (mrem)	ICRP–60 Risk Method	EPA/CERCLA Risk Method
2001 Savannah River Fish			
1-Year Exposure	0.26	1.9E–07	1.9E–07
30-Year Exposure	8	5.7E–06	5.8E–06
50-Year Exposure	13	9.5E–06	9.7E–06
Dose Standard			
100-mrem/year All Pathway			
1-Year Exposure	100	7.3E–05	6.3E–05
30-Year Exposure	3,000	2.2E–03	1.9E–03
50-Year Exposure	5,000	3.7E–03	3.2E–03

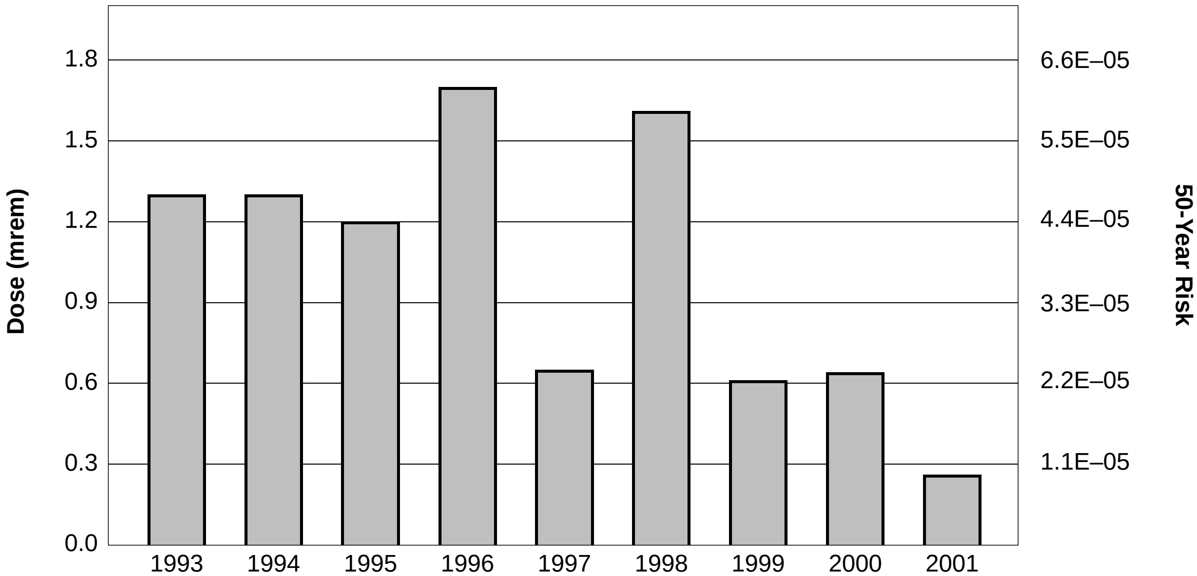

Figure 5–6 Annual Potential Radiation Doses and 50-Year Potential Risks from Consumption of Savannah River Creek Mouth Fish, 1993–2001

Dose to Aquatic Animal Organisms

DOE Order 5400.5 establishes an interim dose standard for protection of native aquatic animal organisms. The absorbed dose limit to these organisms is 1 rad per day (0.01 Gy per day) from exposure to radioactive material in liquid effluents released to natural waterways.

Hypothetical doses to various aquatic biota (fish, shellfish, algae, raccoon, and duck) in SRS streams are calculated annually to demonstrate compliance with this 1-rad-per-day dose standard. Upper-limit doses are calculated with measured radioactivity transport and minimum flow rates for each surface stream. Flow rates are chosen to maximize the biota dose. Source terms (stream transport) are provided by the site's Environmental Monitoring Section.

The CRITR computer code [Soldat et al., 1974], incorporated as part of the LADTAPII code, calculates internal and external doses to aquatic biota and to higher trophic levels that depend on aquatic biota for food. The CRITR Code is one of the three aquatic biota dose codes currently recommended by DOE [DOE, 1991].

External doses are calculated with the same external dose factors used for man [DOE, 1988]. Internal doses are based on the physical size (effective radius) of the biota and on effective energies provided for each radionuclide for each radius. Because of their size and eating habits, ducks usually are the aquatic biota that receive the largest dose.

In 2001, the maximum dose to aquatic biota was estimated at 0.004 rad per day (0.00004 Gy per day), which potentially occurred in ducks inhabiting Four Mile Creek. This is 0.4 percent of the 1-rad-per-day DOE dose limit.

Initial Screening of Biota Doses Using DOE Biota Concentration Guides

For 2001, a screening of biota doses at SRS was performed using the DOE Biota Concentration Guides (BCGs) listed in the proposed DOE standard entitled *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* [DOE, 2000].

The aquatic systems evaluation includes exposures to primary (herbivores) and secondary (predators) aquatic animals. Aquatic plants are not considered. The terrestrial systems evaluation includes exposures to terrestrial plants and animals.

For the aquatic systems evaluation portion of the BCGs, an initial screening was performed using maximum radionuclide concentration data for the 12 EMS stream sampling locations from which co-located water and sediment samples are collected. An exception was location FM–2B because of its historically high cesium and tritium concentration levels. This location was included in the initial screening even though no co-located sediment sample was collected there.

For water samples, the unidentified alpha and beta concentrations were conservatively added to the identified plutonium-239 and cesium-137 concentrations, respectively. Gross alpha and beta analyses are not performed on sediment or soil samples.

The combined water-plus-sediment BCG sum of the fractions was used for the aquatic systems evaluation. A sum-of-the-fractions value less than one indicates the sampling site has passed the initial pathway screen.

For the terrestrial systems evaluation portion of the BCGs, an initial screening was performed using concentration data from the five EMS onsite radiological soil sampling locations. Only one soil sample per year is collected from each location.

For 2001, stream sampling locations FM–A7, FM–2B, and R–1 failed the initial aquatic systems screen. All other locations, including the five soil sampling locations, passed.

For the three locations that failed, an additional assessment was performed using annual average radionuclide concentrations. All three locations passed this secondary screen (the sum of the fractions of each was less than 1.0).

Chapter 6

Nonradiological Effluent Monitoring

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NONRADIOACTIVE air emissions originating at Savannah River Site (SRS) facilities are monitored at their points of discharge by direct measurement, sample extraction and measurement, or process knowledge. Air monitoring is used to determine whether all emissions and ambient concentrations are within applicable regulatory standards.

Nonradiological liquid effluent monitoring encompasses sampling and analysis and is performed by the Environmental Protection Department's Environmental Monitoring Section (EMS), the Site Utilities Department, and the Savannah River Technology Center.

A complete description of EMS sampling and analytical procedures used for nonradiological monitoring can be found in sections 1101–1111 (SRS EM Program) of the *Savannah River Site Environmental Monitoring Section Plans and Procedures*, WSRC–3Q1–2, Volume 1. A summary of data results is presented in this chapter; more complete data can be found in *SRS Environmental Data for 2001* (WSRC–TR–2001–00475).

Airborne Emissions

The South Carolina Department of Health and Environmental Control (SCDHEC) regulates nonradioactive air emissions—both criteria pollutants and toxic air pollutants—from SRS sources. Each source of air emissions is permitted or exempted by SCDHEC, with specific limitations identified. The bases for the limitations are outlined in various South Carolina and federal air pollution control regulations and standards. Many of the applicable standards are source dependent, i.e., applicable to certain types of industry, processes, or equipment. However, some standards govern all sources for criteria and toxic air pollutants and ambient air quality. Air pollution control regulations and standards applicable to SRS sources are discussed briefly in appendix A, "Applicable Guidelines, Standards, and Regulations." The SCDHEC air standards for toxic air pollutants can be found at http://www.scdhec.net/baq on the Internet.

At SRS, there are 172 permitted/exempted nonradiological air emission sources, 133 of which were in operation in some capacity during 2001. The remaining 39 sources either were being maintained in a "cold standby" status or were under construction.

Description of Monitoring Program

Major nonradiological emissions of concern from stacks at SRS facilities include sulfur dioxide, carbon monoxide, oxides of nitrogen, particulate matter smaller than 10 microns, volatile organic compounds (VOCs), and toxic air pollutants. Facilities that have such emissions include diesel engine-powered equipment, package No. 2 fuel oil steam generators, powerhouse coal-fired boilers, the Defense Waste Processing Facility, the in-tank precipitation process, groundwater air strippers, and various other process facilities. Emissions from SRS sources are determined during an annual emissions inventory from calculations using source operating parameters such as fuel oil consumption rates, total hours of operation, and the emission factors provided in the U.S. Environmental Protection Agency (EPA) "Compilation of Air Pollution Emission Factors," AP–42. The calculation for boiler sulfur dioxide emissions also uses the average sulfur content of the coal and assumes 100-percent liberation of sulfur and 100-percent conversion to sulfur dioxide. Most of the processes at SRS are unique sources requiring nonstandard, complex calculations that use process chemical or material throughputs, hours of operation, chemical properties, etc., to determine actual emissions. In addition to the annual emissions inventory, compliance with various standards is determined in several ways, as follows:

At the SRS powerhouses, stack compliance tests are performed every 2 years for each boiler by airborne emission specialists under contract to SRS. The tests include

- sampling of the boiler exhaust gases to determine particulate emission rates and carbon dioxide and oxygen concentrations
- laboratory analysis of coal for sulfur content, ash content, moisture content, and British Thermal Unit (BTU) output

Sulfur content and BTU output are used to calculate sulfur dioxide emissions. SCDHEC also conducts visible-emissions observations during the tests to verify compliance with opacity standards. The day-to-day control of particulate matter smaller than 10 microns is demonstrated by opacity meters in all SRS powerhouse stacks.

The A-Area powerhouse also has a baghouse dust collection system for the ash handling process. The permit for this system requires monitoring the pressure drop across the baghouse.

For the package steam generating boilers in K-Area and for two portable units, compliance with sulfur dioxide standards is determined by analysis of the fuel oil purchased from the offsite vendor. The percent of sulfur in the fuel oil must be below 0.5 and is reported to SCDHEC each quarter. Compliance with particulate emission standards initially was demonstrated by mass-balance calculations rather than stack emission tests.

Compliance by SRS diesel engines and other process stacks is determined during annual compliance inspections by the local SCDHEC district air manager. The inspections include a review of operating parameters; the operating hours recorded in logbooks; an examination of continuous-emission monitors, where required for process or boiler stacks; and a visible-emissions observation for opacity. In 2000, SCDHEC revised permits for diesel-powered equipment to require the use of annual fuel oil consumption as the basis for determining permit compliance. Fuel oil consumption records are compiled monthly for each permitted diesel unit, and total unit consumption is compared to a total allowable consumption limit. This method of compliance determination was implemented in January 2001.

With the exception of the Consolidated Incineration Facility (CIF), which must be tested once every 3 years for both toxic and criteria air pollutants, there are no specific monitoring requirements for SRS sources of toxic air pollutants. Because some toxic air pollutants also are regulated as VOCs, some SRS sources are required to calculate and report VOC emissions on a quarterly basis.

Table 6–1
SRS Power Plant Boiler Capacities

Location	Number of Boilers	Capacity (BTU/hr)
A-Area	2	71.7E+06
H-Area	3	71.1E+06

Compliance by all toxic air pollutant and criteria pollutant sources also is determined by using EPA-approved air dispersion models. Air dispersion modeling is extremely conservative unless refined models are used. The Industrial Source Complex Version No. 3 model was used to predict maximum ground-level concentrations occurring at or beyond the site boundary for new sources permitted in 2001.

Monitoring Results

As noted earlier, the calculation of emissions each year as part of an annual emissions inventory is the primary means of monitoring SRS air sources. In 2001, operating data were compiled and emissions calculated for 2000 operations for all site air emission sources. Because this process, which begins in January, requires up to 6 months to complete, this report will provide a comprehensive examination of total 2000 emissions, with only limited discussion of available 2001 monitoring results. A review of the calculated emissions for calendar year 2000 determined that SRS sources had operated in compliance with permitted emission rates. Actual 2001 emissions will be compiled and reported in depth in the *SRS Environmental Report for 2002*.

Two power plants with five coal-fired boilers are operated by Westinghouse Savannah River Company (WSRC) at SRS. These boilers are used to generate steam, which is used for facility heating systems and, where required, as process steam. The location, number of boilers, and capacity of each boiler for these plants are listed in table 6–1. The A-Area and H-Area boilers are overfeed stoker fed and use coal as their only fuel. As indicated earlier, the coal-fired boilers are required to be stack tested every 2 years. In order to stagger the test dates for the A-Area boilers, A-Area boiler No. 1 was stack tested in February 2001, approximately 13 months before the test actually was required. Test results, shown in table 6–2, indicated the boiler was being operated in compliance with permitted emission rates. All three H-Area boilers, which are in standby status, will be tested upon being restarted.

The A-Area boiler ash handling system includes a filter baghouse for control of particulate emissions

Table 6–2
Boiler Stack Test Results (A-Area)

Boiler	Pollutant	Emission Rates	
		lb/10^6 BTU	lb/hr
A #1	Particulates[a]	0.43	31.94
	Sulfur dioxide[a]	NC[b]	NC[b]

a The compliance level is 0.6 lb/million BTU for particulates and 3.5 lb/million BTU for sulfur dioxide.

b Not calculated

when removing ash from the boilers. The permit for this system requires maintenance, calibration, and monitoring of the differential pressure across the baghouse to ensure proper operation of the baghouse filters. During the annual compliance inspection in March 2001, SCDHEC determined that the gauge and instrumentation had not been maintained and calibrated as required. This resulted in SRS being issued a notice of violation, but the site still achieved a permit compliance rate of 99 percent for 2001.

SRS also has four package steam generating boilers fired by No. 2 fuel oil. The steam from these boilers is used primarily to heat buildings during cold weather, but also for process steam. The location, number of boilers, and capacity of each boiler are shown in table 6–3. During 2001, only the 76.8- and 38.0-million BTU/hr boilers were operated. The percent of sulfur in the fuel oil burned during the year was certified by the vendor to meet the requirements of the permit. The two 17.0-million BTU/hr boilers had not been operated in several years and therefore were excessed in 2001.

At SRS, 102 permitted and exempted sources, both portable and stationary, are powered by internal combustion diesel engines. These sources include portable air compressors, diesel generators, emergency cooling water pumps, and fire water pumps ranging in size from 150 to 2,050 kilowatts for generators and 200 to 520 horsepower for air compressor and pump engines. During the 2001 compliance inspections, the hours of operation, fuel oil consumption, and opacity for all inspected diesel engines were found to be in compliance. Fuel oil consumption for all diesel engines operated in 2000 was 573,363 gallons. Total fuel consumption for 2001 will be included in the report for calendar year 2002.

Table 6–3
SRS Package Steam Boiler Capacities

Location	Number of Boilers	Capacity (BTU/hr)
K-Area	1	76.8E+06
K-Area	1	38.0E+06
Portable	2	17.0E+06

Table 6–4
2000 Criteria Pollutant Air Emissions

Pollutant Name	Actual Emissions[a] (Tons/Year)
Sulfur dioxide	4.83E+02
Total suspended particulates	3.72E+02
PM_{10} (particulate matter 10 microns)	1.49E+02
Carbon monoxide	2.66E+03
Ozone (volatile organic compounds)	1.44E+02
Gaseous fluorides (as hydrogen fluoride)	1.23E–01
Nitrogen dioxide	3.51E+02
Lead	1.30E–01

a From all SRS sources (permitted and nonpermitted)

Another significant source of criteria pollutant emissions at SRS is the burning of forestry areas across the site. The U.S. Department of Agriculture Forest Service–Savannah River (USFS–SR, formerly the Savannah River Natural Resource Management and Research Institute) periodically conducts controlled burning of vegetation and undergrowth as a means of preventing uncontrolled forest fires. During 2000, USFS–SR personnel burned 10,039 acres across the site.

Other sources of criteria pollutants at SRS are too numerous to discuss here by type. Table 6–4 provides the 2000 atmospheric emissions results for all SRS sources, as determined by the air emissions inventory conducted in 2001. All calculated emissions were within applicable SCDHEC standards and permit limitations during 2000.

Thirty-one of the SRS permitted sources are permitted for toxic air pollutants; 17 of these were operated during 2001. Several of the toxic air pollutant sources—specifically, the soil vapor extraction and air stripper units—have permit conditions requiring the calculation of the running total annual VOC emissions, which are to be calculated quarterly. During 2001, the calculated annual VOC emissions were determined to be well below the permit limit for each unit. As discussed in the description of the monitoring program, the CIF must be stack tested every 3 years. This facility last was tested in April 1997 and was not due for testing again until April 2000. However, all CIF operations were suspended in 2000, and the facility was placed on cold standby. Stack testing thus was postponed until the resumption of operations.

Total toxic air pollutant emissions at SRS are determined annually in tons per year for each pollutant. It should be noted that some toxic air pollutants (e.g., benzene) regulated by SCDHEC also are, by nature, VOCs. As such, the total for VOCs in table 6–4 includes toxic air pollutant emissions. It also should be noted that table 6–4 includes the emissions for some hazardous air pollutants that are regulated under the Clean Air Act but not by SCDHEC Standard No. 8. These pollutants are included because they are compounds of some Standard No. 8 pollutants.

Ambient Air Quality

Under existing regulations, SRS is not required to conduct onsite monitoring for ambient air quality; however, the site is required to show compliance with various air quality standards. To accomplish this, air dispersion modeling was conducted during 2001 for new emission sources or modified sources as part of the sources' construction permitting process. The modeling analysis showed that SRS air emission sources were in compliance with applicable regulations.

South Carolina and Georgia continue to monitor ambient air quality near SRS as part of the network associated with the Clean Air Act. Resulting data are available to the public through (1) the South Carolina Bureau of Air Quality and (2) the Georgia Department of Natural Resources, Environmental Protection Division, Air Protection Branch.

Liquid Discharges

Description of Monitoring Program

SRS monitors nonradioactive releases to surface waters through the National Pollutant Discharge Elimination System (NPDES), as mandated by the Clean Water Act. As required by EPA and SCDHEC, SRS has NPDES permits for discharges to the waters of the United States and South Carolina. These permits require that SRS test water discharged from the site for certain pollutants. Also mandated are specific sites to be monitored, parameters to be tested, and monitoring frequency—as well as analytical, reporting, and collection methods. Detailed requirements for each permitted discharge point—including parameters sampled for, permit limits for each parameter, sampling frequency, and method for collecting each sample—can be found in the individual permits, which are available to the public through SCDHEC's Freedom of Information office at (803) 734–5376.

In 2001, SRS discharged water into site streams and the Savannah River under three NPDES permits: one for industrial wastewater (SC0000175) and two for stormwater runoff—SCR00000 (industrial discharge) and SCR10000 (construction discharge). A fourth permit, ND0072125, is a "no discharge" water pollution control land application permit that regulates sludge application and related sampling at onsite sanitary wastewater treatment facilities.

Permit SC0000175 regulated 31 industrial wastewater outfalls in 2001 (figure 6–1). Permit SCR000000 requires a representative sampling of site stormwater discharges; the 2001 stormwater sampling program included 13 outfalls. Permit SCR100000 does not require sampling unless requested by SCDHEC to address specific discharge issues at a given construction site; SCDHEC did not request such sampling in 2001.

NPDES samples are preserved in the field according to 40 CFR 136, the federal document that lists specific sample collection, preservation, and analytical methods acceptable for the type of pollutant to be analyzed. Chain-of-custody procedures are followed after collection and during transport to the analytical laboratory. The samples then are accepted by the laboratory and analyzed according to procedures listed in 40 CFR 136 for the parameters required by the permit.

The effectiveness of the NPDES monitoring program is documented by a surveillance program involving chemical and biological evaluation of the waters to which effluents have been discharged. More monitoring information can be found in chapters 7, "Nonradiological Environmental Surveillance," and 10, "Special Surveys and Projects."

Monitoring Results

SRS reports analytical results to SCDHEC through a monthly discharge monitoring report, which includes an explanation concerning any analytical measurements outside permit limits and a summary of all analyses performed at each permitted outfall.

Twenty-eight of the 31 outfalls permitted by SC0000175 in 2001 discharged. Results from 24 of the 5,386 sample analyses performed during the year exceeded permit limits.

A list of 2001 NPDES exceedances appears in table 6–5. Figure 6–2 shows the NPDES exceedances at SRS from 1992 through 2001, along with the site's compliance rate for each year. SRS achieved a

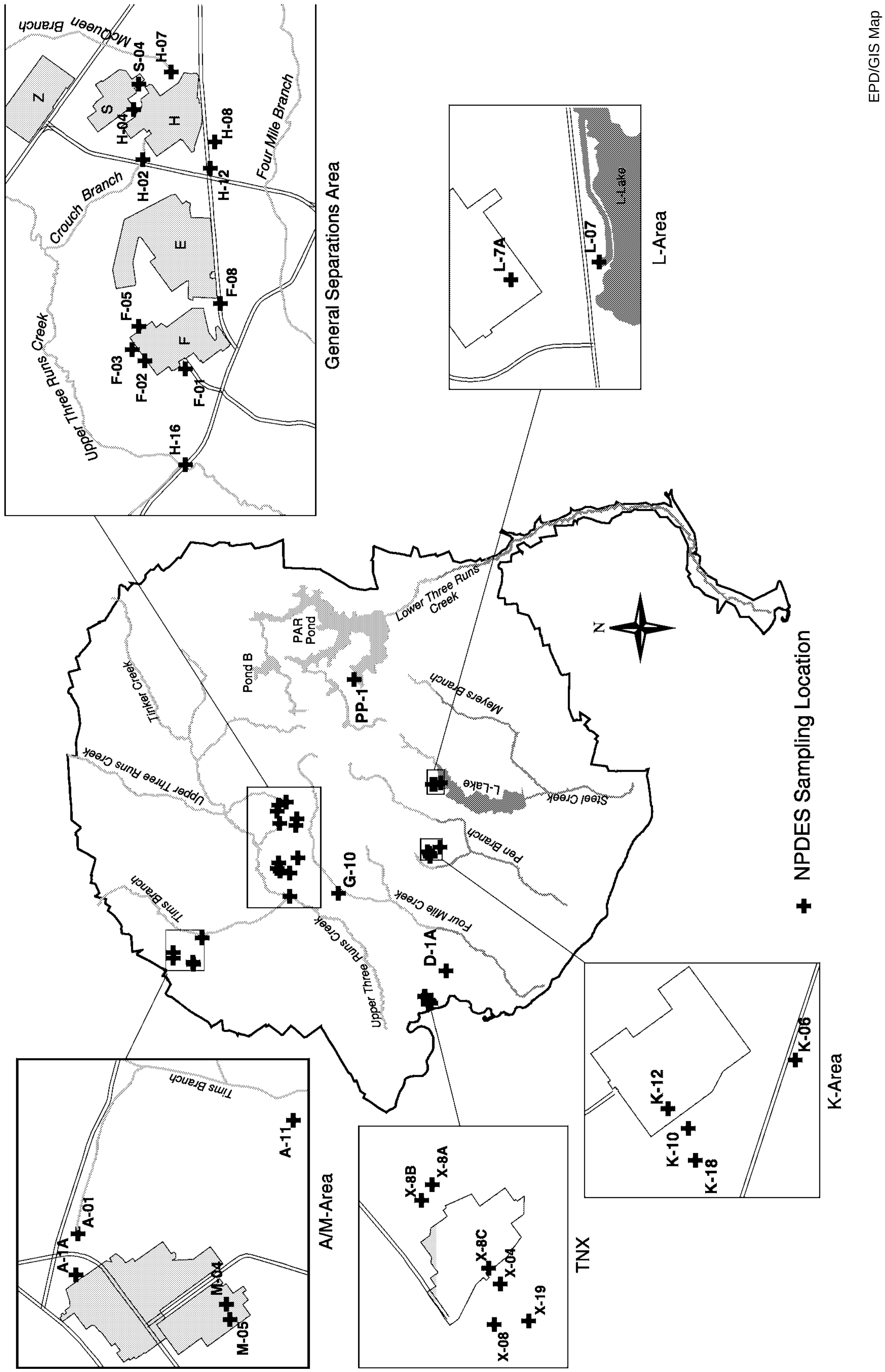


Figure 6–1 NPDES Sampling Locations
Thirty-one industrial wastewater outfalls were regulated at SRS under NPDES Permit SC0000175 during 2001.

99.6-percent compliance rate—higher than the DOE-mandated 98-percent rate.

The 2001 exceedance total of 24 represents an increase from the 18 exceedances of 2000. Chronic-toxicity failures accounted for 17 of the 24 exceedances. The remaining seven were attributable to process upsets, analytical errors, or unknown reasons. Toxicity identification evaluation analyses have been unable to determine the source of the toxicity. It likely is an artifact associated with the low-hardness condition of SRS waters and the condition's effects on the non-native test organism *(Ceriodaphnia dubia*) mandated for use by the NPDES protocol (rather than due to a specific toxicant). The site is exploring this possibility through a series of chronic toxicity tests (i.e., tests of survivorship and reproduction during long-term exposure to SRS waters, as well as to toxicants) using a native test species (*Daphnia ambigua*). Preliminary data suggested that *Daphnia ambigua* may be a more appropriate test organism because of its lack of sensitivity to the low-hardness conditions of SRS waters.

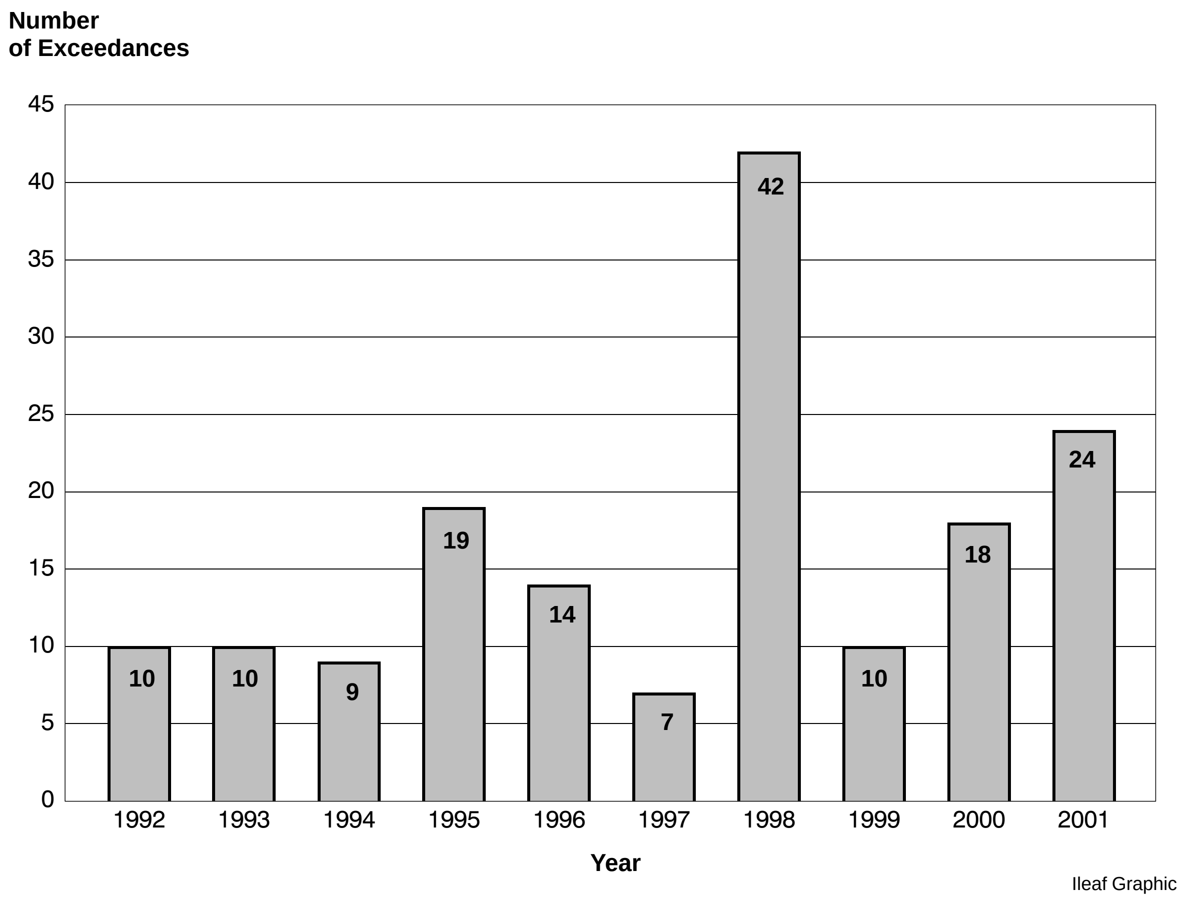
SRS received approval from EPA and SCDHEC in late 2001 to use *Daphnia ambigua* as the species for chronic-toxicity testing. For technical and legal reasons, however, the site appealed this approval, and negotiations began between SRS and SCDHEC to resolve the issues in question. Meanwhile, the site continues to conduct chronic-toxicity testing using *Ceriodaphnia dubia* and *Daphnia ambigua.* Results have shown that the effluent often fails using *Ceriodaphnia dubia* but consistently passes with *Daphnia ambigua.*

During 1996 NPDES permit application testing, it was noted that the A–01 outfall effluent had high concentrations of copper and zinc as well as chronic-toxicity failures. During permit negotiations, SRS agreed to eliminate these problems by October 1, 1999. Due to a misunderstanding between the site and SCDHEC, this deadline was not met, and a consent order subsequently was issued extending the compliance deadline to October 1, 2001. SRS personnel studied the compliance problem and constructed a wetland treatment system (completed in 2001) to remove metals and thus comply with the permit limits. Since startup of this system, the metal concentrations have consistently decreased and have been within permit limits. The chronic-toxicity problems continued with *Ceriodaphnia dubia* through 2001, however.

The early toxicity difficulties were considered hard failures attributable to mortality among the test organisms. The failures during 2001 are believed to be due to slight differences between the reproductive numbers of the control organisms and the test organisms; similar problems were encountered at the A–11 and G–10 outfalls. These more recent failures are believed to have been caused by the softness of the effluent.

A total of 425 analyses were performed during 2001 on stormwater discharge samples. SCDHEC has not mandated permit limits for stormwater outfalls.

During the second quarter of 2001, dewatered sludge was sampled and analyzed for pollutants of concern, and approximately 39 cubic yards of sludge was applied to the land. No sludge was applied during the first, third, and fourth quarters. The analytical results indicated that pollutant concentrations were within regulatory limits.



Year	*Number of Analyses*	*Compliance Rate*
1992	7,729	99.9%
1993	8,000	99.9%
1994	7,568	99.9%
1995	7,515	99.8%
1996	5,737	99.8%
1997	5,758	99.9%
1998	5,790	99.3%
1999	5,778	99.8%
2000	5,496	99.7%
2001	5,386	99.6%

Figure 6–2 History of NPDES Exceedances at SRS, and Site's Compliance Rate, 1992–2001
The chart and table provide historical information about NPDES exceedances from SRS liquid discharges to South Carolina waters, including the number of exceedances—and the site's compliance rate—for each year from 1992 to 2001.To determine the compliance rate, the number of analyses not exceeding limits for a given year is divided by the total number of analyses. For example, 5,386 analyses were performed in 2001, with 24 exceedances. To calculate the compliance rate for that year, divide 5,362 (5,386 minus 24) by 5,386 for a quotient of .9955—or 99.6 percent.

Table 6–5
2001 Exceedances of SCDHEC-Issued NPDES Permit Liquid Discharge Limits at SRS

Page 1 of 2

Department/ Division	Outfall	Date	Parameter Exceeded	Result	Possible Cause	Corrective Action
SUD	K–06	Jan. 24	pH	8.7 SU	High-pH boiler discharge	Coordinate discharge with cooling water
SUD	K–06	Jan. 25	pH	8.8 SU	High-pH boiler discharge	Coordinate discharge with cooling water
FSS/LSD/LOS	A–01	Oct. 8	C–TOX	Fail	Unknown[a]	Under investigation
FSS/LSD/LOS	A–01	Nov. 5	C–TOX	Fail	Unknown[a]	Under investigation
ER	A–11	Jan. 8	C–TOX	Fail	Unknown[a]	Under Investigation
ER	A–11	Feb. 12	C–TOX	Fail	Unknown[a]	Under Investigation
ER	A–11	March 5	C–TOX	Fail	Unknown[a]	Under Investigation
ER	A–11	April 16	C–TOX	Fail	Unknown[a]	Under Investigation
ER	A–11	May 7	C–TOX	Fail	Unknown[a]	Under Investigation
ER	A–11	June 6	C–TOX	Fail	Unknown[a]	Under Investigation
ER	A–11	July 26	C–TOX	Fail	Unknown[a]	Under Investigation
ER	A–11	Aug. 7	C–TOX	Fail	Unknown[a]	Under Investigation
ER	A–11	Sept. 14	C–TOX	Fail	Unknown[a]	Under Investigation
ER	A–11	Oct. 8	C–TOX	Fail	Unknown[a]	Under Investigation
ER	A–11	Nov. 5	C–TOX	Fail	Unknown[a]	Under Investigation
ER	A–11	Dec. 4	C–TOX	Fail	Unknown[a]	Under Investigation
TSD	X–08	Jan. 25	TSS	43 mg/L	X–8B system work led to detritus discharge	Conduct work in no-discharge mode
SUD	G–10	April 30	C–TOX	Fail	Unknown[a]	Under investigation
SUD	G–10	May 20	C–TOX	Fail	Unknown[a]	Under investigation
SUD	G–10	Nov. 26	C–TOX	Fail	Unknown[a]	Under investigation
SUD	G–10	Aug. 11, Aug. 12	Frequency of flow analysis	29 of 31 reported; 31 of 31 required	Lightning disabled flow meters; no flow available	Equipment repaired
SWD	H–16	Sept. 4	Frequency of BOD analysis	3 of 30 reported; 4 of 30 required	Subcontract lab missed hold time	Lab revised procedures/responsibilities

a This outfall failed the C–TOX test, but an investigation into the cause of the failure could not determine a toxicant in the effluent. An alternate species has been proposed, and the outfall has consistently passed the test using the new species.

Table 6–5
2001 Exceedances of SCDHEC-Issued NPDES Permit Liquid Discharge Limits at SRS

Page 2 of 2

Department/ Division	Outfall	Date	Parameter Exceeded	Result	Possible Cause	Corrective Action
NMS&S	F–02	Oct. 22	Permit Part I.A.34	Visible foam	"Simple Green" cleaning agent used to clean CLAB coils; washwater drained to outfall	Cleaning operations stopped; controls evaluated for future operations; sitewide implications addressed

Key: *BOD – Biochemical oxygen demand*
C-TOX – Chronic toxicity
SU – Standard unit
TSS – Total suspended solids

Chapter 7

Nonradiological Environmental Surveillance

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To Read About . . . See Page . . .

NONRADIOACTIVE environmental surveillance at the Savannah River Site (SRS) involves the sampling and analysis of surface water (six onsite streams and the Savannah River), drinking water, sediment, groundwater, and fish. Surface water, drinking water, sediment, and fish surveillance programs are discussed in this chapter. A description of the groundwater program can be found in chapter 8, "Groundwater."

The Environmental Protection Department's Environmental Monitoring Section (EMS) and the Savannah River Technology Center (SRTC) perform nonradiological surveillance activities. 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). In addition, the Academy of Natural Sciences of Philadelphia (ANSP) conducts environmental surveys on the Savannah River through a program that began in 1951. A brief discussion of these surveys appears on page 106.

A complete description of the EMS sample collection and analytical procedures used for nonradiological surveillance 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). A summary of analytical results is presented in this chapter; however, more complete data can be found in *SRS Environmental Data for 2001* (WSRC–TR–2001–00475).

In 2001, approximately 6,300 nonradiological analyses for specific chemicals and metals were performed on about 1,200 samples, not including groundwater.

SRS currently does not conduct onsite surveillance for nonradiological ambient air quality. However, to ensure compliance with SCDHEC air quality regulations and standards, SRTC conducted air dispersion modeling for all site sources of criteria pollutants and toxic air pollutants in 1993. This modeling indicated that all SRS sources were in compliance with air quality regulations and standards. Since that time, additional modeling conducted for new sources of criteria pollutants and toxic air pollutants has demonstrated continued compliance by the site with these regulations and standards. The states of South Carolina and Georgia continue to monitor ambient air quality near the site as part of a network associated with the federal Clean Air Act. (See chapter 6 for more information about criteria pollutants and toxic air pollutants.)

Surface Water

SRS streams and the Savannah River are classified as "Freshwaters" by SCDHEC. Freshwaters are defined as surface water suitable for

- primary—and secondary—contact recreation and as a drinking water source after conventional treatment in accordance with SCDHEC requirements
- fishing and survival and propagation of a balanced indigenous aquatic community of fauna and flora
- industrial and agricultural uses

Appendix A, "Applicable Guidelines, Standards, and Regulations," provides some of the specific guides used in water quality surveillance, but because some of these guides are not quantifiable, they are not tracked.

Description of Surveillance Program

SRS stream and Savannah River nonradiological surveillance is conducted for any evident degradation that could be attributed to the water discharges regulated by the site National Pollutant Discharge Elimination System (NPDES) permits and materials that may be released inadvertently from sources other than routine release points.

In addition, nonradiological surveillance is conducted to compare the SRS contribution of pollutants with background levels of chemicals from natural sources and from contaminants produced by municipal sewage plants, medical facilities, and other upriver industrial facilities.

Each SRS stream receives varying amounts of treated wastewater and rainwater runoff from site facilities. Stream locations are sampled for water quality at monthly and quarterly frequencies by the conventional grab-collection technique. Each grab sample shows the water quality at the time of sampling only.

River sampling sites are located upriver of, adjacent to, and downriver of the site. In the surveillance program, site streams and the Savannah River are sampled monthly for various physical and chemical properties. Surface water sampling locations are shown in figure 7–1.

To monitor the quality of water coming onto and leaving the site, field measurements for conductivity, dissolved oxygen, pH, and temperature are taken monthly and laboratory analyses are conducted for other water quality parameters, such as metals, pesticides/herbicides (quarterly), and other physical and chemical properties. Comparison of the results from upstream and downstream locations (locations that are below process areas or at points where the water leaves the site) indicates any impact the site may have had on the water.

The natural chemical and physical parameters measured monthly on each stream and in the river vary to some extent throughout the year. This natural variation can be trended on a month-to-month basis. When results diverge greatly from the historical norm, an abnormal discharge event or occurrence in the environment may be indicated. An investigation is held to determine if a release has occurred.

Surveillance Results

Comparison of the upstream and downstream locations where available (Upper Three Runs) and month-to-month trends for each of these stations indicated normal trends for a southern pine forest stream. The upstream pH varied within a range of 5.0 to 6.7 at Upper Three Runs–1A and between 5.7 and 6.9 at Tinker Creek–1. Conductivity ranged from a low of 12 µmhos/cm at the Upper Three Runs–1A location to a high of 39 µmhos/cm at Tinker Creek–1. The downstream station at Upper Three Runs–4 had a pH range of 6.0 to 6.7 and a conductivity range of 21 to 27 µmhos/cm.

Nitrate levels for most river and stream locations usually ranged below 0.50 mg/L. Steel Creek–4 had the highest nitrate concentration of all the streams at 1.3 mg/L—a one-time occurrence the cause of which is not known. Concentrations ranged downward to below the practical quantitation limit (PQL).

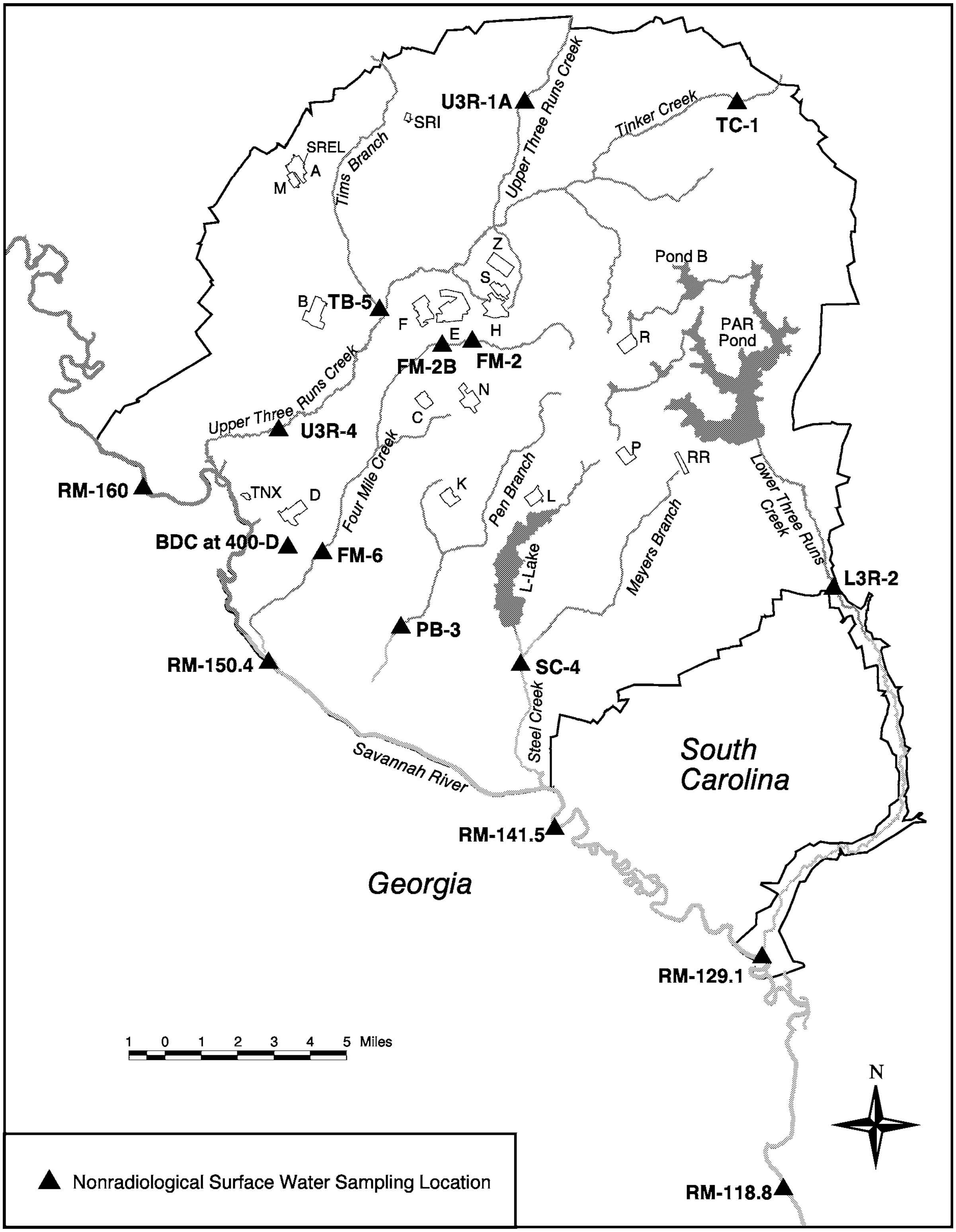
Average phosphate levels were typically higher in the Savannah River than in onsite streams. River levels ranged from an average of 0.105 mg/L at River Mile 118.8 to 0.151 mg/L at River Mile 150.4. The highest average on site was 0.129 mg/L on Beaver Dam Creek at 400–D. Lower Three Runs–2 was second, with approximately the same average.

With the exception of the 400–D location, total suspended solids averaged lower on site than in the river. The 400–D location had high total suspended solids during March (reason unknown), which raised the location's average to 8.9 mg/L. Excluding 400–D, onsite total suspended solids averages ranged from a low of 2.5 mg/L at Steel Creek–4 to a high of 6.5 mg/L at Four Mile Creek–2B. In the river, the low average was at River Mile 160 (7.5 mg/L), and the high average was at River Mile 129.1 (12.2 mg/L).

Hardness in the Savannah River ranged from a low below the PQL at River Mile 118.8 and River Mile 150.4 to a high of 37 mg/L—also at River Mile 118.8. On site, the low was below the PQL at two locations for the entire year (Upper Three Runs–4 and Upper Three Runs–1A), and the high was 41 mg/L at Lower Three Runs–2.

Aluminum, cadmium, chromium, copper, iron, manganese, nickel, and zinc were seen in surface waters at all river and stream locations. Mercury was seen above the quantitation limit in the Savannah River and in onsite streams. Levels ranged from a high of 0.05 mg/L at Four Mile–2 to below the PQL at several locations. Copper was found at various locations, both in the river and in site streams. All positive results were near the quantitation limit.

One pesticide, Beta BHC, was found in 2001 near the quantitation limit at Four Mile Creek–6, River Mile 150.4, River Mile 141.5, River Mile 129.1, and River Mile 118.8. No herbicides were detected during 2001.



EPD/GIS Map

Figure 7–1 Nonradiological Surface Water Sampling Locations
Surface water samples are collected from five Savannah River and eleven SRS stream locations and are analyzed for various chemical and physical properties.

Analyses of the data continue to indicate that SRS discharges are not significantly affecting the water quality of the streams or the river.

Drinking Water

Most of the drinking water at SRS is supplied by three systems that have treatment plants in A-Area, D-Area, and K-Area. The site also has 15 small drinking water facilities at remote security barricades, field laboratories, and field offices that serve populations of fewer than 25 persons (figure 7–2).

Well water from the McBean, Congaree, Black Creek, and Middendorf aquifers is utilized for the 18 drinking water systems. Many of these well water supplies require treatment to ensure that SCDHEC and U.S. Environmental Protection Agency (EPA) drinking water quality standards are maintained. Treatment processes include aeration to remove dissolved gases; filtration to remove iron; and addition of potable water treatment chemicals to adjust pH, prevent piping corrosion, and prevent bacterial growth.

Description of Surveillance Program

SRS drinking water supplies are tested routinely by site personnel and by SCDHEC to ensure compliance with SCDHEC and EPA drinking water standards (which can be found at http://www.epa.gov/safewater/mcl.html on the Internet) and monitoring requirements. This testing includes

- daily testing to monitor concentration of any potable water treatment chemicals added
- monthly or quarterly testing to confirm that bacteria are not present
- periodic testing for metals, organic and inorganic chemicals, and radionuclides

Surveillance Results

All samples collected from SRS drinking water systems during 2001 were in compliance with SCDHEC and EPA water quality limits (maximum contaminant levels).

Sediment

EMS's nonradiological sediment surveillance program provides a method of determining the deposition, movement, and accumulation of nonradiological contaminants in stream systems.

Description of Surveillance Program

The nonradiological sediment program consists of the collection of sediment samples at eight onsite stream locations and three Savannah River locations (figure 7–3). Collection is made by either a Ponar sediment sampler or an Emery pipe dredge sampler. The samples are analyzed for various inorganic contaminants (metals) and pesticides/herbicides by the Toxicity Characteristic Leaching Procedure (TCLP). This method analyzes for the soluble constituents in sediment. The program is designed to check for the existence and possible buildup of the inorganic contaminants as well as for pesticides/herbicides.

Surveillance Results

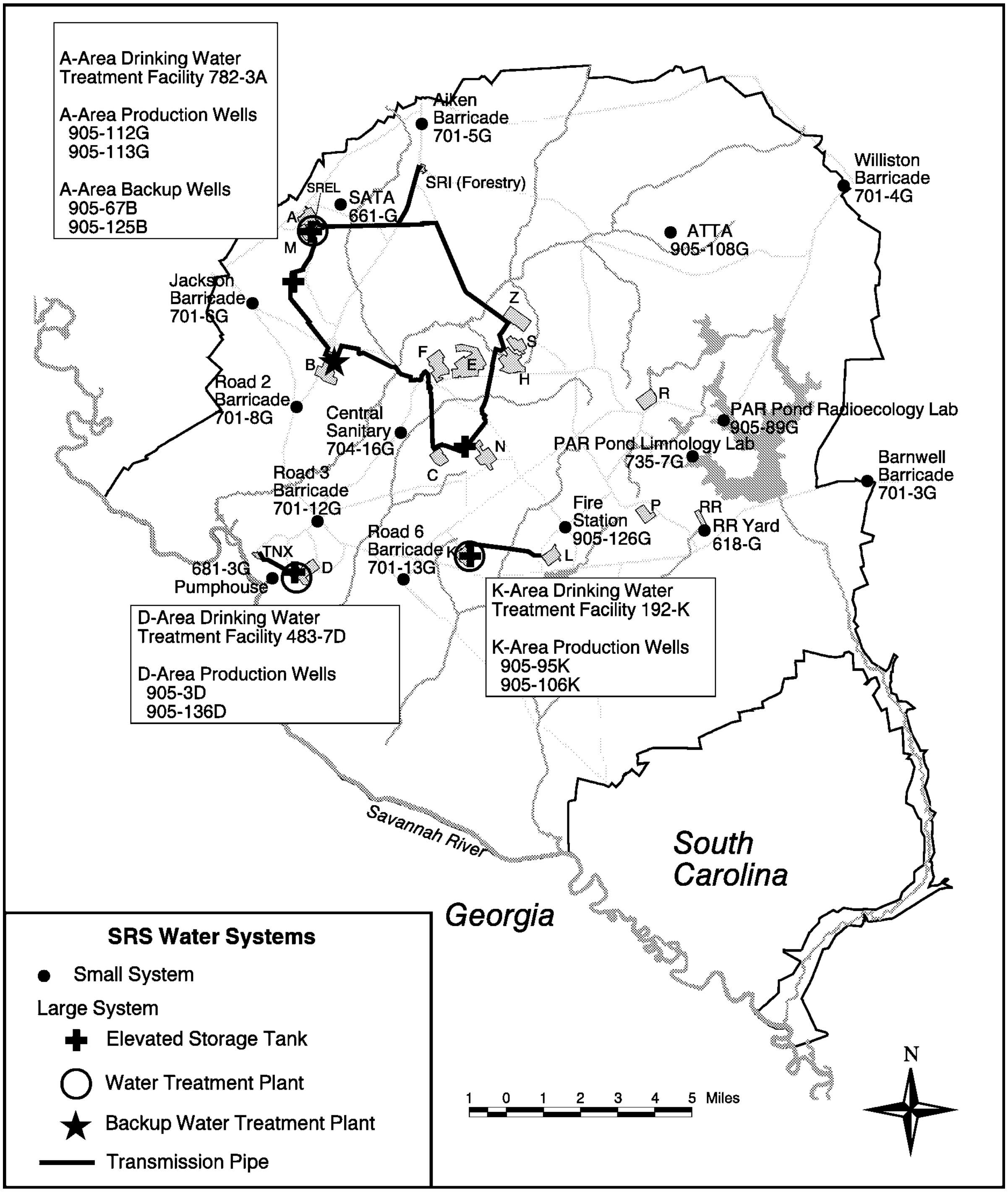
In 2001, as in the previous 5 years, no pesticides or herbicides were found to be above the quantitation limits in sediment samples. All pesticide/herbicide results were below the the PQL of the EPA analytical procedures used.

Barium, chromium, copper, lead, manganese, selenium, and zinc were seen in sediment at one or more river and/or stream locations. Levels for these metals were consistent with those seen in soil samples. From year to year, most metals vary from nondetectable levels to very low levels.

In 2001, copper was detected at Lower Three Runs–2 (0.065 mg/L) and Upper Three Runs–1A (0.056 mg/L). In recent years, it has ranged as high as 0.103 mg/L at Tinker Creek–1 (control location) to below the PQL at several locations, including Tinker Creek–1.

No mercury was detected in at any of the location sites in 2001, as was the case in 2000. In 1999, Upper Three Runs–4 showed 0.0001 mg/L of mercury, which is at the PQL. The 1998 level at Tinker Creek–1 was slightly above the PQL. No mercury was detected at any site in 1996 and 1997. In 2001, EMS completed an evaluation of mercury analysis at SRS using the new EPA 1631 method, which has a much lower PQL (0.006 ng/L) than the method used previously in the monitoring program. It was determined, however, that there would be no need to change the method used previously and adopt the new method.

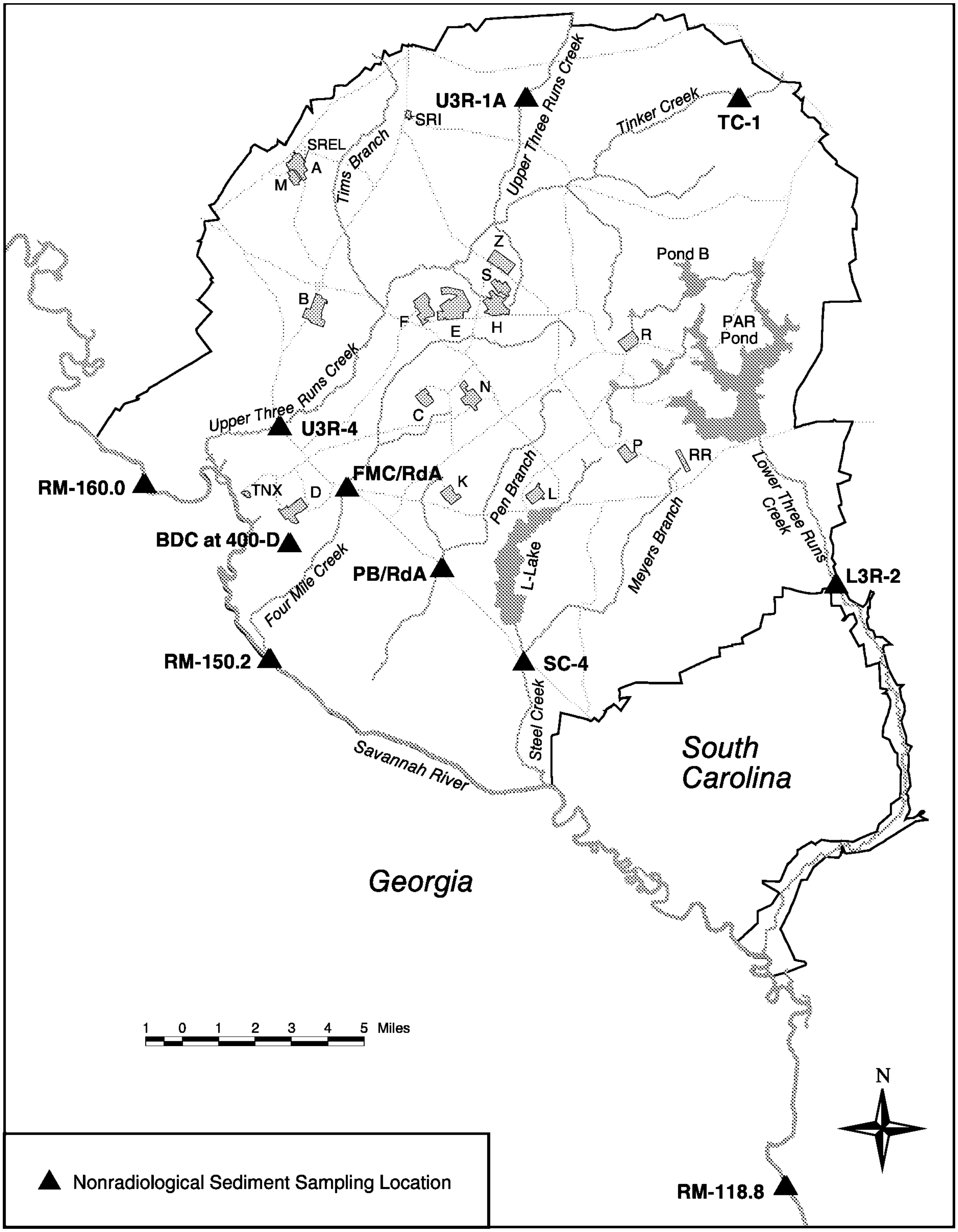
Cyanide was not detected at any location in 2001. No significant trends were observed for metals in the Savannah River or on site in 2001.



EPD/GIS Map

Figure 7–2 Drinking Water Systems

Most of the drinking water at SRS is supplied by three systems. The site also has 15 small drinking water facilities that serve populations of fewer than 25 persons. The three larger systems are depicted by transmission pipes, elevated storage tanks, water treatment plants, and a backup water treatment plant.



EPD/GIS Map

Figure 7–3 Nonradiological Sediment Sampling Locations

Sediment samples are collected at eight onsite stream locations and three Savannah River locations. The samples are analyzed for various inorganic contaminants (metals) and pesticides/herbicides.

Perspective on Mercury

Mercury in the environment can come from natural sources, such as volcanoes and venting of the earth's crust. Mercury also can come from manmade sources and processes, such as fungicides and fossil fuel combustion byproducts and the manufacture of chlorine, sodium hydroxide, plastics, textiles, and electrical apparatus. Testing by EPA during 2000 determined that 99 percent of the mercury in the Savannah River comes from atmospheric deposition [EPA, 2001b].

An important source of mercury in the SRS region may be in releases upriver of the site. Much of the mercury detected in SRS fish has been attributed to offsite sources, such as Savannah River water [Davis et al., 1989]. Savannah River water is pumped onto the site to support fire protection efforts and the sanitary waste treatment plant and to maintain L-Lake's water level. The water subsequently is released into site streams and lakes.

Naturally occurring mercury cycles between land, water, and air. As mercury enters streams and rivers through rainfall, runoff, and discharges, it is converted to the chemical compound methylmercury by bacterial and other processes. As part of the natural cycling, some methylmercury is absorbed by plants and animals into their tissues. Fish absorb methylmercury from food they ingest and from water as it passes over their gills; the methylmercury then is bound in their tissues. Consumption by people of fish containing methylmercury then completes the mercury pathway to humans. The amount of fish that can be eaten safely varies with (1) the concentration of methylmercury, (2) the amount consumed, and (3) the frequency of consumption. These factors are the basis of calculations performed during "risk analysis," a method to determine how much fish can be consumed safely.

State and federal regulatory agencies calculate the health risk associated with the consumption of fish, then recommend consumption guidelines based on that risk. Adherence to these guidelines can effectively control one's exposure to methylmercury. A list of fish advisories and/or recommended consumption limits can be obtained from state environmental agencies. EPA criteria taken from "Guidance For Assessing Chemical Contaminant Data For Use In Fish Advisories, Volume II Risk Assessment And Fish Consumption Limits" (EPA 823–B–94–004, June 1994), gives the monthly consumption limits for chronic systemic health endpoint for the general population.

Fish

Description of Surveillance Program

EMS analyzes the flesh of fish caught from onsite streams and ponds and from the Savannah River to determine concentrations of mercury in the fish [SRS EM Program, 2001]. The freshwater fish analyzed (bass, bream, and catfish) represent the most common edible species of fish in the Central Savannah River Area (CSRA), an 18-county area in Georgia and South Carolina that surrounds Augusta, Georgia, and includes SRS. Saltwater fish analyzed in 2001 included mullet, redfish, and sea trout. (Sampling locations for fish are depicted in a map on page 60 in chapter 4, "Radiological Environmental Surveillance.")

Surveillance Results

In 2001, 185 fish were caught from SRS streams and ponds and the Savannah River and analyzed for mercury. Because of low water, no fish were caught from the Pen Branch–3, Four Mile Creek–6, Steel Creek–4, Upper Three Runs–4, and Beaver Dam Creek locations.

The mercury concentrations in fish analyzed from onsite waters ranged from a high of 1.020 µg/g in a bass from Pond B to a low of 0.030 in a bream from L-Lake. Mercury concentrations in offsite fish ranged from a high of 1.530 µg/g in a bass from the Augusta Lock and Dam area to a low of 0.006 in mullet downstream of the Highway 17 Bridge area. The average quantitation limit for mercury in fish flesh is 0.008 µg/g.

Overall individual results of all samples indicated that bass contained the highest levels of mercury. After bass, the order of fish with the next highest levels of mercury was mixed, depending on location.

Table 3–57 in the EPA publication mentioned in the sidebar on page 105 indicates that the recommended monthly consumption limit for fish collected at the highest offsite location for 2001 (Augusta Lock and Dam) would be between one and two 8-ounce servings per month.

Academy of Natural Sciences of Philadelphia River Quality Surveys

Description of Surveys

The Patrick Center for Environmental Research of ANSP has conducted biological and water quality surveys of the Savannah River since 1951. The surveys are designed to assess potential effects of SRS contaminants and warm water discharges on the general health of the river and its tributaries. This is accomplished by looking for

- patterns of biological disturbance that are geographically associated with the site
- patterns of change over seasons or years that indicate improving or deteriorating conditions

Results of the 2000 comprehensive survey provide no compelling evidence of any SRS impact on water quality or on biological communities in the Savannah River. Complete results of this survey can be found in *2000 Savannah River Biological Surveys for Westinghouse Savannah River Company* (WSRC–TR–2002–00057).

Samples were collected for the 2001 survey, but could not be analyzed in time for the results to be published in this report.

Chapter 8
Groundwater

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To Read About . . . See Page . . .

DURING the past 40 years, scientists have begun to understand the complexity of the hydrologic system. Water on the land surface and in the atmosphere is easily studied, but water existing in pores and fractures beneath the surface is less accessible. Water infiltrates into soils and rock beneath the ground, then moves along pressure gradients—sometimes for short distances before emerging in streams and lakes; sometimes across hundreds of miles over many years. While water in a surface stream may flow many miles in a day, groundwater may move only a few hundred feet in a year.

As scientists have come to understand the phenomenon of groundwater, they have come to appreciate the risks that come from contamination finding its way into this dynamic system. During the 20th century, waste from industrial and public activities was discovered in groundwater, and scientists found that cleaning water underground was much more difficult than removing contaminants from surface water. As a result, federal and state governments enacted statutes designed to protect the groundwater and to clean up contamination found in groundwater. Understanding, using, protecting, and cleaning up groundwater are significant aspects of the Savannah River Site (SRS) groundwater program.

SRS is located atop sediments of the Atlantic Coastal Plain composed predominantly of sand and clay. Water flows easily through the sand layers but is retarded by less permeable clay beds, creating a complex system of aquifers. Operations during the life of SRS have resulted in contamination migrating into groundwater at various locations on the site (figure 8–1), predominantly in the central areas of the site. The ongoing movement of water into the ground, through the aquifer system, and then into streams and lakes—or even into deeper aquifers—continues to carry contamination along with it, resulting in spreading plumes.

To address this problem, the site has developed, over several decades, a comprehensive network of monitoring wells that have helped SRS scientists understand the physical groundwater system, locate plumes of contamination in groundwater, and monitor the progress of cleanup efforts. In addition to monitoring, the site has a comprehensive groundwater protection and remediation program that will be described later in this chapter. The chapter also will describe SRS's physical groundwater system; its monitoring, protection, and remediation programs; and—in summary form—the monitoring results.

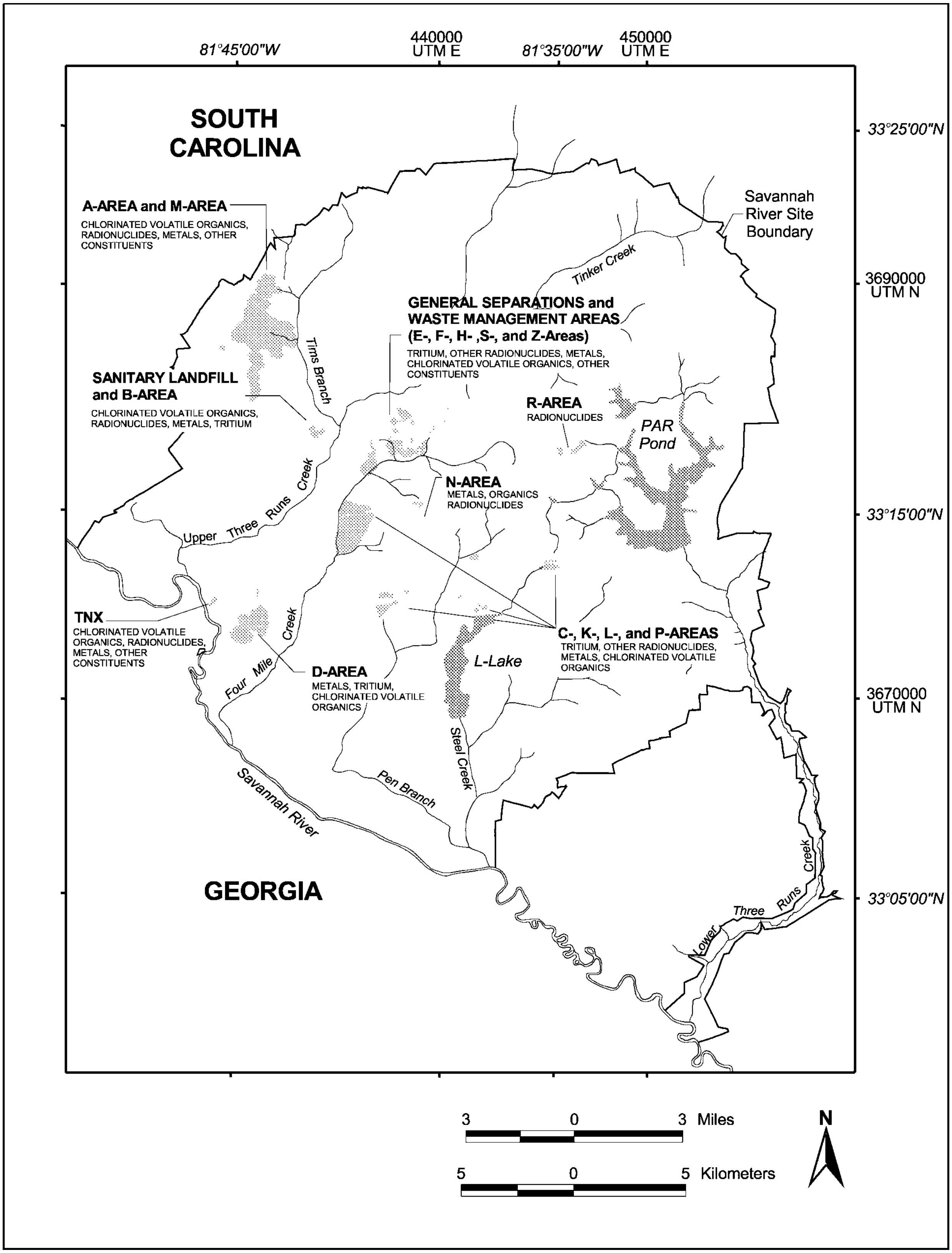
This chapter provides an overview of the groundwater monitoring program at SRS; more detailed groundwater monitoring results can be obtained by contacting the manager of the Westinghouse Savannah River Company (WSRC) Environmental Protection Department (EPD) at 803–725–1728.

The *Environmental Protection Department's Well Inventory* (ESH–EMS–2000–470), which is available to the public, contains detailed maps of the wells at each monitored location.

Groundwater at SRS

SRS is underlain by sediment of the Atlantic Coastal Plain. The Atlantic Coastal Plain consists of a southeast-dipping wedge of unconsolidated sediment that extends from its contact with the Piedmont Province at the Fall Line to the edge of the continental shelf. The sediment ranges from Late Cretaceous to Miocene in age and comprises layers of sand, muddy sand, and clay with subordinate calcareous sediments. It rests on crystalline and sedimentary basement rock.

The hydrostratigraphy of SRS has been subject to several classifications. The hydrostratigraphic classification established in Aadland et al., 1995, and in Smits et al., 1996, is widely used at SRS and is



SRTC/ER Map

Figure 8–1 Facilities Monitored by the SRS Monitoring Well Network; Shaded Areas Indicate Extent of Groundwater Contamination in 2001.

Key for Figure 8–1

A-Area/M-Area
- A-Area/M-Area Recovery Well Network
- A-Area Background Well Near Firing Range
- A-Area Burning/Rubble Pits/A-Area Ash Pile
- A-Area Coal Pile Runoff Containment Basin
- A-Area Metals Burning Pit
- A–014 Outfall
- M-Area Hazardous Waste Management Facility & M-Area Plume Definition
- Metallurgical Laboratory Seepage Basin
- Miscellaneous Chemical Basin
- Motor Shop Oil Basin
- Savannah River Laboratory Seepage Basins
- Silverton Road Waste Site

General Separations/Waste Management (E-Area, F-Area, H-Area, S-Area, & Z-Area)
- Burial Grounds Perimeter
- Burma Road Rubble Pit
- E-Area Vaults near the Burial Grounds
- F-Area Ash Basin
- F-Area Burning/Rubble Pits
- F-Area Canyon Building/A-Line Uranium Recovery Facility
- F-Area Coal Pile Runoff Containment Basin
- F-Area Effluent Treatment Cooling Water Basin
- F-Area Retention Basins
- F-Area Sanitary Sludge L& Application Site
- F-Area Seepage Basins/Inactive Process Sewer Line
- F-Area Seepage Basins Remediation Extraction Wells/ Tank
- F-Area Seepage Basins Remediation Injection Wells/ Tank
- F-Area Tank Farm
- H-Area Auxiliary Pump Pit
- H-Area Canyon Building
- H-Area Coal Pile Runoff Containment Basin
- H-Area Effluent Treatment Cooling Water Basin
- H-Area Retention Basins
- H-Area Seepage Basins/Inactive Process Sewer Line
- H-Area Seepage Basins Remediation Extraction Wells & Tank
- H-Area Seepage Basins Remediation Injection Wells & Tank
- H-Area Tank Farm/Tank Farm Groundwater Operable Unit
- Hazardous Waste/Mixed Waste Disposal Facility
- HP-52 Outfall/Warner’s Pond Area
- Old Burial Ground
- Old F-Area Seepage Basin
- Old H-Area Retention Basin
- S-Area Defense Waste Processing Facility
- S-Area Low-Point Pump Pit
- S-Area Vitrification Building
- Waste Solidification/Disposal Facility
- Wells Between the F-Area Canyon Building & the Naval Fuel Material Facility
- Z-Area Low-Point Drain Tank
- Z-Area Saltstone Facility Background Wells

C-Area
- C-Area Burning/Rubble Pit
- C-Area Coal Pile Runoff Containment Basin
- C-Area Disassembly Basin
- C-Area Reactor Seepage Basins
- Injection Wells of the C-Area Reactor

K-Area
- K-Area Ash Basin
- K-Area Bingham Pump Outage Pit
- K-Area Burning/Rubble Pit
- K-Area Coal Pile Runoff Containment Basin
- K-Area Disassembly Basin
- K-Area Reactor Seepage Basin
- K-Area Retention Basin
- K-Area Tritium Sump

L-Area
- Chemicals, Metals, & Pesticides Pits
- L-Area Acid/Caustic Basin/L-Area Oil & Chemical Basin
- L-Area Bingham Pump Outage Pits
- L-Area Burning/Rubble Pit
- L-Area Disassembly Basin
- L-Area Reactor Seepage Basin
- L-Area Research Wells

P-Area
- P-Area Bingham Pump Outage Pit
- P-Area Burning/Rubble Pit
- P-Area Coal Pile Runoff Containment Basin
- P-Area Disassembly Basin
- P-Area Reactor Seepage Basins

R-Area
- R-Area Acid/Caustic Basin
- R-Area Bingham Pump Outage Pit
- R-Area Burning/Rubble Pits
- R-Area Coal Pile
- R-Area Disassembly Basin
- R-Area Reactor Seepage Basins

Sanitary Landfill & B-Area
- B-Area Microbiology Wells
- Sanitary Landfill/Interim Sanitary Landfill

Central Shops (N-Area)
- Ford Building Seepage Basin
- Hazardous Waste Storage Facility
- Hydrofluoric Acid Spill
- N-Area Diesel Spill
- N-Area Burning/Rubble Pits
- N-Area (Central Shops) Sludge Lagoon
- N-Area Fire Department Training Facility
- N-Area Heavy Equipment Wash Basin and Burning/ Rubble Pit

D-Area & TNX-Area
- D-Area Burning/Rubble Pits
- D-Area Oil Seepage Basin
- D-Area Coal Pile, Coal Pile Runoff Containment Basin, & Ash Basins
- New/Old TNX Seepage Basins
- Road A Chemical Basin (Baxley Road)
- TNX-Area Assessment Wells
- TNX-Area Background Wells
- TNX-Area Points along Seepline
- TNX-Area Operable Unit Wells
- TNX-Area Floodplain Wells
- TNX-Area Recovery Wells
- TNX Burying Ground
- TNX Intrinsic Remediation Piezometers
- TNX Permeable Wall Demonstration Well Installation
- TNX Outfall Delta

Other Sites
- Accelerator for Production of Tritium Area
- SREL Flowing Springs Site

regarded as the current SRS standard. This system is consistent with the one used by the U.S. Geological Survey (USGS) in regional studies that include the area surrounding SRS [Clarke and West, 1997]. Figure 8–2 is a chart that indicates the relative position of hydrostratigraphic units and relates hydrostratigraphic units to corresponding lithologic units at SRS and to the geologic time scale. This chart was modified from Aadland et al., 1995, and Fallaw and Price, 1995.

The hydrostratigraphic units of primary interest beneath SRS are part of the Southeastern Coastal Plain Hydrogeologic Province. Within this sequence of aquifers and confining units are two principal subcategories, the overlying Floridan Aquifer System and the underlying Dublin-Midville Aquifer System. These systems are separated from one another by the Meyers Branch Confining System. In turn, each of the systems is subdivided into two aquifers, which are separated by a confining unit.

In the central to southern portion of SRS, the Floridan Aquifer System is divided into the overlying Upper Three Runs Aquifer and the underlying Gordon Aquifer, which are separated by the Gordon Confining Unit. North of Upper Three Runs Creek, these units are collectively referred to as the Steed Pond Aquifer, in which the Upper Three Runs Aquifer is called the M-Area Aquifer zone, the Gordon Aquifer is referred to as the Lost Lake Aquifer zone, and the aquitard that separates them is referred to as the Green Clay confining zone [Aadland et al., 1995]. The Upper Three Runs Aquifer/Steed Pond Aquifer is the hydrostratigraphic unit within which the water table usually occurs at SRS; hence, it is informally referred to as the “water table” aquifer.

The Dublin-Midville Aquifer System is divided into the overlying Crouch Branch Aquifer and the underlying McQueen Branch Aquifer, which are separated by the McQueen Branch Confining Unit. The Crouch Branch Aquifer and McQueen Branch Aquifer are names that originated at SRS [Aadland et al., 1995]. These units are equivalent to the Dublin Aquifer and the Midville Aquifer, which are names originating with the USGS [Clarke and West, 1997].

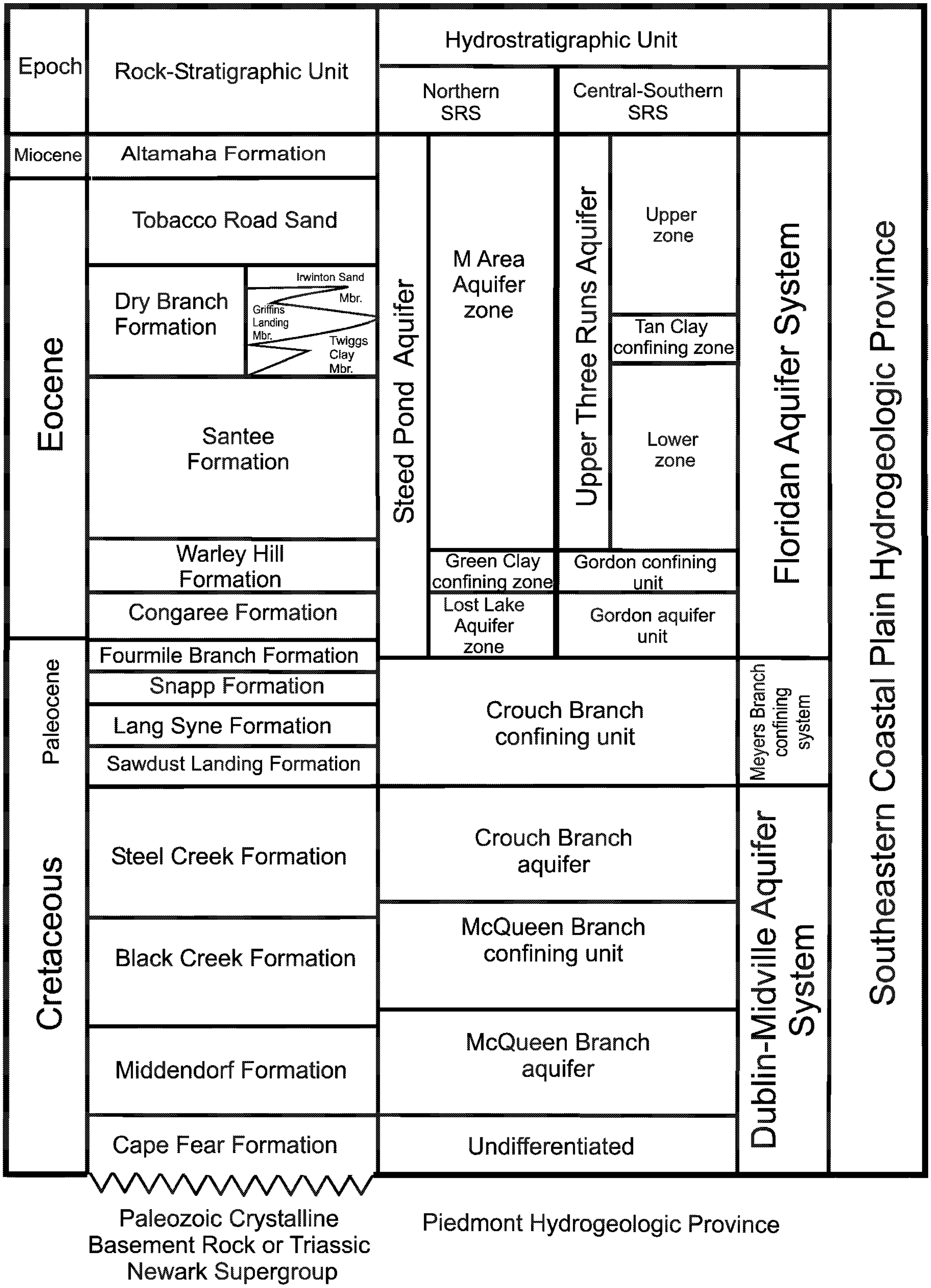
Figure 8–3 is a three-dimensional block diagram of the hydrogeologic units at SRS and the generalized groundwater flow patterns within those units. These units are from shallowest to deepest: the Upper Three Runs/Steed Pond Aquifer (or water table aquifer), the Gordon/Lost Lake Aquifer, the Crouch Branch Aquifer, and the McQueen Branch Aquifer.

Groundwater recharge is a result of the infiltration of precipitation at the land surface; the precipitation moves vertically downward through the unsaturated zone to the water table. Upon entering the saturated zone at the water table, water moves predominantly in a horizontal direction toward local discharge zones along the headwaters and midsections of streams, while some of the water moves into successively deeper aquifers. The water lost to successively deeper aquifers also migrates laterally within those units toward the more distant regional discharge zones. These typically are located along the major streams and rivers in the area, such as the Savannah River. Groundwater movement within these units is extremely slow when compared to surface water flow rates. Groundwater velocities also are quite different between aquitards and aquifers, ranging at SRS from several inches to several feet per year in aquitards and from tens to hundreds of feet per year in aquifers.

Potentiometric contour maps for this report were contoured using 2000 data. An exception is the Crouch Branch Aquifer; its contours were updated during 2001 based on measurements in new wells in the northwestern part of the site and offsite wells near Jackson, South Carolina. However, the current potentiometric surfaces of the aquifers are not significantly different from those depicted in maps in this report.

Figure 8–4 illustrates the water table configuration at SRS for second quarter 2000; the contours were initially taken from the SRS long-term mean water table configuration [Hiergesell, 1998]. Water level measurements obtained in second quarter 2000 then were posted on this map and contours then were adjusted to be consistent with time-specific measurements. Horizontal groundwater movement in the water table aquifer is in a direction that is perpendicular to the contours, proceeding from areas of higher fluid potential (recharge areas) to areas of lower fluid potential, where it discharges along the reaches of perennial streams at SRS.

The potentiometric level contours for the Gordon/Lost Lake Aquifer, Crouch Branch Aquifer, and McQueen Branch Aquifer are illustrated in figures 8–5, 8–6, and 8–7, respectively. These contours are based on water level measurements obtained from SRS regional cluster wells in second quarter 2000; however, additional water level measurements obtained from monitoring wells also were used to construct the Gordon/Lost Lake Aquifer contours in A-Area, M-Area, and the general separations area of SRS. As with the water table, horizontal groundwater movement is in a direction perpendicular to the contours and proceeds from



Modified from Aadland et al, 1995, and Fallaw and Price, 1995

Figure 8–2 Hydrostratigraphic Units at SRS

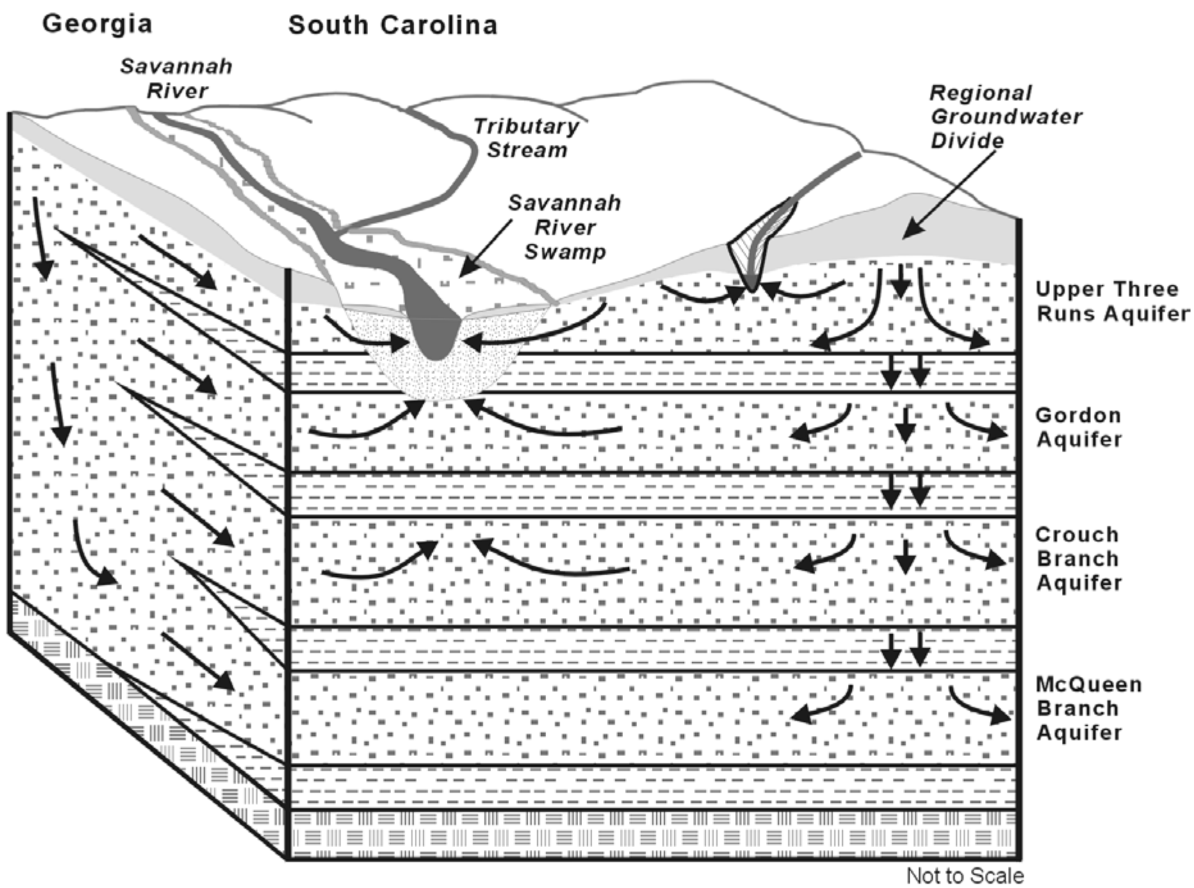
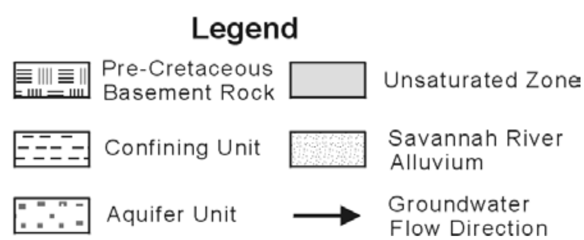


Figure 8–3 Groundwater at SRS

The groundwater flow system at SRS consists of four major aquifers separated by confining units. Flow in recharge areas generally migrates downward as well as laterally—eventually either discharging into the Savannah River and its tributaries or migrating into the deeper regional flow system.

Modified from Clarke and West, 1997



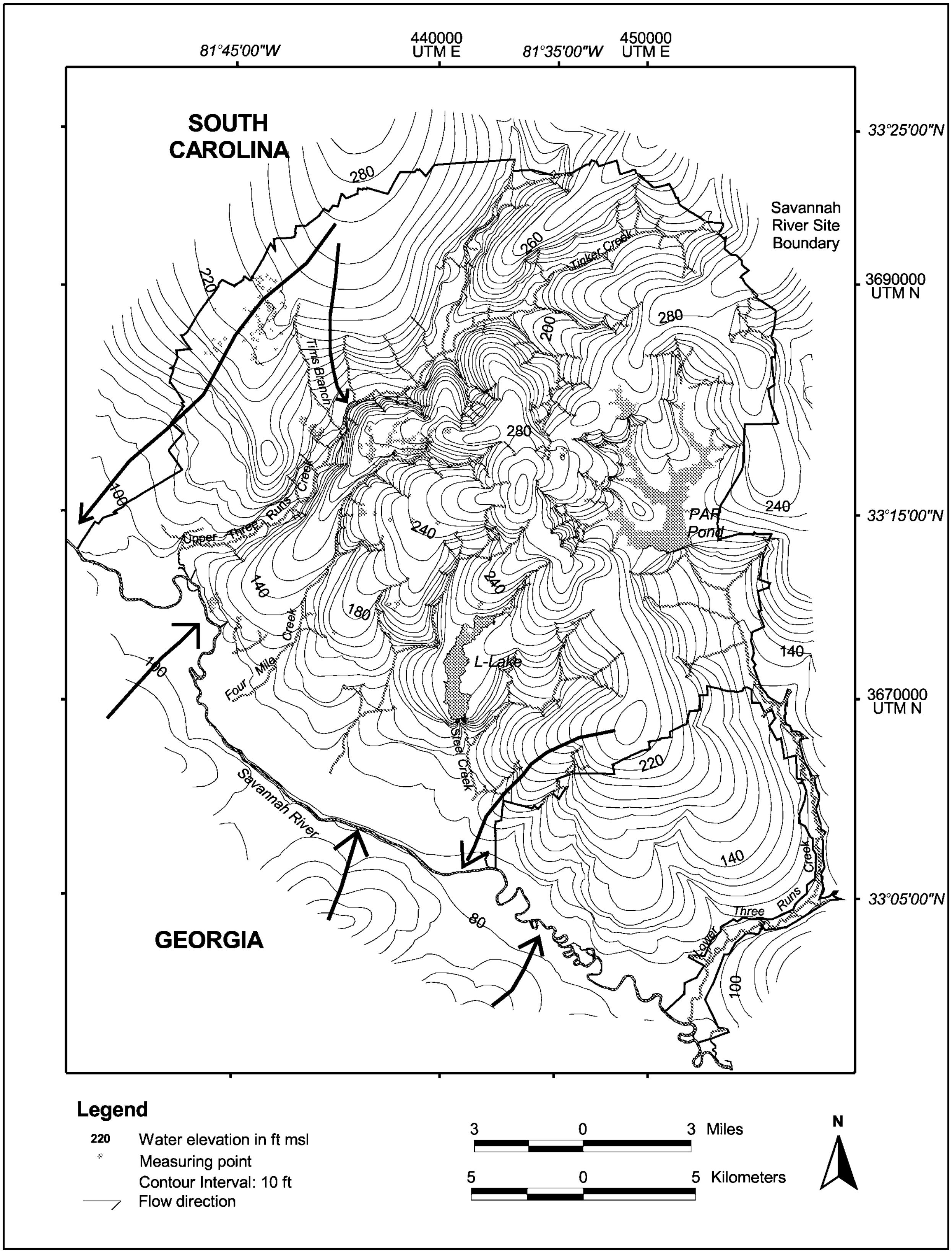
areas of higher fluid potential to areas of lower fluid potential.

Monitoring wells are used extensively at SRS to assess the effect of site activities on groundwater quality. Most of the wells monitor the upper groundwater zone, although wells in lower zones are present at the sites with the larger groundwater contamination plumes. Groundwater in areas indicated on figure 8–1 contains one or more constituents at or above the levels of the DWS of the U.S. Environmental Protection Agency (EPA).

Groundwater Protection Program at SRS

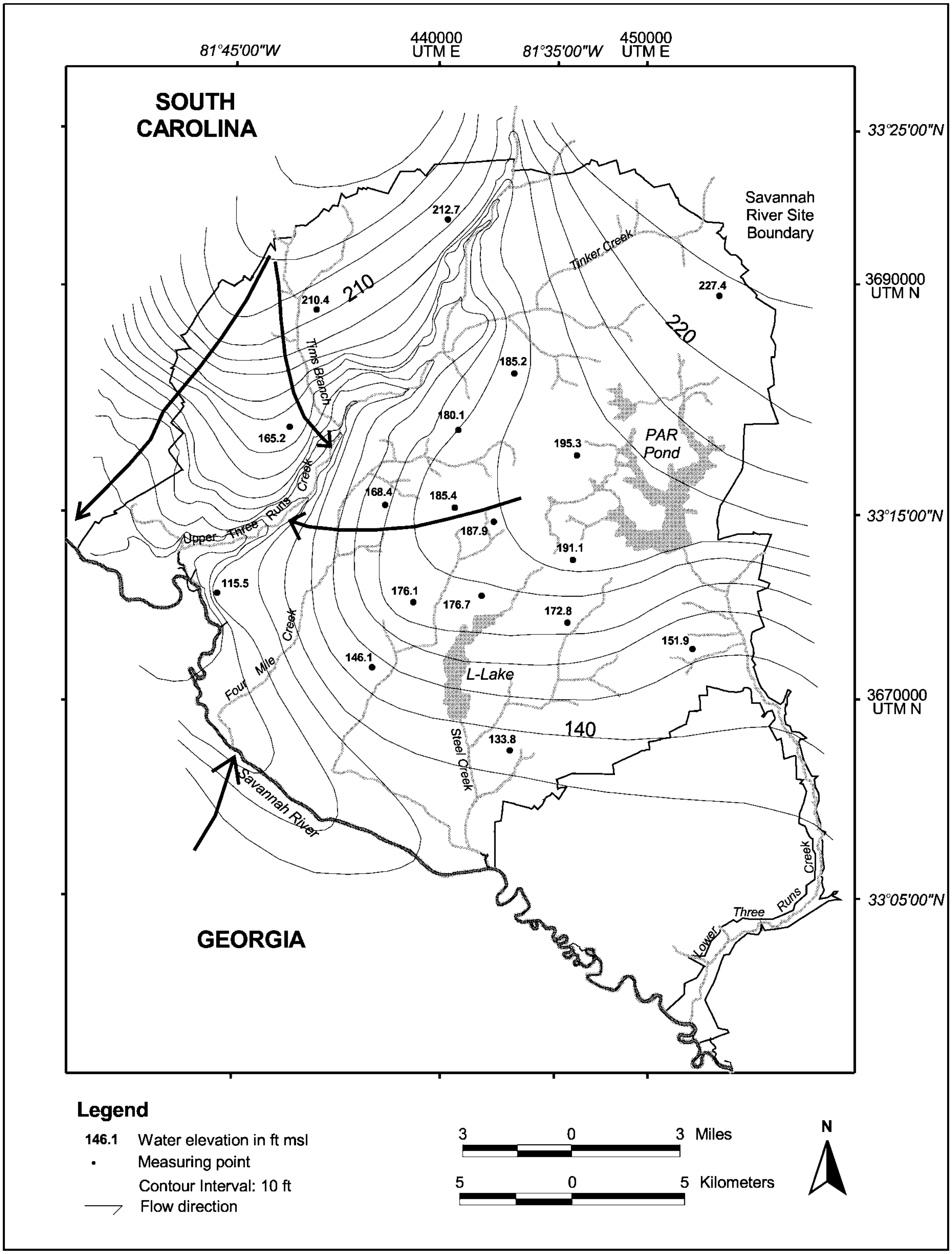
The SRS groundwater program was audited by both the U.S. Department of Energy (DOE) and WSRC during 2000 and 2001. Findings of these assessments resulted in the early revision of the site Groundwater Protection Management Program Plan (GPMP; WSRC–TR–2001–00379) to codify improvements to the program. The GPMP described five function elements of the SRS program that are designed to meet federal and state laws and regulations, DOE orders, and site policies and procedures. These elements include

- investigating site groundwater
- using site groundwater
- protecting site groundwater
- remediating contaminated groundwater
- reporting the results of these efforts to stakeholders



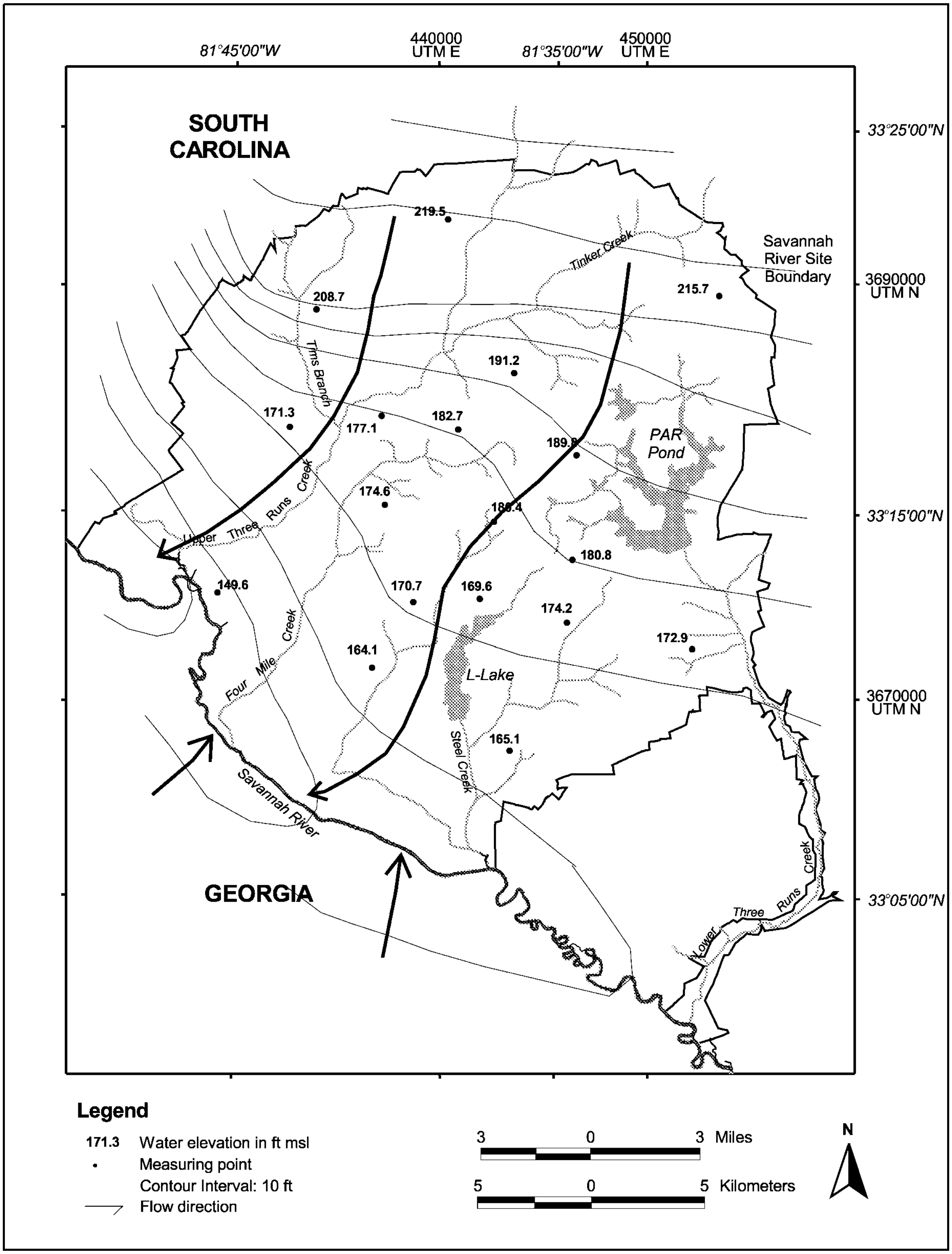
SRTC/EST Map

Figure 8–4 Water Table Contours at SRS



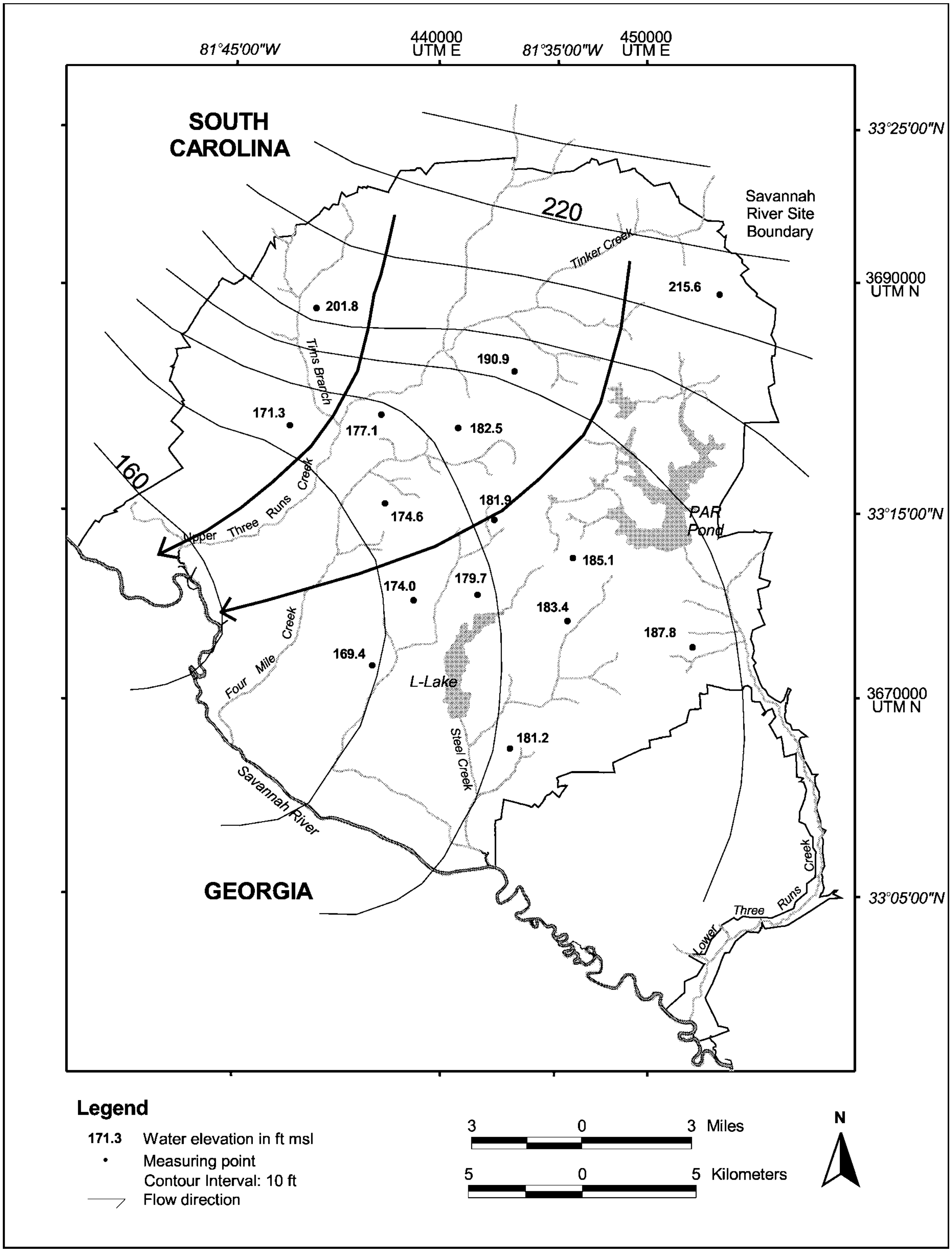
SRTC/EST Map

Figure 8–5 Potentiometric Surface of the Gordon Aquifer at SRS



SRTC/EST Map

Figure 8–6 Potentiometric Surface of the Crouch Branch Aquifer at SRS



SRTC/EST Map

Figure 8–7 Potentiometric Surface of the McQueen Branch Aquifer at SRS

SRS identified specific program goals in each of these areas to maintain its commitment to a groundwater program that protects human health and the environment. Groundwater monitoring is a key tool used in each of the first four elements, and monitoring results form the basis for evaluations that are reported to site stakeholders.

Investigating SRS Groundwater

An extensive program is in place at SRS to acquire new data and information on the groundwater system. This program is multifaceted and is conducted across departmental boundaries at the site because of the different charters and mandates of these organizations. Investigations include both the collection and analysis of data to understand groundwater conditions on regional and local scales at SRS. Research efforts at the site generally are conducted to obtain a better understanding of subsurface processes and mechanisms or to define new approaches to subsurface remediation.

Investigative efforts focus on the collection and analysis of data to characterize the groundwater flow system. Characterization efforts at SRS include the following activities:

- the collection of geologic core material and the performing of seismic profiles to better delineate subsurface structural features
- the installation of wells to allow the periodic collection of both water levels and groundwater samples at strategic locations
- the development of water table and potentiometric maps to delineate the direction of groundwater movement in the subsurface
- the performance of various types of tests to obtain *in situ* estimates of hydraulic parameters needed to estimate groundwater velocities

Analysis of data on the regional scale is needed to provide a broad understanding of groundwater movement patterns at SRS that can be used as a framework to better understand the migration of contaminants at the local scale near individual waste units. Surface water flow characteristics also are defined at the site on the regional scale and are significant to risk analyses because perennial streams are the receptors of groundwater discharge—some of which contains contaminants from SRS waste units. Because the site boundary does not represent a groundwater boundary, regional studies are helpful in understanding the movement of groundwater both onto the site from the surrounding area and vice versa.

The collection and analysis of data describing subsurface hydrogeologic conditions at or near individual waste units is needed to design effective remediation systems. Characterization embraces both traditional and innovative technologies to accomplish this goal. The installation of monitoring wells and piezometers is a traditional investigative method to allow the collection of (1) water levels, which are used to define flow directions, and (2) groundwater samples, which are analyzed to monitor contaminant plume migration within the groundwater flow system. Electric logs acquired during well installation are used to delineate the subsurface hydrostratigraphy. Examples of newer technologies include the use of

- direct-push technology, such as the cone penetrometer, to collect one-time groundwater samples at investigation sites and to help establish hydrostratigraphic contacts
- the “rotosonic” method for bore holes to collect core and install wells

Various tests are also conducted, as needed, to obtain *in situ* estimates of subsurface hydraulic properties that can be used to calculate groundwater velocities.

Numerical models have been used extensively as an analytical tool at SRS for both regional- and local-scale investigations. Models have been utilized for a variety of reasons, but primarily to (1) define the regional groundwater movement patterns at SRS and the surrounding areas, (2) enhance the understanding of contaminant migration in the subsurface, and (3) support the design of remediation systems. At SRS, major groundwater modeling efforts have focused on A/M-Area, F-Area, H-Area, the Burial Ground Complex, and several of the reactor areas where the most extensive subsurface contamination is known to exist.

Research on groundwater issues is conducted at SRS to obtain a better understanding of subsurface mechanisms, such as (1) the interaction of contaminants with the porous media matrix, and (2) the factors that impact the rate of migration of contaminants within the groundwater flow system. Research to address relevant issues often is conducted through cooperative studies with investigators at various public universities and private companies, while other efforts are conducted exclusively by SRS employees.

Using SRS Groundwater

SRS derives its own drinking and production water supply from groundwater. The site ranks as South Carolina’s largest self-supplied industrial consumer of groundwater, utilizing approximately 5.3 million gallons per day. SRS domestic and process water systems are supplied from a network of approximately 40 site groundwater wells in widely scattered locations across the site, of which eight supply the primary drinking water system for the site. Treated well water is supplied to the larger site facilities by the A-Area, D-Area and K-Area domestic water systems. Each system has wells, a treatment plant, elevated storage tanks, and distribution piping. The wells range in capacity from 200 to 1,500 gallons per minute.

These three systems supply an average of 1.1 million gallons per day of domestic water to customers in these areas. The domestic water systems supply site drinking fountains, lunchrooms, restrooms, and showering facilities with water meeting state and federal drinking water quality standards. Process water is used for equipment cooling, facility washdown water, and as makeup water for site cooling towers and production processes.

The South Carolina Department of Health and Environmental Control (SCDHEC) periodically samples the large- and small-system wells for Safe Drinking Water Act contaminants. An unscheduled biannual SCDHEC sanitary survey also is performed.

In 1983, SRS began reporting its water usage annually to the South Carolina Water Resources Commission (and later to SCDHEC). Since that time, the amount of groundwater pumped on site has dropped by 50 percent—from 10.8 million gallons per day during 1983–1986 to 5.3 million gallons per day during 1997–2000. The majority of this decrease is attributable to the consolidation of site domestic water systems, which was completed in 1997. Thirteen separate systems, each with its own supply wells, were consolidated into three systems located in A-Area, D-Area, and K-Area. Site facility shutdowns and reductions in population were also contributing factors. The amount of groundwater pumped at SRS has had only localized effects on water levels in the Cretaceous aquifers, and it is unlikely that water usage at the site ever will cause drawdown problems that could impact surrounding communities.

The process water systems in A-Area, F-Area, H-Area, K-Area, L-Area, S-Area and TNX-Area meet site demands for boiler feedwater, equipment cooling water, facility washdown water, and makeup water for cooling towers, fire storage tanks, chilled-water-piping loops, and site test facilities. These systems are supplied from dedicated process water wells ranging in capacity from 100 to 1,500 gallons per minute. In K-Area, the process water system is supplied from the domestic water wells. At some locations, the process water wells pump to ground-level storage tanks, where the water is treated for corrosion control. At other locations the wells directly pressurize the process water distribution piping system without supplemental treatment.

The site groundwater protection program integrates information learned about the properties of SRS aquifers with site demand for drinking and process water. SRS ensures a high level of drinking water supply protection by performing (1) monitoring above and beyond SCDHEC monitoring and (2) periodic evaluations of production wells. Additional protection will be realized under a site wellhead protection program that meets the requirements of the South Carolina Source Water Assessment Program described below.

Protecting SRS Groundwater

SRS is committed to protecting the groundwater resource beneath the site. A variety of activities contribute to this goal, including

- construction, waste management, and monitoring efforts to prevent or control sources of groundwater contamination
- monitoring programs (both groundwater and surface water) to detect contamination
- a strong groundwater cleanup program through the Environmental Restoration Division (ERD)

Monitoring provides the best means to detect and track groundwater contamination. To ensure that no unknown contamination poses a risk, SRS depends on a sitewide groundwater monitoring and protection effort—the site Groundwater Surveillance Monitoring Program (GSMP). This new program is an upgraded replacement of the site screening program.

Because aquifer conditions and groundwater quality vary in the temporal domain, an ongoing groundwater surveillance monitoring program is a fundamental part of any groundwater protection effort. SRS is continually improving its surveillance program, which meshes with the regulatory program that addresses contaminated groundwater.

Whereas the remediation monitoring program is performed for the purpose of regulatory compliance (e.g., defining contamination in a hazardous waste management facility or solid waste management unit, assessing the effectiveness of corrective action, etc.), the GSMP addresses sitewide groundwater protection in accordance with DOE Order 5400.1, “General Environmental Protection Program.”

One goal of the GSMP is to protect potential offsite receptors from contamination by detecting contamination in time to apply appropriate corrective actions. SRS is a large site, and most groundwater contamination is located in the central site areas (figure 8–1). However, the potential for offsite migration exists, and the consequences of such an outcome are serious enough to warrant a comprehensive prevention program.

SRS has evaluated groundwater flow and determined, for each aquifer, where groundwater flows across the site boundary, since the location of groundwater flow would be a conservative surrogate for any potential contaminant migration. Monitoring at those locations is being strengthened by the addition of several new well clusters to ensure early detection of any contamination migrating toward the site boundary. If contamination is ever detected, appropriate reporting and remediation efforts can be initiated by DOE.

Another pathway for existing groundwater contamination to flow offsite is by discharge into surface streams and subsequent transport into the Savannah River. SRS monitors site streams for contamination, and new wells have been installed in recent years along several site streams to detect contamination before it enters the stream and to assess its concentration in groundwater.

Another function of the groundwater protection program is to monitor groundwater around operating facilities to ensure that any potential contamination emanating from any facility is detected in a timely manner. This monitoring includes the tank farms and canyon facilities in the central site area. In addition, surveillance monitoring is performed at various wells around the site to detect any new or previously undetected contaminant plumes.

A major challenge of the site groundwater program is the careful evaluation of the hundreds of thousands of new data records generated each year. The GSMP includes analysis using a combination of new computer automation tools and "hands on" groundwater expertise to screen all the recent records in the site groundwater database each year. This evaluation seeks unexpected results in any site wells that might indicate new or changing groundwater contamination.

SRS is cooperating with SCDHEC to develop and implement source water assessment and protection programs. After an assessment program has been approved and implemented, the SRS groundwater protection program will focus on protection efforts. The primary aspect of the source water assessment and protection programs will be wellhead protection, given that SRS derives its drinking water exclusively from groundwater. Other aspects will include strategies for preventing contamination and controlling existing contamination through the SRS program. The program will evaluate waste minimization, spill prevention and control, well abandonment, and future land use. More information about this initiative can be found at http//www.epa.gov/safewater/protect.html.

Remediating Contaminated SRS Groundwater

SRS has maintained an environmental restoration effort for many years. ERD personnel manage groundwater cleanup of contaminated groundwater associated with Resource Conservation and Recovery Act (RCRA) hazardous waste management facilities or Federal Facility Act units. ERD's mission is to aggressively manage the inactive waste site and groundwater cleanup program so that

- schedules for environmental agreements are consistently met
- the utilization of financial and technology resources are continually improved
- the overall risk posed by existing contaminated sites is continually reduced

The strategy of ERD, which has developed a management action plan for groundwater, revolves around developing an appropriate regulatory framework for each waste site, assessing the degree and extent of contamination, and remediating the contaminated groundwater to its original beneficial use. In cases where that remediation goal is impractical, ERD intends to prevent plume migration and exposure and to evaluate alternate methods of risk reduction.

Reporting Results of Groundwater Program Activities

In addition to its annual environmental report, SRS publishes several reports related to the site groundwater program. Some of these are referenced in this chapter, including (1) compliance and investigation reports developed for groundwater remediation activities, (2) a sampling schedule describing annual monitoring activities (3) various site-specific groundwater monitoring reports for regulatory compliance (4) quarterly groundwater monitoring reports, and (5) the biannual well inventory. Beginning in 2002, an annual report of the site Groundwater Surveillance Monitoring Program also will be issued.

Description of the Groundwater Monitoring Program

The groundwater monitoring program at SRS gathers information to determine the effect of site operations on groundwater quality. The program is designed to

- assist SRS in complying with environmental regulations and DOE directives
- provide data to identify and monitor constituents in the groundwater
- permit characterization of new facility locations to ensure that they are suitable for the intended facilities
- support basic and applied research projects

The groundwater monitoring program at SRS is conducted by the Environmental Geochemistry Group (EGG) of EPD's Environmental Monitoring Section (EMS). To assist other departments in meeting their responsibilities, EGG provides the services for installing monitoring wells, collecting and analyzing samples, and reporting results.

The *WSRC Environmental Compliance Manual* (WSRC–3Q1) provides details about the following aspects of the groundwater monitoring program:

- well siting, construction, maintenance, and abandonment
- sample planning
- sample collection and field measurements
- analysis
- data management
- related publications, files, and databases

The remainder of this chapter presents overviews of several of these topics, along with information specific to 2001.

Sample Scheduling and Collection

EMS schedules groundwater sampling either in response to specific requests from SRS personnel or as part of its ongoing groundwater monitoring program. These groundwater samples provide data for reports required by federal and state regulations and for internal reports and research projects. The groundwater monitoring program schedules wells to be sampled at intervals ranging from quarterly to triennially.

Personnel outside EMS may request sample collection as often as weekly. Constituents that may be analyzed are commonly imposed by permit or work plan approval. Those include metals, field parameters, suites of herbicides, pesticides, volatile organics, and others. Radioactive constituents that may be analyzed by request include gross alpha and beta measurements, gamma emitters, iodine-129, strontium-90, radium isotopes, uranium isotopes, and other alpha and beta emitters.

Groundwater samples are collected from monitoring wells, generally with either pumps or bailers dedicated to the well to prevent cross–contamination among wells. Occasionally, portable sampling equipment is used; this equipment is decontaminated between wells.

Sampling and shipping equipment and procedures are consistent with EPA, SCDHEC, and U.S. Department of Transportation guidelines. EPA–recommended preservatives and sample–handling techniques are used during sample storage and transportation to both onsite and offsite analytical laboratories. Potentially radioactive samples are screened for total activity (alpha and beta emitters) prior to shipment to determine appropriate packaging and labeling requirements.

Deviations (caused by dry wells, inoperative pumps, etc.) from scheduled sampling and analysis for 2001 are enumerated in the SRS quarterly groundwater monitoring reports cited previously in this chapter.

Analytical Procedures

In 2001, General Engineering Laboratories of Charleston, South Carolina; Recra LabNet Philadelphia of Lionville, Pennsylvania; and Sanford Cohen and Associates of Montgomery, Alabama, performed most of the groundwater analyses. In addition, the General Engineering Mobile Laboratory performed onsite analyses of volatile organics and semivolatile organics and metals. EMAX Laboratories, Inc., of Torrance, California, performed analyses for several sampling projects, and MicroSeeps of Pittsburgh, Pennsylvania, performed natural attenuation analyses. The contracted laboratories are certified by SCDHEC to perform specified analyses.

The EMS laboratory at SRS screened potentially radioactive samples for total activity prior to shipment. General Engineering Laboratories performed radiological analyses, and Thermo NUtech of Oak Ridge, Tennessee, subcontracted radiological analyses from Recra LabNet Philadelphia.

Full lists of constituents analyzed, analytical methods used, and the laboratories' estimated quantitation limits are given in the SRS quarterly groundwater reports referenced earlier.

Evaluation of Groundwater Data

EMS receives analytical results and field measurements as reports and as ASCII files that are loaded into databases at SRS. For 2001, logbooks track receipt and transfer of data to the Geochemical Information Management System (GIMS) database or to the Environmental Restoration Data Management System (ERDMS), and computer programs present the data in a format that can be validated.

Quality control practices include the following:

- verification of well names and sample dates for field and analytical data
- verification that all analyses requested on the chain-of-custody forms were completed by each laboratory
- identification of data entry problems (e.g., duplicate records, incorrect units)
- comparison of analytical data to historical data and review of the data for transcription, instrument, or calculation errors
- comparison of blind replicates and laboratory in-house duplicates for inconsistencies
- identification of laboratory blanks and blind blanks with elevated concentrations

Possible transcription errors and suspect results are documented and submitted to the appropriate laboratory for verification or correction. No changes are made to the database until the laboratory documents the problem and solution. Changes to the database are recorded in a logbook.

The quarterly groundwater monitoring reports identify queried results verified by the laboratory and list groundwater samples associated with blanks having elevated results. These reports also present the results of intralaboratory and interlaboratory quality assurance comparisons (chapter 9, “Quality Assurance”).

Changes to the Groundwater Monitoring Program during 2001

Well Abandonments and Additions; Changes to the Sampling Schedule

During 2001, two wells were abandoned—one in A-Area/M-Area and another in the A-Area burning/rubble pits.

The following 212 wells were scheduled to be monitored for the first time in 2001:

- Fifty-one new wells in the chemicals, metals, and pesticides pits in order to determine the nature and extent of contamination
- Two wells in the Jackson Wells project as wells added to the GSMP.
- Thirteen wells in the miscellaneous chemical basins for an Inductively Coupled Plasma/Remedial Action Implementation Plan
- Fifteen wells in the southern sector for the Groundwater Effectiveness Monitoring Strategy for the proposed Southern Sector Phase 1 Groundwater Corrective Action
- Twenty wells in the A-Area burning/rubble pits for Interim Corrective Measures Implementation/Remedial Action Implementation Plan
- Twenty-four wells in the D-Area expanded operable unit for the RCRA Facility Investigation/Remedial Investigation Workplan Addendum
- Twelve wells in the F-Area Seepage Basins Injection Study to provide information to be utilized in the evaluation of the Base Injection Study
- Seventeen wells for the A-Area/M-Area Cretaceous Wells project for A-Area/M-Area groundwater
- Nine wells at the R-Reactor seepage basins to provide additional field data to support the development of the Corrective Measures Study/Feasibility Study
- Six wells at the H-Area groundwater treatment unit to establish decontamination factors to facilitate remedial decision making
- Thirteen wells at the Mixed Waste Management Facility for RCRA compliance sampling
- Fourteen wells in the General Site for the GSMP
- Thirteen wells in the sanitary landfill for compliance with South Carolina Hazardous Waste Management Regulations, Solvent Rag Settlement (91–51–SW), GWQAP 1995; and comprehensive monitoring evaluation audit ESH–CGP–2000–00136
- Three wells in A-Area/M-Area for production well sampling at SCDHEC request

Groundwater Monitoring Results at SRS

This section summarizes groundwater monitoring results during 2001 for each of the following areas at SRS:

- A-Area and M-Area
- C-Area
- D-Area and TNX-Area
- General separations and waste management areas (E-Area, F-Area, H-Area, S-Area, and Z-Area)
- K-Area
- L-Area and chemicals, metals, and pesticides pits
- N-Area
- P-Area
- R-Area
- Sanitary landfill

Additional information about groundwater contamination, monitoring, and cleanup in most of these areas can be found at the following internet address: http://www.srs.gov/general/pubs/fulltext/fulltext–2001.htm.

Groundwater Contamination at A-Area and M-Area

The administration and manufacturing areas (A-Area and M-Area) are located in the northwestern part of SRS and include a number of facilities associated with the site's groundwater cleanup and monitoring programs (figure 8–1). The area contains facilities that were used for the manufacture of reactor fuel and target assemblies, support services, laboratories, and administration. The manufacturing facilities were operational from the 1950s into the early 1980s. Major contaminants include volatile constituents, particularly trichloroethylene and tetrachloroethylene, used as degreasers in old manufacturing processes. Wastewater from the manufacturing operations flowed into the M-Area Settling Basin and the Lost Lake, a shallow body of water that received runoff from the settling basin; these two units make up the hazardous waste management facilities (HWMF). Additional details about the A-Area and M-Area groundwater cleanup and monitoring programs can be found in the SRS RCRA permit application and FFA documents.

Cleanup activities, focusing on both groundwater and the overlying soil column, have substantially altered the groundwater flow and spread of contamination. These efforts have included the capping of basins and the extraction of contaminants from groundwater. To contain the trichloroethylene and tetrachloroethylene plumes in groundwater, SRS installed groundwater recovery systems in A-Area and M-Area. These systems include pumping wells installed in the Steed Pond aquifer and air stripper units for treating the water. The clean water is discharged through a permitted outfall to an SRS stream. Groundwater monitoring and numerical modeling tasks have demonstrated the effectiveness of the groundwater recovery systems in controlling migration of the trichloroethylene and tetrachloroethylene plumes associated with the HWMF. Since the system began operating in 1984, almost a million pounds of solvents have been recovered via the groundwater recovery systems in A-Area and M-Area. The corrective action plan, approved by SCDHEC in 1987, requires groundwater cleanup operation and monitoring in A-Area and M-Area for 30 years.

Other technologies are in use at A-Area and M-Area to recover chlorinated solvent plumes and perform *in situ* remediation. These plumes are associated with individual operable units or facilities, but also may commingle or be in hydraulic communication with the larger trichloroethylene and tetrachloroethylene plume in the Steed Pond aquifer beneath A-Area and M-Area. Twenty-three vertical recirculation wells are in use at the miscellaneous chemical basin and in the southern sector of A-Area and M-Area. Also, phytoremediation is in use at the southern sector to recover the distal (low concentration) area of the groundwater plume. Air sparging wells and shallow soil vapor extraction units are operating at the A-Area burning/rubble pits. Soil vapor extraction is in use at the A–014 outfall, M-Area settling basin, and miscellaneous chemical basin.

In September 2000, SRS began operation of a technology known as dynamic underground stripping (DUS). DUS was deployed at the M-Area solvent storage tank area, which was known to have a dense nonaqueous phase liquid source that released volatile organic compounds (VOCs) to the A-Area and M-Area groundwater plume. The DUS technology vaporizes VOCs in the permeable zones of the treatment area by injecting steam into the subsurface soil and heating the VOC contaminants above their boiling points. Contaminants are removed by physical transport to extraction wells and by *in situ* destruction of contaminants with a thermally accelerated oxidation process. When DUS operations were discontinued in September 2001, more than 70,000 pounds of VOCs had been removed from the treatment area.

Groundwater Contamination at C-Area

Several groundwater contaminant plumes have been characterized by data collected from numerous monitoring wells and cone penetrometer locations in the C-Area groundwater operable unit (figure 8–1). Significant plumes of tritium and trichloroethylene have been identified in the area. Two distinct tritium plumes have been identified—a northern tritium plume and a southern tritium plume. These plumes are derived from several separate sources, some of them undetermined at this time. In addition, two distinct plumes of trichloroethylene have been identified: a northern trichloroethylene plume, and a southern trichloroethylene plume. The source location of the northern trichloroethylene plume has been identified at the C-Area burning/rubble pit, and the source of the southern trichloroethylene plume is an undefined area inside of the C-Area reactor fence.

The two tritium plumes and the southern trichloroethylene plume, which emanates from the C-Area reactor, are administratively associated with the C-Area groundwater operable unit. The trichloroethylene plume from the C-Area burning/rubble pit is administratively associated with the C-Area burning/rubble pit operable unit.

As indicated by the field-derived plume configuration, groundwater originating from just beneath the C-Reactor building (105–C) appears to be flowing south, southwest with eventual discharge to Castor Creek and Fourmile Branch. Groundwater migrating from potential source locations of the C-Area burning/rubble pit trichloroethylene and tritium plumes appears to be flowing to the west, with eventual discharge to Fourmile Branch.

Groundwater Contamination at D-Area and TNX-Area

D-Area, located in the southwest part of SRS, includes a large coal-fired power plant and decommissioned heavy water facilities. TNX-Area, also located in the southwest part of the site, was used to test equipment and develop new designs. Several units are associated with groundwater monitoring and cleanup in these two areas (figure 8–1).

Contamination at D-Area and TNX-Area occurs in the Upper Three Runs aquifer, a shallow water table (figure 8–3). Volatile organic constituents, particularly trichloroethylene, are the primary contaminants. In D-Area, there is substantial contamination of the groundwater near the coal pile, coal pile runoff containment basin, and ash basins. This contamination is consistent with low-pH conditions, the leaching of coal and coal ash, and the discharge of chlorinated degreasing solvents. The most widespread contaminant at D-Area is trichloroethylene; other contaminants include heavy metals and tritium. A phytoremediation system is being tested for the treatment of groundwater contaminated by trichloroethylene. A separate plume of volatile organics (especially trichloroethylene) and lead has been associated with disposal activities at the D-Area oil seepage basin. A groundwater mixing zone application was approved by SCDHEC in 1998 for chlorinated solvents.

There is a shallow plume of contaminated groundwater beneath much of TNX-Area and downgradient into the Savannah River Swamp. Contaminants in the groundwater include radionuclides, heavy metals, and VOCs—especially trichloroethylene. The highest concentrations of trichloroethylene are found northwest and southeast of the TNX burying ground. A separate plume appears to be moving to the southwest of the TNX outfall delta toward the X–08 ditch. Groundwater cleanup at TNX-Area utilizes a groundwater recovery system and a soil vapor extraction system. Geosiphon wells have been installed in the lower swamp area for recovering trichloroethylene that is moving toward the Savannah River.

Groundwater Contamination at the General Separations and Waste Management Areas

The separations and waste management areas, which include E-Area, F-Area, H-Area, S-Area, and Z-Area, are located in the center of SRS. Reactor-produced materials are processed in the chemical separations plants, or “canyons,” at F-Area and H-Area. The separations and waste management areas, also called the General Separations Area (GSA), contain many units associated with the groundwater monitoring and cleanup programs (figure 8–1).

Both surface and groundwater divides run from east to west between Upper Three Runs Creek and Fourmile Branch. In the Upper Three Runs aquifer (figure 8–3), groundwater in the northern GSA flows north into Upper Three Runs Creek, while groundwater in in the southern GSA flows into Fourmile Branch. The flow dynamics change in the Gordon aquifer, where flow is to the northwest over most of the GSA.

The most extensive groundwater monitoring and cleanup programs in these areas are associated with three RCRA-regulated facilities—the F-Area HWMF, the H-Area HWMF, and the Burial Ground Complex. Tritium is the most common contamination at all three facilities, but metals, other radionuclides, and volatile organic constituents also are present. A complex groundwater cleanup system has been operating at the F-Area and H-Area HWMFs for several years, but work at the Burial Ground Complex now is directed toward plume characterization. Much of the cleanup emphasis is on constraining the flow of contaminant plumes into Fourmile Branch.

Groundwater Contamination at K-Area

There are four known plumes of groundwater contamination in K-Area (figure 8–1). Primary contaminants include trichloroethylene, tetrachloroethylene and tritium. A small, isolated plume of trichloroethylene and tetrachloroethylene is associated with the K-Area burning/rubble pit and rubble pile, on the northeast side of the K-Area reactor. There is no continuing source, and the plume is not discharging to surface water. A groundwater mixing zone application has been approved for this operable unit.

A tritium plume, termed “tritium anomaly plume,” is located northwest of the reactor (figure 8–1). This plume has not been fully characterized, but extends at least 2,000 feet from somewhere inside the reactor fence to a surface discharge point in Indian Grave Branch. It has been named the tritium anomaly plume because especially high tritium values have been measured in monitoring wells and surface water. This plume is slated to be investigated under the K-Area groundwater operable unit. In addition, the K-Area Groundwater Operable Unit will include another tritium plume emanating from the vicinity of the retention basin and discharging into surface water and a trichloroethylene plume intermingled with the tritium anomaly plume. These plumes will be investigated under the site RCRA/Comprehensive Environmental Response, Compensation, and Liability Act program.

Groundwater Contamination at L-Area and the Chemicals, Metals, and Pesticides Pits

L-Area groundwater contamination is associated with several units, including the chemicals, metals, and pesticides pits, the L-Area burning/rubble pit, and several units located next to and in the L-Area reactor area (figure 8–1).

Contaminants above the maximum contaminant limit from the chemicals, metals, and pesticides pits include tetrachloroethylene, trichloroethylene, and daughter products; lindane; carbon tetrachloride; and chloroform. Groundwater flows north, northwest from the pits toward Pen Branch. Groundwater modeling in this area is under way.

At the L-Area burning/rubble pit, carbon tetrachloride is the only groundwater constituent of concern. Groundwater in this area flows west toward Pen Branch, downstream of the chemicals, metals, and pesticides pits. Groundwater flow and transport modeling in this area has been completed. Contamination will not discharge to surface water based on modeling predictions. There is also an approved groundwater mixing zone.

Contamination in the reactor area includes trichloroethylene, tetrachloroethylene and tritium. Groundwater in this area flows south toward L Lake. Groundwater modeling will begin for these plumes in fiscal year 2002.

Groundwater Contamination at N-Area

N-Area, also called the Central Shops area, is located in the central part of SRS and provides supply, maintenance, and other support services for the site (figure 8–1). Groundwater contamination in N-Area is associated with organic compounds, including chlorinated solvents (trichloroethylene), as well as heavy metals.

Chlorinated solvents have been used throughout N-Area. It is believed that most of the solvents ended up in floor drains that emptied into a drainage ditch near the center of the area. Groundwater contamination in N-Area has been detected only at the SRL oil test site and at the heavy-equipment wash basin and Central Shops burning/rubble pit (631–5G). An effort is under way to administratively create a new groundwater operable unit in N-Area because it is believed that the source of the groundwater contamination is the drainage ditch, not the surface units.

At the SRL oil test site, groundwater contamination (tetrachloroethylene, trichloroethylene, and carbon tetrachloride) has been detected in both shallow and deep zones of the Upper Three Runs aquifer (figure 8–2). The SRL oil test site was developed (1975–1977) to evaluate the natural biodegradation of petroleum waste or waste oil.

The heavy-equipment wash basin and Central Shops burning/rubble pit was used to clean and maintain equipment until 1981. The highest concentrations of trichloroethylene (6,500 parts per billion) exist in the shallow Upper Three Runs aquifer near the outfall. In this area, a competent clay layer just beneath the surface supports a perched-water zone, which flows toward the drainage ditch. The trichloroethylene plume exists in two “lobes.” One moves downgradient on top of a clay layer in the Upper Three Runs aquifer; the other has been drawn deeper into the lower part of the Upper Three Runs aquifer toward a shallow groundwater production well (now abandoned).

Groundwater Contamination at P-Area

Groundwater in P-Area is discharging in the Steel Creek watershed (figure 8–1). The area is still in the early stages of characterization, and groundwater modeling has not yet begun. Current data suggest that tritium and trichloroethylene plumes exist above the maximum contaminant limit. No site-specific groundwater modeling documents are available yet for this area.

Groundwater Contamination at R-Area

Groundwater contamination exists at concentrations above maximum contaminant limits in R-Area (figure 8–1). Contamination includes tritium, strontium-90, tetrachloroethylene, and trichloroethylene. Three operable units in R-Area are geographically associated with groundwater contamination—the R-Area reactor seepage basins, the R-Area Bingham pump outage pits, and the R-Area burning/rubble pits.

The tritium plume is widespread, exceeds the maximum contaminant limit, and is poorly defined. This contaminant will be characterized under the R-Area groundwater operable unit. Strontium-90 contamination has been discovered adjacent to the R-Area Reactor seepage basins in the very shallow groundwater. Vadose zone modeling and flow and transport modeling are in progress for this plume, which is not discharging to surface water. Final reports are expected June 2002. The tetrachloroethylene and trichloroethylene plumes are associated with the R-Area Bingham pump outage pit and with the R-Area burning/rubble pits and rubble pile. These plumes will be addressed under the R-Area groundwater operable unit. The nearest possible discharge area for the R-Area Bingham pump outage pits plume is Joyce Branch, upstream from PAR Pond. The likely discharge point for the plume near the R-Area burning/rubble pits and rubble pile is Pond 4 of PAR Pond.

Groundwater Contamination at the Sanitary Landfill

The sanitary landfill is located in B-Area, south of Road C, about halfway down the slope of the Aiken Plateau to Upper Three Runs Creek (figure 8–1). The landfill received general SRS wastes for disposal—such as paper, cafeteria wastes, plastics, wood, cardboard, rags, scrap metal, pesticide bags, asbestos (in bags), and sludge from SRS wastewater treatment facilities—beginning in 1974. The “trench and fill” method of waste disposal was used, and the wastes were covered by natural soil or a fabric substitute. The natural water table is in or near the bottom of the waste trenches. The sanitary landfill ceased operations in 1994.

Sanitary landfills are intended to receive only nonradioactive, nonhazardous waste. However, until October 1992, some hazardous wastes (specifically, solvent-laden rags and wipes used for cleaning, decontamination, and instrument calibration) were buried in portions of SRS’s original 32-acre landfill and its southern expansion. Groundwater contamination consists of low concentrations of VOCs, but tritium, metals, and other radionuclides also are present.

Several remediation activities have been successful in addressing groundwater contamination at the sanitary landfill. A RCRA-style cap was installed over the main and southern expansion sections in 1996–1997. The cap has been effective in eliminating (1) the recharge effects of precipitation through the landfill trenches and (2) the mobility of contaminants in the wastes.

A biosparging system consisting of two horizontal wells began operation in 1999. These wells are installed south and southwest of the landfill and intercept the vinyl chloride plume that extends beyond the point-of-compliance wells south of the landfill. This remediation system involves the injection of air and nutrients resulting in the volatilization and degradation of trichloroethylene and vinyl chloride.

Groundwater monitoring results have shown that the landfill cap has reduced the migration of contaminants into the groundwater under the sanitary landfill and has facilitated the reductive dechlorination of chlorinated solvents. Also, the biosparging system has proven effective in groundwater cleanup.

Chapter 9
Quality Assurance

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To Read About . . . See Page . . .

THE Environmental Monitoring Section (EMS) of the Savannah River Site's (SRS) Environmental Protection Department (EPD) maintains a quality assurance (QA) program to continuously verify the integrity of data generated by its own environmental monitoring program and by its subcontracted laboratories.

Various definitions have been suggested for QA and quality control (QC). Frequently, the terms are used interchangeably. In the EMS program, QA consists of the system whereby the laboratory can assure clients and other outside entities, such as government agencies and accrediting bodies, that the laboratory is generating data of proven and known quality. QC refers to those operations undertaken in the laboratory to ensure that the data produced are generated within known probability limits of accuracy and precision.

Although QC represents the core activity in a QA program, the latter encompasses planned and systematic actions necessary to provide the evidence needed to assure that quality is achieved. The QA program has two basic goals:

- to create a management system that reduces the probability of error
- to detect and correct any errors that have occurred

Another QA component is quality assessment, which refers to the evaluation activities that provide assurance that the QC job is being done effectively.

Each aspect of the EMS environmental monitoring program, from sample collection to data reporting, must address QC and quality assessment standards defined in the *Savannah River Site Environmental Monitoring Section Quality Assurance Plan* (WSRC–3Q1–2, Volume 3, Section 8000).

This chapter summarizes the EMS QA/QC program. Guidelines and applicable standards for the program are referenced in appendix A, "Applicable Guidelines, Standards, and Regulations."

Tables containing the 2001 QA/QC data can be found in *SRS Environmental Data for 2001* (WSRC–TR–2001–00475). Nonradiological detection limits also are provided in *SRS Environmental Data for 2001*.

A more complete description of the QA/QC program can be found in *Savannah River Site Environmental Monitoring Section Plans and Procedures* (WSRC–3Q1–2, Volume 1, Section 1100).

QA/QC for Environmental Monitoring Section Laboratories

General objectives of the QA/QC program include

- validity, traceability, and reproducibility of reported results
- comparability of results within databases
- representativeness of each sample to the population or condition being measured
- accuracy and precision

Training for Personnel

EMS personnel are responsible for understanding and complying with all requirements applicable to the activities with which they are involved. Consequently, appropriate training courses are provided to assist them in fulfilling their responsibilities. Courses include training on applicable QA procedures, Occupational Safety and Health Administration-mandated training, and General Employee Training. Regulations and procedures that govern the environmental monitoring program are emphasized.

EMS analysts begin with specific training determined by job assignment. The section's technical work is

Statistical Terms

mean measurement of central tendency, commonly called the average

mean relative difference measure of reproducibility of identical chemical analyses

percent difference measure of accuracy used to compare "known" values with laboratory measurements; represents the absolute difference between the known and measured value divided by the known value; usually multiplied by 100 to be expressed as a percentage

based on its environmental procedures in sampling, radiochemistry, water quality, counting room, and data management and computer support.

Internal Quality Assurance Program

Specific QA checks and accepted practices are conducted by each EMS group, as described in the following paragraphs.

Field Sampling Group

Blind Sample Program EMS routinely conducts a blind sample program for field measurements of pH to assess the quality and reliability of field data measurements. Measurements of pH are taken in the field using the same equipment as is used for routine measurements.

During 2001, blind pH field measurements were taken for 24 samples. All field pH measurements were within the U.S. Environmental Protection Agency's (EPA's) suggested acceptable control limit of ± 0.4 pH units of the true (known) value.

Instrumentation Calibration EMS personnel also measure total residual chlorine, dissolved oxygen, and temperature in water samples; but because of the difficulties in providing field standards, these measurements are not suitable for a blind sample program. Therefore, quality control of these analyses relies instead on instrumentation calibration, per the section's procedures.

Chemistry and Counting Laboratories

Laboratory performance is evaluated through instrument checks, control charts, and data analyses. Within the Environmental Chemistry and Analysis group, graphical control checks and numerical trending are conducted on technician and method performance, with reports generated for sample results that exceed warning limits. The counting laboratory runs source checks and instrument backgrounds and performs calibrations regularly to monitor and characterize instrumentation.

Routine samples prepared and counted in EMS laboratories are subject to a variety of quality control checks to assess and ensure validity. The Environmental Chemistry and Analysis group prepares spike, blank, duplicate, and blind samples to check the performance of routine analyses. Spike samples and blank samples are used to calculate a recovery efficiency of an analytical method, to adjust for background radiation, and to evaluate counting equipment performance.

Blind Tritium Samples Blind tritium samples provide a continuous assessment of laboratory sample preparation and counting. The tritium activity is unknown to the technicians preparing the samples or the counting laboratory personnel. The blind samples

QA Terminology in the Laboratory

accuracy degree of agreement between a measurement and an accepted reference or true value

bias systematic (constant) underestimation or overestimation of the true value

spike sample sample to which a known amount of a substance has been added

precision measure of mutual agreement among individual measurements of the same property, under prescribed, similar conditions.

duplicate sample repeated but independent determinations on the same sample

blind sample (blind duplicate) mock sample of known constituent(s) or concentration(s); used as a control

blank samples clean samples analyzed to establish a baseline or background value used to adjust or correct results

control chart graphical chart of some measured parameter for a series of samples are prepared from National Institute of Standards and Technology (NIST)-traceable material or standardized against NIST material. The results are added to control charts to identify trends. During 2001, 12 blind samples were analyzed for tritium. All tritium results were within the control limits except two, which were close to the method detection limits. The results of these blind samples were used to validate analytical work in the chemistry and counting laboratories.

Laboratory Certification The EMS laboratory is certified by the South Carolina Department of Health and Environmental Control (SCDHEC) for the following analytes:

- under the Clean Water Act (CWA)—chemical oxygen demand, total suspended solids, and field pH, total residual chlorine, and temperature
- under the Resource Conservation and Recovery Act (RCRA)—50 volatile organic compounds (VOCs)

During 2001, the EMS laboratory was certified for 26 metal analytes under the CWA program and 27 metal analytes under the RCRA program by the SCDHEC Office of Laboratory Certification.

Data Verification and Validation

Results received from the counting laboratory are electronically evaluated by the Environmental Monitoring Computer Automation Program (EMCAP). Sample parameters—such as air flows, counting aliquots, and decay times—are flagged if values exceed preset limits or vary significantly from previous entries. An acceptance range for each analysis, based on historical results, is calculated for all routine environmental samples. Sample results outside the acceptance range are submitted for individual review, which may result in repeating the analyses, recounting, recalculating, or resampling for verification.

Before data are reported, they must be reviewed and validated by qualified personnel. Electronic verification is performed on 100 percent of the data stored in EMS databases. Through this verification, data anomalies are removed or data are rejected if there is disagreement with EMS QA/QC policies. The validation methods and criteria are documented in *WSRC Quality Assurance Manual* (WSRC–1Q, section 21–1, "Quality Assurance Requirements for the Collection and Evaluation of Environmental Data") and in EMS environmental geology procedures. Quality control requirements for managing, evaluating, and publishing environmental monitoring data are defined in WSRC–3Q1–2, volume 3, section 8000 (procedure 8250, "Quality Control Program for Environmental Data Management and Publications").

In 2001, an automated capability was implemented for the statistical evaluation of duplicate samples in the EMS laboratory. This process eliminated manual data entry and thus reduced the possibility of human error. More timely evaluations of duplicate measurements were performed, resulting in a significant quality assurance check regarding sample measurements.

External Quality Assurance Program

In 2001, the EMS laboratory participated in the U.S. Department of Energy (DOE) Quality Assurance Program (QAP), an interlaboratory comparison program that tracks performance accuracy and tests the quality of environmental data reported to DOE by its contractors.

Under this program, the DOE Environmental Measurements Laboratory (DOE/EML) sends samples to participating laboratories twice a year and compares the laboratories' results to program values. These comparisons verify the accuracy of EMS radiochemical analytical results. The quality control chemist maintains control charts to monitor trends and bias for each matrix (e.g., water, air filter, vegetation, soil) and analysis for various nuclides.

Reference samples for the QAP program—including soil/sediment, water, vegetation, and air filter samples—are prepared by DOE/EML and sent to the participating laboratories. Analytical results are reported to DOE/EML and are compared with the test results of other laboratories. DOE/EML evaluates the results and distributes a report to the participating laboratories. Results are rated as acceptable (A), acceptable with warning (W), and not acceptable (N). Control charts are maintained according to DOE/EML control limits. The following EMS analytical methods and instruments are tested in these studies:

- gamma emitters by gamma spectroscopy
- actinides by alpha spectroscopy
- strontium and gross alpha/beta by gas-flow proportional counters
- tritium by liquid scintillation

Work was completed in March on the 54th set of QAP samples for a radiological laboratory intercomparison. EMS analyzed 12 isotopes in air, 12 in soil, seven in vegetation, and 11 in water for a total of 42 results. Thirty-six of the results were rated "A," four were rated "W," and two were rated "N." A performance rating of 95 percent acceptable was achieved for this study. (This rating was calculated by dividing the “As” and the “Ws” by the total number of results.)

In QAP set 55, which was completed in September, EMS analyzed 12 isotopes in air, 14 in soil, seven in vegetation, and 11 in water for a total of 44 results. Thirty-five of the results were rated “A,” eight were rated “W,” and one was rated “N.” A performance rating of 98 percent acceptable was achieved for this study. (This rating was calculated by dividing the “As” and the “Ws” by the total number of results.) EMS QA personnel consider 80 percent to be a minimum acceptance rate in this program.

The March results rated nonacceptable were for lead-212 in soil and for tritium in water. EMS investigated each nonacceptable result to determine its cause, its seriousness. and appropriate corrective measures. Investigation conclusions were:

- Lead-212 in soil appeared biased low by 30 percent, probably due to spectral interference. Other low-energy gamma emitters seemed biased low by 10–20 percent, suggesting that instrument efficiency calibration curves need to be adjusted. Lead-212 is not a nuclide of major concern in the monitoring program.
- Tritium in water was reported as 268 percent high. This result was calculated incorrectly. A spike value was identified erroneously as a duplicate measurement and was averaged with the sample result. Had this computation error not occurred, the result would have been within acceptable limits. Software correction is the best long-term corrective measure. For the short term, manual data transfers can prevent this error from recurring.

The September results showed one nonacceptable result. Americium-241 on an air filter was reported as biased low by 62 percent. Americium-241 is a nuclide of major concern in the monitoring program. Investigation of this result was inconclusive. Instrument control charts showed no long-term bias for americium-241, and the sample preparation history showed no irregularities.

QA/QC for Subcontract Laboratories/Environmental Monitoring Section Laboratories

Subcontract laboratories providing analytical services must have a documented QA/QC program and meet the quality requirements defined in WSRC–1Q. The subcontract laboratories used during 2001 and the types of analyses performed are listed in table 9–1.

EMS personnel perform an annual evaluation of each subcontract laboratory to ensure that the laboratories maintain technical competence and follow the required QA programs. Each evaluation includes an examination of laboratory performance with regard to sample receipt, instrument calibration, analytical procedures, data verification, data reports, records management, nonconformance and corrective actions, and preventive maintenance. EMS provides reports of the findings and recommendations to each laboratory and conducts followup evaluations as necessary.

Nonradiological Liquid Effluents

Nonradiological liquid effluent samples are collected at each permitted SRS outfall according to requirements in the National Pollutant Discharge Elimination System (NPDES) permit issued by SCDHEC (discussed in appendix A, page 143). Effluent samples are analyzed by four laboratories—three onsite laboratories and one subcontract laboratory. Laboratories must be certified by SCDHEC for all analyses. The EMS laboratory performs analyses for temperature, pH, most total suspended solids, and total residual chlorine. The Site Utilities Division (SUD) Wastewater Laboratory performs analyses for pH, biological oxygen demand, and total suspended solids on sanitary facility wastewater samples. The TNX Effluent Treatment Facility performs analyses for temperature and pH. Shealy Environmental Services, Inc. (SESI), was the primary subcontractor for the NPDES program throughout 2001.

Interlaboratory Comparison Program

Interlaboratory comparison studies are used to compare the quality of results between laboratories performing the same analyses.

During 2001, SESI and other EMS subcontract laboratories (listed on page 133) participated in various InterlaB WatR™ Supply Water Pollution (WP) and Water Supply (WS) Performance Evaluation Programs. Performance results by the subcontract laboratories can be found in table 9–2.

An accredited commercial provider, Environmental Resources Associates (ERA), administered these programs. The format for the WP statistical summary is based on EPA’s national standards for water proficiency testing studies criteria. The format for the WS statistical summary is based on the Safe Drinking Water Act regulated acceptance limits. The statistical summaries are designed to show subcontract laboratories’ performance against the national WP

Table 9–1
Subcontract Laboratories for 2001

EMAX Laboratories, Inc.
(Torrence, Calif.)

groundwater nonradiological analyses

General Engineering Laboratories
(Charleston, S.C.)

groundwater radiological and nonradiological analyses

soil/sediment

waste characterization

General Engineering Mobile Laboratory
(formerly RFI Mobile Laboratory)
(Savannah River Site)

groundwater radiological and nonradiological analyses

soil radiological and nonradiological analyses

Lionville Laboratory (formerly Recra LabNet Philadelphia)
(Lionville, Pa.)

groundwater nonradiological analyses

soil/sediment

waste characterization

Microseeps, Inc.
(Pittsburgh, Pa.)

groundwater nonradiological analyses

soil gas

soil/sediment

site evaluation

Sanford Cohen & Associates
(Montgomery, Al.)

groundwater radiological analyses

soil/sediment radiological analyses

waste characterization radiological analyses

Shealy Environmental Services, Inc.
(Cayce, S.C.)

NPDES analyses

analyses for SRS streams and the Savannah River

Thermo NUtech
(Oak Ridge, Tenn.)

groundwater radiological analyses

and WS studies formerly run by EPA. The proficiency rating is calculated as follows: acceptable parameters divided by total parameters analyzed, multiplied by 100.

EPA uses WP and WS results to certify laboratories for specific analyses. As part of the recertification process, EPA requires that subcontract laboratories investigate the outside-acceptance-limit results and implement corrective actions as appropriate.

All laboratories (commercial and government) that analyze NPDES samples participate in the Discharge Monitoring Report–Quality Assurance (DMR–QA) study. Under this program, the laboratories obtain test samples from ERA. This provider, as required by EPA, is accredited by NIST. For the 2001 DMR–QA study, SESI used the WP 76 study (table 9–2).

The test samples from the provider have known chemical parameters—such as chemical oxygen demand—and contain known concentrations of constituents—such as total suspended solids, oil and grease, and certain trace metals. The report contains a statistical analysis of all data, as well as documentation of the known sample value, with stated acceptance limits and warning limits. Accepted variations from the known sample value depend on a variety of factors, including the precision of the analysis and the extent to which the results can be reproduced.

SESI reported acceptable results for 15 of 15 NPDES parameters and acceptable results for seven of nine voluntary analytes. EMS reported acceptable results for three of three parameters, SUD reported acceptable results for one of three parameters, and TNX Effluent Treatment Facility reported an acceptable result for one parameter. SESI's results were not acceptable for total Kjeldahl nitrogen and nitrate. SUD's results were not acceptable for pH and biological oxygen demand. Both SESI and SUD have corrective action plans in place to investigate and correct problems, and both reported acceptable results on subsequent samples for the unacceptable parameters.

EMS subcontract laboratories are required to have a corrective action plan to investigate and correct problems encountered in their performance.

Intralaboratory Comparison Program

SRS's intralaboratory program compares performance within a laboratory by analyzing duplicate and blind samples throughout the year. NPDES DMR protocol requires SRS to assign a "0" value to all nondetect values for reporting purposes. To facilitate data evaluation and provide consistency,

Table 9–2 Subcontract Laboratory Performance in ERA Water Pollution and Water Supply Studies

Laboratory	Water Pollution Studies (Percent Acceptable)	Water Supply Studies (Percent Acceptable)
Lionville	WP 72 (98%)[a]	WS 60 (98%)[b]
General Engineering	WP 75 (100%)	WS 54 (95%)[c]
General Engineering Mobile Lab	WP 75 (93%)[d]	
SESI	WP 74 (97%)[e]	WP 76 (100%)[f]

a Results for ammonia as N, total residual chlorine, and 2,4, 5–T were not acceptable.

b Results for fluoride, hexachlorobenzene, and simazine were not acceptable.

c Results for thallium, total organic carbon, bromide dichlorodifluromethane, dildrin, endrin, lindane, and methoxychlor were not acceptable.

d Results for phananthrene aroclor 1232, 1254, 1232, and 1254, dieldrin, benzo(b)fluoranthene, bis(2–chloroethyl)ether, 2,4–dinitrotoluene, hexachlorocyclopentadiene, isophorane, N–nitrosodiphenylamine, and 2–methylphenol were not acceptable.

e Results for potassium, sodium, nitrate as N, total Kjeldahl nitrogen, boron, molybdenum, and hexavalent chromium were not acceptable.

f All required NPDES results were acceptable. SESI had a 92% acceptable rate on voluntary analyte results. Results for total Kjeldahl nitrogen and nitrate were unacceptable. These analytes are not part of the NPDES program.

SRS assigns a value of “0” to all QA/QC nondetect analysis results.

SESI and the EMS laboratory analyzed a total of 93 duplicate samples during 2001. SESI analyzed 66 duplicate samples for various parameters, and EMS analyzed 27 duplicate samples for various parameters. Nondetectable results were reported for 74 of the 93 duplicate samples.

Percent difference calculations showed that six of the 66 duplicate samples analyzed by SESI were outside the EMS internal QA/QC requirement (± 20 percent of the true value).Three of the exceptions were at or near the detection limit, where accuracy is influenced more by uncertainties associated with analytical capability. Generally, exceptions in this range are not considered a problem.The other three exceptions appeared to be related to an analytical error, sample contamination, or improper sampling techniques.

Percent difference calculations showed that four of the 27 duplicate samples analyzed by EMS were outside the EMS internal QA/QC requirement (± 20 percent of the true value). Three of the exceptions were at or near the detection limit, where accuracy is influenced more by uncertainties associated with analytical capability. Generally, exceptions in this range are not considered a problem. The other exception appeared to be related to either an analytical error, sample contamination, or improper sampling techniques.

SESI and EMS analyzed a total of 128 blind samples during 2001. SESI analyzed 90 blind samples for various parameters, and EMS analyzed 38 blind samples for various parameters. Nondetectable results were reported for 90 of the 128 blind samples.

Percent difference calculations showed that 10 of the 89 blind samples analyzed by SESI were outside the EMS internal QA/QC requirement (± 20 percent of the true value). Eight of the exceptions were at or near the detection limit, where accuracy is influenced more by uncertainties associated with analytical capability. Generally, exceptions in this range are not considered a problem. The other two exceptions appeared to be related to an analytical error, sample contamination, or improper sampling techniques.

Percent difference calculations showed that five of the 38 blind samples analyzed by EMS were outside the EMS internal QA/QC requirement (± 20 percent of the true value). Four of the exceptions were at or near the detection limit, where accuracy is influenced more by uncertainties associated with analytical capability. Generally, exceptions in this range are not considered a problem. The other exception appeared to be related to either an analytical error, sample contamination, or improper sampling techniques.

Results for the duplicate and blind sampling programs met expectations, with no indications of consistent problems in the laboratory.

Stream and River Water Quality

The water quality program requires quality checks of 10 percent of the samples to verify analytical results. Analyses are required to be performed by a certified laboratory. Duplicate grab samples from SRS streams and the Savannah River were analyzed by SESI and the EMS laboratory in 2001. SESI analyzed samples for hardness, herbicides, nitrate + nitrite, phosphorus, pesticides, and total organic carbon. EMS analyzed duplicate samples for chemical oxygen demand, metals, and total suspended solids. A total of 664 analyses were performed.

Thirty-one samples were outside the ± 20 percent acceptance limit. For all of these results, the actual differences were small and the parameter concentrations low. Fifteen of the 31 analyses were at or near the detection limit, where accuracy is influenced more by uncertainties associated with analytical capability. Exceptions in this range generally are not considered a problem. The remaining 16 analyses—one for nickel, three for phosphorus, two for copper, one for manganese, two for chemical oxygen demand, one for mercury, and six for total suspended solids—could be attributed to laboratory analytical error, sample contamination, or improper sampling technique.

Groundwater

Groundwater analyses at SRS are performed by subcontract laboratories. During 2001, EMAX Laboratories, Inc., the EMS laboratory, General Engineering Laboratories, Lionville Laboratory, and Microseeps, Inc., were the primary subcontractors for nonradiological analyses. General Engineering Laboratories, Sanford Cohen & Associates, and Thermo NUtech were the primary subcontractors for radiological analyses. In addition, General Engineering Mobile Laboratory performed onsite analyses of volatile and semivolatile organics and metals.

SRS requires that subcontract laboratories investigate the outside-acceptance-limit results and implement corrective actions as appropriate.

Internal QA

During 2001, approximately 5 percent of the samples collected (radiological and nonradiological) for the RCRA and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) programs were submitted to the primary laboratory for analysis as blind duplicates and to a different laboratory as a QA check. The laboratories' results were evaluated on the basis of the percentage within an acceptable concentration range.

A statistical measure, the mean relative difference (MRD), is calculated to assess result reproducibility and laboratory performance. The laboratories also analyze approximately 10 percent of samples as intralaboratory QA checks. Interlaboratory comparisons were conducted between the following:

- General Engineering/Lionville
- General Engineering/Microseeps
- General Engineering/Sanford Cohen & Associates
- General Engineering Mobile/Sanford Cohen & Associates
- Lionville/General Engineering Mobile
- Thermo NUtech/General Engineering
- Thermo NUtech/General Engineering Mobile

Analytes outside or near acceptance limits do not appear to be systematic or to exhibit any identifiable trends. Full results for all QA/QC evaluations, including MRD calculations where appropriate, can be obtained by contacting the manager of the Westinghouse Savannah River Company (WSRC) Environmental Protection Department (EPD) at 803–725–1728.

External QA (Environmental Resource Associates Standards)

Water Pollution and Water Supply Studies During 2001, General Engineering, General Engineering Mobile, and Lionville participated in various WP and WS studies (WP and WS studies are described on page 130). Performance result summaries can be found in table 9–2.

Quarterly Assessments During 2001, EMS conducted quality assessments of the primary analytical laboratories to review their performance on certain analyses. Each laboratory received a set of certified environmental quality control standards from ERA, and its results were compared with the ERA-certified values and performance acceptance limits. The performance acceptance limits are listed as guidelines for acceptable analytical results, given the limitations of the EPA methods used to determine these parameters. The performance acceptance limits closely approximate the 95 percent confidence interval.

ERA became a certified producer of standards for the EPA WP/WS program in 1999. To accommodate this program, the compound list for several standards produced by ERA was expanded to incorporate the

Table 9–3 Subcontract Laboratory Performance on ERA Standards

Laboratory	1st Quarter 2001	Percent Within Limits 2nd Quarter 2001	3rd Quarter 2001
EMS		95.5[a]	95.5[b]
General Engineering	98.3[c]	98.3[d]	94.5[e]
General Engineering–Mobile Lab	95.2[f]	94.4[g]	88.2[h]
Microseeps		92.3[i]	97.8j
Lionville	93.8[k]	94.2[l]	84.1[m]

a The result for strontium was not acceptable.
b The result for strontium was not acceptable.
c Results for chloride, 2,4,5–T, and total phosphates (as P) were not acceptable.
d Results for chloride, dimethyl phthalate, and total phosphates (as P) were not acceptable.
e Results for bis(2–chloroethyl) ether, PCB 1016, trichloroethylene, and turbidity were not acceptable.
f Results for benzo[a]anthracene, dieldrin, di–n–butyl phthalate, fluorene, and xylenes were not acceptable.
g Results for benzo[b]fluoranthene, benzo[k]fluoranthene, 4–chloroaniline, endrin, hexachlorobutadiene, toxaphene, and 1,2,4–trichlorobenzene were not acceptable.
h Results for 1,3–dichlorobenzene, 1,2–dichloropropane, dieldrin, endrin, 1,2,4–trichlorobenzene, and trichloroethylene were not acceptable.
i Results for acetone, bis(2–chloroethoxy) methane, 2–chloronaphthalene, 1,1–dichloroethane, 1,2–dichloroethane, 2,4–dimethyl phenol, dimethyl phthalate, 2,4–dinitrophenol, nickel, and PCB 1242 were not acceptable.
j Results for antimony, cobalt, and iron were not acceptable.
k Results for ammonia nitrogen, bis(2–chloroethoxy) methane, 2,4–D, 1,2–dichlorobenzene, di–n–octyl phthalate, fluoride, hexachloroethane, pH, toxaphene, and 1,2,4–trichlorobenzene and were not acceptable.
l Results for acenaphthylene, ammonia nitrogen, 1,4–dichlorobenzene, dichloromethane (methylene chloride), fluoride, hexachlorobutadiene, naphthalene, 1,2,4–trichlorobenzene, total phosphates (as P), and toxaphene and were not acceptable.
m Results for 2,4–D, 1,3–dichlorobenzene, 2–methyl–4,6–dinitrophenol, and tetrachloroethylene were not acceptable.

full set of the National Environmental Laboratory Accreditation Conference (NELAC) analytes. Laboratories now are asked to identify standards that are below detection as well as those that are above detection.

NELAC is a voluntary association of state and federal agencies with full opportunity for input from the private sector. NELAC's purpose is to establish and promote mutually acceptable performance standards for the operation of environmental laboratories. EPA's National Environmental Laboratory Accreditation Program provides support to NELAC. When the standards are adopted by the state and federal agencies, NELAC will oversee the accrediting authority programs.

Results from the laboratories (EMS, General Engineering, General Engineering Mobile, Microseeps, and Lionville) for the first three quarters are summarized in table 9–3. Fourth-quarter results were not available.

Soil/Sediment

Environmental investigations of soils and sediments, primarily for RCRA/CERCLA units, are performed by subcontract laboratories (General Engineering, General Engineering Mobile, Lionville, Microseeps,, and Sanford Cohen & Associates —table 9–1, page 131).

Data are validated by EMS according to EPA standards for analytical data quality unless specified otherwise by site customers. Sixty projects were begun in 2001. Most projects, when completed, include a project summary report, which contains

- a project QA/QC summary
- a discussion of validation findings
- tables of validated and qualified data

The EMS validation program is based on an EPA guidance document, *Data Quality Objectives Process for Superfund* (EPA–540–R–93–071). This document identifies QA issues to be addressed, but it does not formulate a procedure for how to evaluate these inputs, nor does it propose pass/fail criteria to apply to data and documents. Hence, the EMS validation program necessarily contains elements from—and is influenced by—several other sources, including

- *QA/QC Guidance for Removal Activities*, interim final guidance, EPA–540–G–90–004
- *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, EPA–540/R–94/012
- *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, EPA–540/R–94/013
- T*est Methods for Evaluating Solid Waste*, EPA, November 1986, SW–846, Third Edition
- *Data Validation Procedures for Radiochemical Analysis*, WHC–SD–EN–SPP–001

Data management personnel in the soil/sediment program perform additional functions to ensure the quality of the data released by EMS. Two people enter the data for each entry to help eliminate errors, and all field, shipping, invoice, and analytical data are 100 percent verified.

Relative percent difference for the soil/sediment program is calculated for field duplicates and laboratory duplicates. A summary of this information is presented in each project report prepared by the Environmental Geochemistry Group of EMS.

Data Review

Several detailed data validation activities have been added to the QA program for groundwater and soil/sediment analyses procured from offsite commercial laboratories:

- laboratory data record reviews (since 1993)
- radiological data reviews (since 1996)
- metals interference reviews (since 1997)

The detailed data review is described in *Savannah River Site Environmental Monitoring Section Plans and Procedures*.

In 2001, the major QA issues that were discovered and addressed in connection with these programs included

- systematic misreporting of gamma spectroscopy detection limits at one laboratory
- systematic calculation errors for five nuclides at another laboratory

These findings illustrate that, although laboratory procedures are well defined, analytical data quality does benefit from technical scrutiny.

Conclusion

The QA/QC program reviews the performance of SRS organizations and its subcontractors to ensure that relevant quality control criteria are satisfied.

Reviews include

- laboratory audits
- field audits of sampling activities
- examination of sample preservation techniques and sample shipping process
- interlaboratory comparisons
- evaluation of analytical results of blanks, standards, and duplicates

Review of SRS subcontractor laboratories indicated that all met or exceeded the performance target criteria. Review of SRS's environmental sampling and analytical programs indicated that most data met applicable quality standards. Any deviations encountered were addressed by appropriate corrective action plans.

Quality assurance goals for the coming year include the following:

- Monitor closely the newly completed acceptance criteria for samples analysis within EMS and its subcontract laboratories.
- Complete EMS's plan to minimize the impact on the quality of sample analysis during EMS's move to a new laboratory facility.

Chapter 10

Special Surveys and Projects

Pete Fledderman
Environmental Protection Department

IN addition to routine sampling and special sampling during nonroutine environmental releases, special sampling for radiological and nonradiological surveys is conducted on and off site by personnel from the Savannah River Site (SRS) Environmental Protection Department's Environmental Monitoring Section (EMS) and from other groups, such as the Savannah River Technology Center (SRTC).

Both short- and long-term radiological and nonradiological surveys are used to monitor the effects of SRS effluents on the site's environment and in its immediate vicinity.

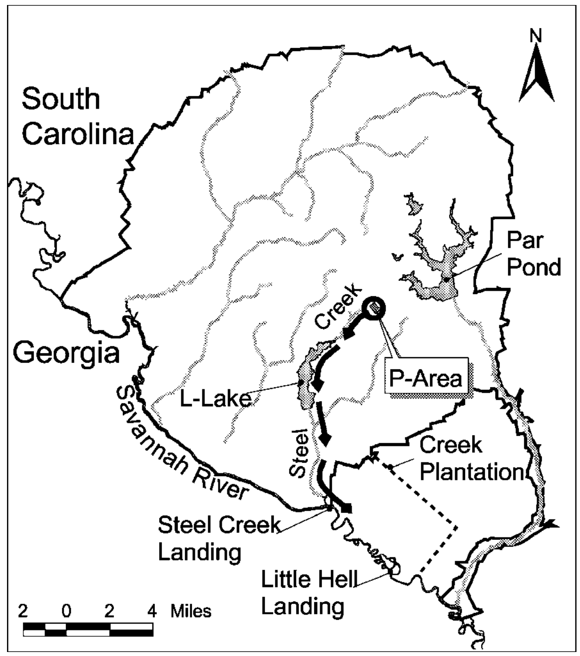
All conclusions discussed in this chapter are based on samples and analyses that have been completed. Because of sampling and/or analytical difficulties, some sample analyses may be missing. These analyses typically are small in number and represent only a very small fraction of the total number of samples. Their exclusion does not affect the results drawn from the data set. Detailed analytical results are presented in *SRS Environmental Data for 2001* (WSRC–TR–2001–00475).

Savannah River Swamp Surveys

Introduction

The Creek Plantation, a privately owned land area located along the Savannah River, borders the southeast portion of SRS. The land is primarily undeveloped and agricultural; it is used in equestrian-related operations and is a recreational hunt club. A portion of Creek Plantation along the Savannah River is a low-lying swamp known as the Savannah River Swamp, which is uninhabited and not easily accessible.

In the 1960s, an area of the Savannah River Swamp on Creek Plantation—specifically, the area between Steel Creek Landing and Little Hell Landing—was contaminated by SRS operations (figure 10–1). Failed experimental fuel elements leaked activity into the



SRTC Map

Figure 10–1 Swamp Contamination
Radioactivity released from SRS operations contaminated the Savannah River Swamp between Steel Creek and Little Hell Landing—an area outside the SRS boundary—during the 1960s. Approximately 25 Ci of cesium-137 and 1 Ci of cobalt-60 were released from the P-Area storage basin to Steel Creek and migrated downstream to a part of the swamp.

P-Area storage basin, from which water occasionally was discharged to Steel Creek. During high river levels, water from Steel Creek flowed along the lowlands comprising the swamp, resulting in the deposition of radioactive material. This water eventually discharged to the Savannah River at Little Hell Landing, contaminating a portion of the Savannah River Swamp. SRS studies estimated that a total of approximately 25 Ci of cesium-137 and 1 Ci of cobalt-60 were deposited in the swamp.

In 1974, a series of 10 sampling trails was established through the swamp, ranging in length from 240 to 3,200 feet (figure 10–2). Fifty-two monitoring

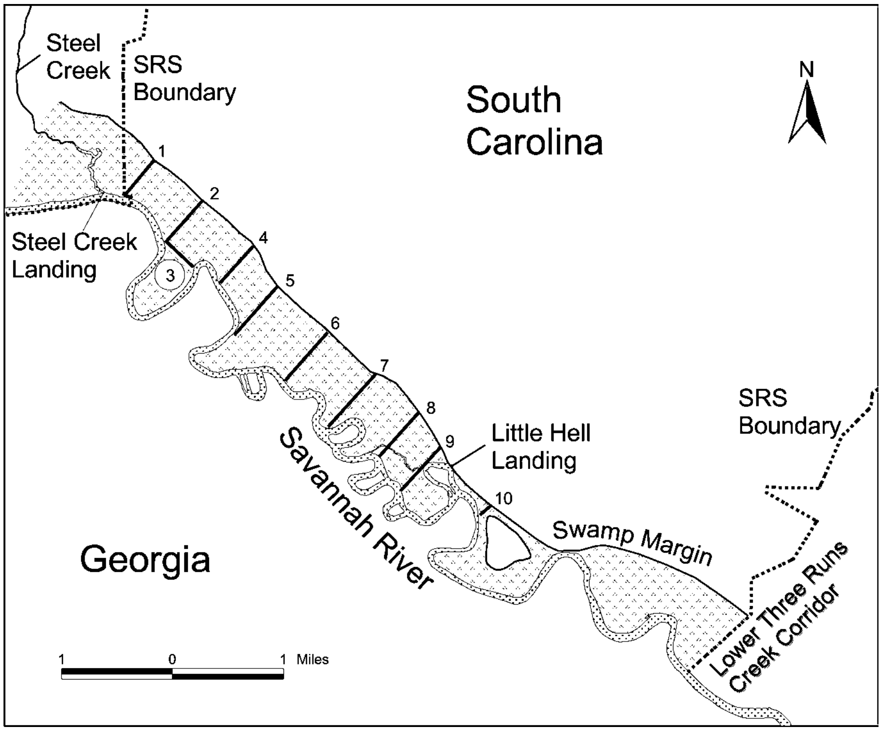


Figure 10–2 Savannah River Swamp Sampling Trails
Ten sampling trails were established in the Savannah River Swamp in 1974 so that surveys could be conducted on the movement of contamination from SRS operations.

SRTC Map

locations were designated on the trails to allow for continued monitoring at a consistent set of locations. Comprehensive and cursory surveys of the swamp have been conducted periodically since 1974. These surveys measure radioactivity levels to determine changes in the amount and/or distribution of radioactivity in the swamp. A cursory survey was conducted in 2001.

Details – 2001 Survey

The 2001 survey was conducted from early June through early September. Cursory surveys are conducted to provide assurance that conditions observed during the more detailed comprehensive surveys have not changed significantly. During cursory surveys, soil and vegetation samples are collected from one location per trail—typically at or near the area of highest observed activity. During the 2001 survey, soil samples were collected from seven of the 10 trails and vegetation samples from nine of the 10 trails.

Analytical Results

All 2001 survey samples were analyzed for gamma-emitting radionuclides, and all vegetation samples were analyzed for total strontium. However, laboratory problems prevented the analysis of soil samples for total strontium. As anticipated, based on source term information and historical survey results, cesium-137 was the primary radionuclide detected. Also, total strontium was present at low concentrations in one vegetation sample.

Cesium-137 was detected in all the soil and vegetation samples. Cesium-137 concentrations varied from approximately 0.2 to 77 pCi/g in soil, and from approximately 0.2 to 26 pCi/g in vegetation. These concentrations are consistent with historical results. In general, higher levels of cesium-137 in soil were observed in the trails closer to the SRS boundary, although somewhat elevated levels in soil were observed as far away as approximately 2 miles (trail 5).

As observed in previous surveys, the vertical distribution profile in soil—that is, the variation of contaminant concentration with depth in a soil column—is not as pronounced in the swamp, where significant scouring and/or deposition is possible, as it is in areas of undisturbed soil. These results indicate some movement (mobilization, movement and/or redeposition) of contamination in the swamp. No elevated cesium-137 levels were observed in samples from trail 10, indicating that the area of contamination has not spread beyond the current survey area boundary.

Cobalt-60 was not detected in any sample, while total strontium was detected in one of the nine vegetation samples.

Thermoluminescent dosimeter (TLD) sets were placed at all 54 monitoring sites to determine ambient gamma exposure rates. All the 50 sets were retrieved from the swamp; the exposure time varied from 43 to 84 days. The gamma exposure rate ranged from 0.19 to 0.74 mrem/day, which is consistent with the range observed in the 2000 survey—the most recent in which exposure rates were determined.

The highest exposure rates were measured on trails 1, 4, and 5. This follows the trends observed in previous surveys. Because of the limited scope of soil sampling, correlations between gamma exposure rate and cesium-137 concentrations in soil could not be examined.

Conclusion

Results of the 2001 survey of the Savannah River Swamp generally were consistent with those observed in previous surveys. Over time, some changes in the spatial distribution of activity throughout the swamp have been observed, which means that some localized movement of activity may be occurring. However, there has been little change in the results from the downstream location (trail 10), which indicates that activity is not migrating out of the identified contaminated area.

Appendix A

Applicable Guidelines, Standards, and Regulations

THE Savannah River Site (SRS) environmental monitoring program is designed to meet state and federal regulatory requirements for radiological and nonradiological programs. These requirements are stated in U.S. Department of Energy (DOE) Order 5400.1, "General Environmental Protection Program," and DOE Order 5400.5, "Radiation Protection of the Public and the Environment"; in the Clean Air Act [Standards of Performance for New Stationary Sources, also referred to as New Source Performance Standards (NSPS), and the National Emission Standards for Hazardous Air Pollutants (NESHAP)]; in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA—also known as the Superfund); in the Resource Conservation and Recovery Act (RCRA); in the Clean Water Act (i.e., National Pollutant Discharge Elimination System—NPDES); and in the National Environmental Policy Act (NEPA). Compliance with environmental requirements is assessed by DOE–Savannah River (DOE–SR), the South Carolina Department of Health and Environmental Control (SCDHEC), and the U.S. Environmental Protection Agency (EPA).

The SRS environmental monitoring program's objectives incorporate recommendations of

- the International Commission on Radiological Protection (ICPR) in *Principles of Monitoring for the Radiation Protection of the Population*, ICRP Publication 43
- DOE orders 5400.1 and 5400.5
- DOE/EH–0173T, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance"

Detailed information about the site's environmental monitoring program is documented in section 1111 (SRS EM Program) of the *SRS Environmental Monitoring Section Plans and Procedures*, WSRC–3Q1–2, Volume 1. This document is reviewed annually and updated every 3 years.

In addition, SRS has implemented and adheres to the SRS Environmental Management System Policy. As a result, the site has obtained International Organization for Standardization (ISO) 14001 certification. The full text of the policy is included in this appendix and begins on page 150.

Drinking water standards (DWS) can be found at http://www.epa.gov/safewater/mcl.html on the Internet, and maximum allowable concentrations of toxic air pollutants can be found at http://www.scdhec.net/baq. More information about certain media is presented in this appendix.

Air Effluent Discharges

DOE Order 5400.5 establishes Derived Concentration Guides (DCGs) for radionuclides in air. DCGs, calculated by DOE using methodologies consistent with recommendations found in International Commission on Radiological Protection (ICRP) publications 26 (*Recommendations of the International Commission on Radiological Protection*) and 30 (*Limits for the Intake of Radionuclides by Workers*), are used as reference concentrations for conducting environmental protection programs at DOE sites. DCGs are not considered release limits. DCGs for radionuclides in air are discussed in more detail on page 146.

Radiological airborne releases also are subject to EPA regulations cited in 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," Subpart H ("National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities").

Regulation of radioactive and nonradioactive air emissions—both criteria pollutants and toxic air pollutants—has been delegated to SCDHEC. SCDHEC, therefore, must ensure that its air pollution regulations are at least as stringent as federal regulations required by the Clean Air Act. This is accomplished by SCDHEC

Regulation 61–62, "Air Pollution Control Regulations and Standards." As with many regulations found in the Code of Federal Regulations (CFR), many of SCDHEC's regulations and standards are source specific. Each source of air pollution at SRS is permitted or exempted by SCDHEC, with specific emission rate limitations or special conditions identified. The bases for the limitations and conditions are the applicable South Carolina air pollution control regulations and standards. In some cases, specific applicable CFRs are also cited in the permits issued by SCDHEC.

Two SCDHEC standards, which govern criteria and toxic air pollutants and ambient air quality, are applicable to all SRS sources. Regulation 61–62.5, Standard No. 2, "Ambient Air Quality Standards," identifies eight criteria air pollutants commonly used as indices of air quality (e.g., sulfur dioxide, nitrogen dioxide, and lead) and provides allowable site boundary concentrations for each pollutant as well as the measuring intervals. Compliance with the various pollutant standards is determined by conducting air dispersion modeling for all sources of each pollutant using EPA-approved dispersion models and then comparing the results to the standard. The pollutants, measuring intervals, and allowable concentrations are given in table A–1. The standards are in micrograms per cubic meter unless noted otherwise.

Table A–1
Criteria Air Pollutants

Pollutant	Interval	μg/m^{3}[a,b]
Sulfur Dioxide	3 hours	1300[c]
	24 hours	365[c]
	annual	80
Total Suspended Particulates	Annual Geometric Mean	75
PM10	24 hours	150[d]
	annual	50[d]
Carbon Monoxide	1 hour	40 mg/m^3
	8 hours	10 mg/m^3
Ozone	1 hour	0.12 ppm[d]
Gaseous Fluorides (as HF)	12-hour avg.	3.7
	24-hour avg.	2.9
	1-week avg.	1.6
Nitrogen Dioxide	annual	100
Lead	Calendar Quarterly Mean	1.5

a Arithmetic average except in case of total suspended particulate matter (TSP)

b At 25 °C and 760 mm Hg

c Not to be exceeded more than once a year

d Attainment determinations will be made based on the criteria contained in appendices H and K, 40 CFR 50, July 1, 1987.

Two-hundred fifty-six toxic air pollutants and their respective allowable site boundary concentrations are identified in Regulation 61–62.5, Standard No. 8, "Toxic Air Pollutants." As with Standard No. 2, compliance is determined by air dispersion modeling. Toxic air pollutants can be found at http://www.scdhec.net/baq.

SCDHEC airborne emission standards for each SRS permitted source may differ, based on size and type of facility, type and amount of expected emissions, and the year the facility was placed into operation. For example, SRS powerhouse coal-fired boilers are regulated by Regulation 61–62.5, Standard No. 1, "Emissions From Fuel Burning Operations." This standard specifies that for powerhouse stacks built before February 11, 1971, the opacity standard is 40 percent. For new sources constructed after this date, the opacity standard typically is 20 percent. The standards for particulate and sulfur dioxide emissions are shown in table A–2.

Regulation 61–62.5, Standard No. 4, "Emissions from Process Industries," is applicable to all SRS sources except those regulated by a different source specific standard. For some SRS sources, particulate matter emission limits are dependent on the weight of the material being processed and are determined from a table in the regulation. For process and diesel engine stacks in existence on or before December 31, 1985, emissions shall not exhibit an opacity greater than 40 percent. For new sources, where construction was started after

Table A–2
Airborne Emission Standards for SRS Coal-Fired Boilers

Sulfur Dioxide	3.6 lb/10^6 BTU[a]
Total Suspended Particulates	0.6 b/10^6 BTU
Opacity	40%

a British Thermal Unit

December 31, 1985, the opacity standard is 20 percent.

As previously mentioned, some SRS sources have both SCDHEC and CFRs applicable and identified in their permits. For the package steam generating boilers in K-Area and two portable package boilers, both SCDHEC and federal regulations are applicable. The standard for sulfur dioxide emissions is specified in 40 CFR 60, Subpart Dc, "Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units," while the standard for particulate matter is found in Regulation 61–62.5, Standard No. 1, "Emissions From Fuel Burning Operations." Because these units were constructed after applicability dates found in both regulations, the opacity limit for these units is the same in both regulations. The emissions standards for these boilers are presented in table A–3.

Table A–3
Airborne Emission Standards for SRS Fuel Oil-Fired Package Boilers

Sulfur Dioxide	0.5 lb/10^6 BTU
Total Suspended Particulates	0.6 b/10^6 BTU
Opacity	20%

Another federal regulation, 40 CFR 60, Subpart Kb, "Standards of Performance for Volatile Organic Liquid Storage Vessels (Including Petroleum Liquid Storage Vessels) for which Construction, Reconstruction, or Modification Commenced after July 23, 1984," specifies types of emission controls that must be incorporated into the construction of a source. In this regulation, the type of control device required is dependent on the size of the tank and the vapor pressures of the material being stored. This regulation is applicable to several sources at SRS, such as the two 30,000-gallon No. 2 fuel oil storage tanks in K-Area or the four mixed solvent storage tanks in H-Area. However, because of the size of these tanks and vapor pressures of the materials being stored, these tanks are not required to have control devices installed. The only requirements applicable to SRS storage tanks are those for record keeping.

(Process) Liquid Effluent Discharges

DOE Order 5400.5 establishes DCGs for radionuclides in process effluents. (DCGs for radionuclides in water are discussed in more detail on page 146.) DCGs were calculated by DOE using methodologies consistent with recommendations found in ICRP, 1987 and ICRP, 1979 and are used

- as reference concentrations for conducting environmental protection programs at DOE sites
- as screening values for considering best available technology for treatment of liquid effluents

DOE Order 5400.5 exempts aqueous tritium releases from best available technology requirements but not from ALARA (as low as reasonably achievable) considerations.

SRS discharges water into site streams and the Savannah River under four NPDES permits: one industrial wastewater permit (SC0000175), one general utility water discharge permit (SCG250162), and two stormwater runoff permits (SCR000000 for industrial discharges and SCR100000 for construction discharges).

A fifth permit (ND0072125) is a no-discharge water pollution control land application permit that regulates sludge generated at onsite sanitary waste treatment plants.

Detailed requirements for each permitted discharge point—including parameters sampled for, permit limits for each parameter, sampling frequency, and method for collecting each sample—can be found in the individual permits, which are available to the public through SCDHEC's Freedom of Information Office at (803) 734–5376.

Site Streams

SRS streams are classified as "Freshwaters" by the South Carolina Pollution Control Act. Freshwaters are defined as surface water suitable for

- primary- and secondary-contact recreation and as a drinking water source after conventional treatment in accordance with SCDHEC requirements
- fishing and survival and propagation of a balanced indigenous aquatic community of fauna and flora

Table A–4
South Carolina Water Quality Standards for Freshwaters

Note: This is a partial list only of water quality standards for freshwaters.

Parameters	Standards
a. Fecal coliform	Not to exceed a geometric mean of 200/100 mL, based on five consecutive samples during any 30-day period; nor shall more than 10 percent of the total samples during any 30-day period exceed 400/100 mL.
b. pH	Range between 6.0 and 8.5.
c. Temperature	Generally, shall not be increased more than 5 °F (2.8 °C) above natural temperature conditions or be permitted to exceed a maximum of 90 °F (32.2 °C) as a result of the discharge of heated liquids. For exceptions, see E–9.A, Regulation 61–68, “Water Classifications and Standards” (June 26, 1998).
d. Dissolved oxygen	Daily average not less than 5.0 mg/L, with a low of 4.0 mg/L.
e. Garbage, cinders, ashes, sludge, or other refuse	None allowed.
f. Treated wastes, toxic wastes, deleterious substances, colored or other wastes, except those in (e) above.	None alone or in combination with other substances or wastes in sufficient amounts to make the waters unsafe or unsuitable for primary-contact recreation or to impair the waters for any other best usage as determined for the specific waters assigned to this class.
g. Ammonia, chlorine, and toxic pollutants listed in the federal Clean Water Act (307) and for which EPA has developed national criteria (to protect aquatic life).	See E–10 (list of water quality standards based on organoleptic data) and E–12 (water quality criteria for protection of human health), Regulation 61–68, “Water Classifications and Standards” (June 26, 1998).

SOURCE: [SCDHEC, 1998]

- industrial and agricultural uses

Table A–4 provides some of the specific guides used in water quality surveillance, but because some of these guides are not quantifiable, they are not tracked in response form (i.e., amount of garbage found).

Savannah River

Because the Savannah River is defined under the South Carolina Pollution Control Act as a Freshwater system, the river is regulated in the same manner as are site streams (table A–4).

Drinking Water

The federal Safe Drinking Water Act (SDWA)—enacted in 1974 to protect public drinking water supplies—was amended in 1980, 1986, and 1996.

SRS drinking water systems are tested routinely by SRS and SCDHEC to ensure compliance with SCDHEC State Primary Drinking Water Regulations, R61–58, and EPA National Primary Drinking Water Regulations, 40 CFR 141.

SRS drinking water is supplied by 18 separate systems, all of which utilize groundwater sources. The three larger consolidated systems (A-Area, D-Area, and K-Area) are actively regulated by SCDHEC and are classified as nontransient/noncommunity systems because each serves more than 25 people. The remaining 15 site water systems, each of which serves fewer than 25 people, receive a lesser degree of regulatory oversight.

Under the SCDHEC-approved, ultra-reduced monitoring plan, lead and copper sampling will not be required again for the A-Area consolidated system until 2004. The D-Area and K-Area consolidated water systems qualified in 1997 for an ultra-reduced monitoring plan. Both D-Area and K-Area will be sampled in 2003 for lead and copper.

The B-Area Bottled Water Facility, which was approved for operation in 1998, is listed as a public water system by SCDHEC and is required to be sampled for bacteriological analysis on a quarterly basis. Unlike the D-Area and K-Area consolidated water systems, lead and copper monitoring are not required.

DWS for specific radionuclides and contaminants can be found on the Internet at http://http://www.epa.gov/safewater/mcl.html.

Groundwater

The analytical results of samples taken from SRS monitoring wells that exceed various standards are discussed in this report. Constituents discussed are compared to final federal primary DWS, or other standards if DWS do not exist, because groundwater aquifers are defined as potential drinking water sources by the South Carolina Pollution Control Act. The DWS can be found at http://www.epa.gov/safewater/mcl.html on the Internet. DWS are not always the standards applied by regulatory agencies to the SRS waste units under their jurisdiction. For instance, standards under RCRA are DWS, groundwater protection standards, background levels, and alternate concentration limits.

Two constituents having DWS—dichloromethane and bis(2-ethylhexyl) phthalate—are not discussed in this report. Both are common laboratory contaminants and are reported in groundwater samples with little or no reproducibility. Both are reported, with appropriate flags and qualifiers, in the data tables of the quarterly reports cited in chapter 8, “Groundwater.”

The standard used for lead, 50 µg/L, is the SCDHEC DWS. The federal standard of 15 µg/L is a treatment standard for drinking water at the consumer’s tap; thus, it is inappropriate for use as a groundwater standard.

Of the radionuclides discussed, only gross alpha, strontium-90, and tritium are compared to true primary DWS. The regulatory standards for radionuclide discharges from industrial and governmental facilities are set under the Clean Water Act, RCRA, and Nuclear Regulatory Commission and DOE regulations. The proposed drinking water maximum contaminant levels discussed in this report are only an adjunct to these release restrictions and are not used to regulate SRS groundwater.

The standard used for gross beta is a screening standard; when public drinking water exceeds this standard, the supplier is expected to analyze for individual beta and gamma emitters. A gross beta result above the standard is an indication that one or more radioisotopes are present in quantities that would exceed the EPA annual dose equivalent for persons consuming 2 liters daily. Thus, for the individual beta and gamma radioisotopes (other than strontium-90 and tritium), the standard discussed in this report is the activity per liter that would, if only that isotope were present, exceed the dose equivalent. Similarly, the standards for alpha emitters discussed in this report are calculated to present the same risk at the same rate of ingestion.

Although radium has a DWS of 5 pCi/L for the sum of radium-226 and radium-228, the standards discussed in this report are the proposed standards of 20 pCi/L for each isotope separately. Radium-226, an alpha emitter, and radium-228, a beta emitter, cannot be analyzed by a single method. Analyses for total alpha-emitting radium, which consists of radium-223, radium-224, and radium-226, are compared to the standard for radium-226.

Four other constituents without DWS are discussed in this report when their values exceed specified levels. These constituents are specific conductance at values equal to or greater than 100 µS/cm, alkalinity (as $CaCO_3$) at values equal to or greater than 100 mg/L, total dissolved solids (TDS) at values equal to or greater than 200 mg/L, and pH at values equal to or less than 4.0 or equal to or greater than 8.5. The selection of these values as standards for comparison is somewhat arbitrary; however, these values exceed levels usually found in background wells at SRS. The occurrence of elevated alkalinity (as $CaCO_3$), specific conductance, pH, and TDS within a single well may indicate leaching of the grouting material used in well construction, rather than degradation of the groundwater.

Potential Dose

The radiation protection standards followed by SRS are outlined in DOE Order 5400.5 and include EPA regulations on the potential doses from airborne releases and treated drinking water.

The following radiation dose standards for protection of the public in the SRS vicinity are specified in DOE Order 5400.5.

Drinking Water Pathway . . . . 4 mrem per year
Airborne Pathway . . . . 10 mrem per year
All Pathways . . . . 100 mrem per year

The EPA annual dose standard of 10 mrem (0.1 mSv) for the atmospheric pathway, which is contained in 40 CFR 61, Subpart H, is adopted in DOE Order 5400.5.

These dose standards are based on recommendations of the ICRP and the National Council on Radiation Protection and Measurements (NCRP).

The DOE dose standard enforced at SRS for drinking water is consistent with the criteria contained in "National Interim Primary Drinking Water Regulations, 40 CFR Part 141." Under these regulations, persons consuming drinking water shall not receive an annual whole body dose—DOE Order 5400.5 interprets this dose as committed effective dose equivalent —of more than 4 mrem (0.04 mSv).

In 2000, EPA promulgated 40 CFR, Parts 9, 141, and 142, "National Primary Drinking Water Regulations; Radionuclides; Final Rule." This rule, which is applicable only to community drinking water systems, finalized maximum contaminant levels (MCLs) for radionuclides, including uranium. In essence, it reestablishes the MCLs from EPA's original 1976 rule. Most of these MCLs are derived from dose conversion factors that are based on early ICRP–2 methods.

However, when calculating dose, SRS must use the more current ICRP–30-based dose conversion factors provided by DOE. Because they are based on different methods, most EPA and DOE radionuclide dose conversion factors differ. Therefore, a direct comparison of the drinking water doses calculated for showing compliance with DOE Order 5400.5 to the EPA drinking water MCLs cannot be made.

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 DCGs, which are found in DOE Order 5400.5 for each radionuclide.

DCGs are used as reference concentrations for conducting environmental protection programs at all DOE sites. DCGs, which are based on a 100-mrem exposure, 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 large distance between most SRS operating facilities and the site boundary, this scenario is improbable.

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

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 releases. These considerations are applicable to direct discharges but not to seepage basin and Solid Waste Disposal Facility (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.

Per 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 effluents and consumes 2 liters of the effluents every day, 365 days a year. However, because of security controls and the large distance between most SRS operating facilities and the site boundary, this scenario is highly improbable, if not impossible.

For each site facility that releases radioactivity, the site's Environmental Monitoring Section (EMS) compares the monthly liquid effluent concentrations and 12-month average concentrations against the DOE DCGs.

Environmental Management

SRS began its cleanup program in 1981. Two major federal statutes provide guidance for the site's environmental restoration and waste management activities—RCRA and CERCLA. RCRA addresses the management of hazardous waste and requires that permits be obtained for facilities that treat, store, or dispose of hazardous or mixed waste. It also requires that DOE facilities perform appropriate corrective action to address contaminants in the environment. CERCLA (also known as Superfund) addresses the uncontrolled release of hazardous substances and the cleanup of inactive waste sites. This act establishes a National Priority List of sites targeted for assessment and, if necessary, corrective/remedial action. SRS was placed on this list December 21, 1989 [Fact Sheet, 2000]. In August 1993, SRS entered into the Federal Facility Agreement (FFA) with EPA Region IV and SCDHEC. This agreement governs the corrective/remedial action process from site investigation through site remediation. It also describes procedures for setting annual work priorities, including schedules and deadlines, for that process [FFA under section 120 of CERCLA and sections 3008(h) and 6001 of RCRA].

Additionally, DOE is complying with Federal Facility Compliance Act requirements for mixed waste management—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 the EPA or state regulators for approval.

The disposition of facilities after they are declared excess to the government's mission is managed by the Facilities Disposition Division. The facility disposition process is conducted in accordance with DOE Order 430.1A, "Life Cycle Asset Management," and its associated guidance documents. The major emphases are (1) to reduce the risks to workers, the public, and the environment, and (2) to reduce the costs required to maintain the facilities in a safe condition through a comprehensive surveillance and maintenance program.

Quality Assurance/Quality Control

DOE Order 414.1, "Quality Assurance," sets requirements and guidelines for departmental quality assurance (QA) practices. To ensure compliance with regulations and to provide overall quality requirements for site programs, Westinghouse Savannah River Company (WSRC) developed its *Quality Assurance Management Plan, Rev. 8* (WSRC–RP–92–225). The requirements of WSRC–RP–92–225 are implemented by the *Westinghouse Savannah River Company Quality Assurance Manual* (WSRC 1Q).

The *Savannah River Site Environmental Monitoring Section Quality Assurance Plan*, WSRC–3Q1–2, Volume 3, Section 8000), was written to apply the QA requirements of WSRC 1Q to the environmental monitoring and surveillance program. The EMS WSRC–3Q1 procedure series includes procedures on sampling, radiochemistry, and water quality that emphasize the quality control requirements for EMS.

QA requirements for monitoring radiological air emissions are specified in 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants." For radiological air emissions at SRS, the responsibilities and lines of communication are detailed in *National Emission Standards for Hazardous Air Pollutants Quality Assurance Project Plan (U)* (WSRC–IM–91–60).

To ensure valid and defensible monitoring data, the records and data generated by the monitoring program are maintained according to the requirements of DOE Guide 1324.5B, “Implementation Guide for Use with 36 CFR Chapter XII – Subchapter B Records Management,” and of WSRC 1Q. QA records include sampling and analytical procedure manuals, logbooks, chain-of-custody forms, calibration and training records, analytical notebooks, control charts, validated laboratory data, and environmental reports. These records are maintained and stored per the requirements of *WSRC Sitewide Records Inventory and Disposition Schedule* (WSRC–1M–93–0060).

EMS assessments are implemented according to the following documents:

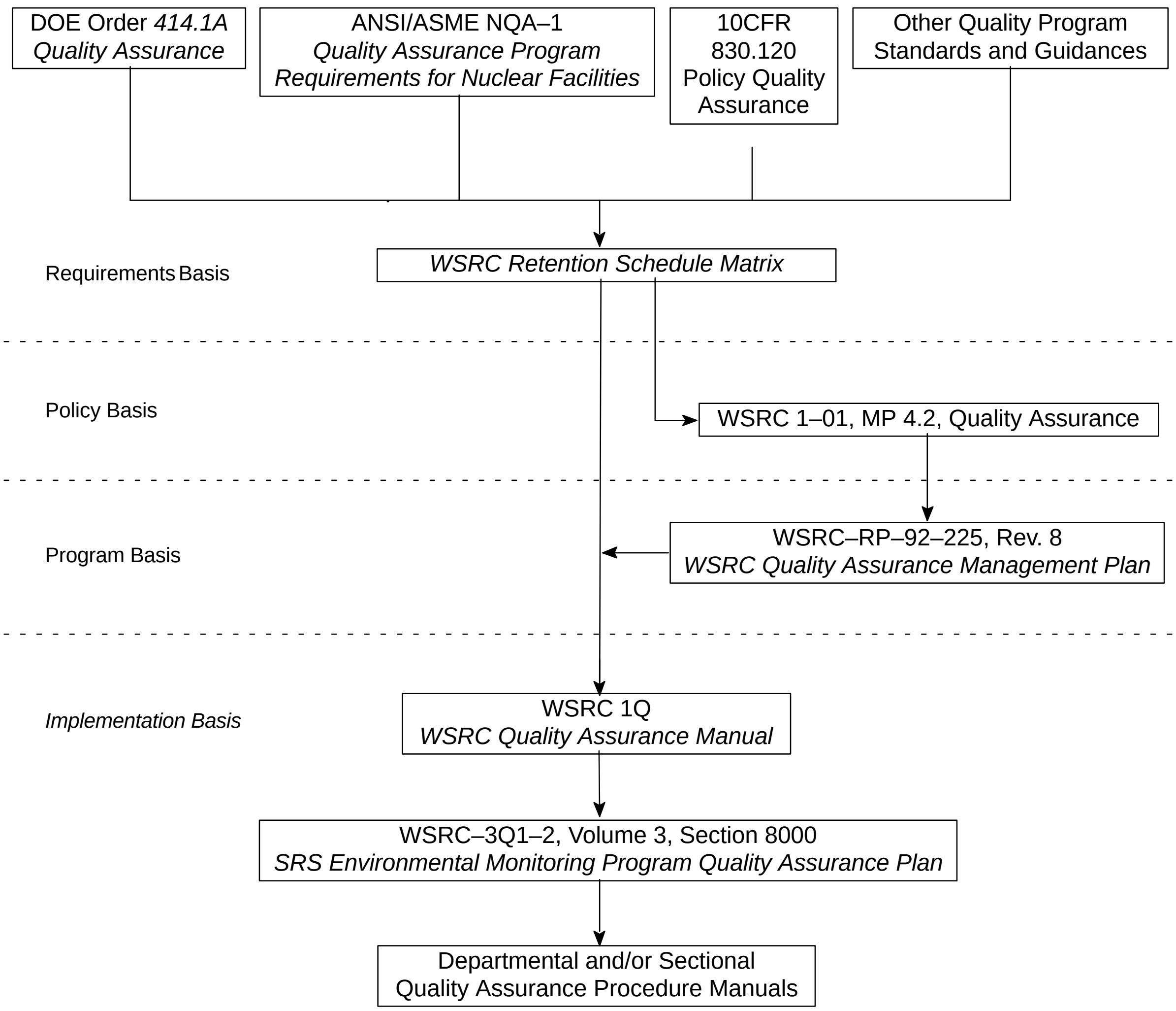
- WSRC 12Q, *Assessment Manual*
- WSRC 1Q
- DOE Order 414.1, “Quality Assurance”
- DOE/EM–0159P, “Analytical Laboratory Quality Assurance Guidance”
- DOE/EM–0157P, “Laboratory Assessment Plates”
- DOE/EH–0173T

Figure A–1 illustrates the hierarchy of relevant guidance documents that support the EMS QA/QC program.

Reporting

DOE Order 231.1, “Environment, Safety and Health Reporting,” requires that SRS submit an annual environmental report.

This report, the *Savannah River Site Environmental Report for 2001*, is an overview of effluent monitoring and environmental surveillance activities conducted on and in the vicinity of SRS from January 1 through December 31, 2001.



Other Quality Program Standards and Guidances

- ISO 1996
- ANSI 1995
- ISO 1999

Documents referenced in this chart are as follows:

- ANSI 1989
- DOE 2000
- DOE 2001a
- WSRC 1992
- WSRC 2001a
- WSRC 2001b
- WSRC 2001j
- WSRC 2001l

Figure A–1 SRS EM Program QA/QC Document Hierarchy
This diagram depicts the hierarchy of relevant guidance and supporting documents for the QA/QC program.

ISO 14001 Environmental Management System

ISO 14001 is the Environmental Management System Standard within the ISO 14000 series of standards, a family of voluntary environmental management standards and guidelines. SRS first achieved ISO 14001 certification in 1997 by demonstrating adherence to and programmatic implementation of the SRS Environmental Management System Policy. Annual audits are conducted to maintain certification, and a recertification audit is conducted every 3 years. The site was recertified in 2000 following the recertification audit, The full text of the policy (without the names of the signatories) follows.

Savannah River Site (SRS) Environmental Management System Policy November 1, 1999

OBJECTIVE:

The objective of this policy is to ensure every employee of the DOE Savannah River Operations Office (SR), all contractors, subcontractors, and other entities performing work at the Savannah River Site (SRS) do so in accordance with the requirements of ISO 14001, DOE Order 5400.1 and the mission, the vision, the core values, and the environmental goals and objectives of the Savannah River Site Strategic Plan.

DIRECTIVE:

Recognizing that all aspects of operations carried out at the SRS may impact the environment, the DOE–SR policy is that all employees, contractors, subcontractors, and other entities performing work at the SRS shall abide by the directives in this document. Westinghouse Savannah River Company (WSRC), Wackenhut Services, Inc. – Savannah River Site (WSI), Savannah River Ecology Laboratory (SREL), General Services Administration – Savannah River Site (GSA), and the Savannah River Natural Resources Management and Research Institute (SRI) shall, by virtue of their signature, endorse the principles stated in this policy.

- This document describes the SRS Environmental Management System Policy. It shall serve as the primary documentation for the environmental goals and objectives of the SRS and shall be available to the public. It shall be centrally maintained and updated as necessary to reflect the changing needs, missions, and goals of the SRS.
- The Environmental Management System shall pursue and measure continual improvement in performance by establishing and maintaining documented environmental objectives and targets that correspond to SRS's mission, vision, and core values. The environmental objectives and targets shall be established for each relevant function and level within DOE–SR and all contractors, subcontractors, and other entities performing work at the SRS for all activities having actual or potentially significant environmental impacts.
- DOE–SR and all contractors, subcontractors, and other entities performing work at SRS shall:

  1 Manage the SRS environment, natural resources, products, waste, and contaminated materials so as to eliminate or mitigate any threat to human health or the environment at the earliest opportunity and implement process improvements as appropriate to ensure continued improvement of performance in environmental management.

  2 Implement a pollution prevention program to reduce waste generation, releases of pollutants, future waste management/pollution control costs; and to minimize environmental impacts as well as promote increased energy efficiency.

  3 Conduct operations in compliance with the letter and spirit of all applicable federal, state, and local laws, regulations, statutes, executive orders, DOE directives and standards/requirements identification documents.

  4 Work cooperatively and openly with appropriate local, state, federal agencies, public stakeholders, and site employees to prevent pollution, achieve environmental compliance, conduct cleanup/restoration activities, enhance environmental quality, and ensure the protection of workers and the public health.

5 Design, develop, construct, operate, maintain, decommission and deactivate facilities and operations in a manner that shall be resource efficient and will protect and improve the quality of the environment for future generations and continue to maintain the SRS as a unique national environmental asset.

6 Recognize that the responsibility for quality communications rests with each individual employee and that it shall be the responsibility of all employees to identify and communicate ideas for improving environmental protection activities and programs at the site.

Adherence to and programmatic implementation of this policy shall be monitored by the DOE–SR Assistant Manager for Environmental Programs in coordination with the contractors, subcontractors, and other entities performing work on the SRS. An annual evaluation of the Environmental Management System, with recommendations for improvement, shall be provided to the undersigned managers. *[Editors' note: The names of the signatories that appeared at the end of the full text of the policy have not been included here.]*

Appendix B

Radionuclide and Chemical Nomenclature

Nomenclature and Half-Life for Radionuclides

Radionuclide	Symbol	Half-life[a,b]	Radionuclide	Symbol	Half-life[a,b]
Actinium-228	Ac-228	6.15 h	Mercury-203	Hg-203	46.61 d
Americium-241	Am-241	432.7 y	Neptunium-237	Np-237	2.14E6 y
Americium-243	Am-243	7370 y	Neptunium-239	Np-239	2.355 d
Antimony-124	Sb-124	60.2 d	Nickel-59	Ni-59	7.6E4 y
Antimony-125	Sb-125	2.758 y	Nickel-63	Ni-63	100 y
Argon-39	Ar-39	269 y	Niobium-94	Nb-94	2.0E4 y
Barium-133	Ba-133	10.7 y	Niobium-95	Nb-95	34.97 d
Beryllium-7	Be-7	53.28 d	Plutonium-238	Pu-238	87.7 y
Bismuth-212	Bi-212	2.14 m	Plutonium-239	Pu-239	2.41E4 y
Bismuth-214	Bi-214	19.9 m	Plutonium-240	Pu-240	6560 y
Carbon-14	C-14	5714 y	Plutonium-241	Pu-241	14.4 y
Cerium-141	Ce-141	32.5 d	Plutonium-242	Pu-242	3.75E5 y
Cerium-144	Ce-144	284.6 d	Potassium-40	K-40	1.27E9 y
Cesium-134	Cs-134	2.065 y	Praseodymium-144	Pr-144	17.28 m
Cesium-137	Cs-137	30.07 y	Praseodymium-144m	Pr-144m	7.2 m
Chromium-51	Cr-51	27.702 d	Promethium-147	Pm-147	2.6234 y
Cobalt-57	Co-57	271.8 d	Protactinium-231	Pa-231	3.28E4 y
Cobalt-58	Co-58	70.88 d	Protactinium-233	Pa-233	27.0 d
Cobalt-60	Co-60	5.271 y	Protactinium-234	Pa-234	6.69 h
Curium-242	Cm-242	162.8 d	Radium-226	Ra-226	1599 y
Curium-244	Cm-244	18.1 y	Radium-228	Ra-228	5.76 y
Curium-245	Cm-245	8.50E3 y	Ruthenium-103	Ru-103	39.27 d
Curium-246	Cm-246	4.76E3 y	Ruthenium-106	Ru-106	1.020 y
Europium-152	Eu-152	13.54 y	Selenium-75	Se-75	119.78 d
Europium-154	Eu-154	8.593 y	Selenium-79	Se-79	6.5E5 y
Europium-155	Eu-155	4.75 y	Sodium-22	Na-22	2.604 y
Iodine-129	I-129	1.57E7 y	Strontium-89	Sr-89	50.52 d
Iodine-131	I-131	8.0207 d	Strontium-90	Sr-90	28.78 y
Iodine-133	I-133	20.3 h	Technetium-99	Tc-99	2.13E5 y
Krypton-85	Kr-85	10.76 y	Thallium-208	Tl-208	3.053 m
Lead-212	Pb-212	10.64 h	Thorium-228	Th-228	1.913 y
Lead-214	Pb-214	27 m	Thorium-230	Th-230	7.54E4 y
Manganese-54	Mn-54	312.1 d	Thorium-232	Th-232	1.40E10 y

a m=minute; h = hour; d = day; y = year
b Reference: Chart of the Nuclides, 15th edition, revised 1996, General Electric Company

Nomenclature and Half-Life for Radionuclides, Continued

Radionuclide	Symbol	Half-life[a,b]	Radionuclide	Symbol	Half-life[a,b]
Thorium-234	Th-234	24.10 d	Uranium-235	U-235	7.04E8 y
Tin-113	Sn-113	115.1 d	Uranium-236	U-236	2.342E7 y
Tin-126	Sn-126	2.5E5 y	Uranium-238	U-238	4.47E9 y
Tritium (Hydrogen-3)	H-3	12.32 y	Xenon-135	Xe-135	9.10 h
Uranium-232	U-232	69.8 y	Zinc-65	Zn-65	243.8 d
Uranium-233	U-233	1.592E5 y	Zirconium-85	Zr-85	7.7 m
Uranium-234	U-234	2.46E5 y	Zirconium-95	Zr-95	64.02 d

a m=minute; h = hour; d = day; y = year
b Reference: Chart of the Nuclides, 15th edition, revised 1996, General Electric Company

Nomenclature for Elements and Chemical Constituent Analyses

Note: Some of the symbols listed in this table came from various databases used to format the data tables in this book and are included here to assist the reader in understanding the tables.

Constituent	Symbol	Constituent	Symbol
Aluminum	Al (or AL)	Nitrite, Nitrate	NO2,NO3 (or NO_2, NO_3 or NO2/NO3))
Ammonia	NH_3	pH	pH (or PH)
Ammonia as Nitrogen	NH_3–N (or AN)	Phenol	PHE
Antimony	Sb (or SB)	Phosphorus	P
Arsenic	As (or AS)	Phosphate	PO_4 (or PO4–P or PO_4–P)
Barium	Ba (or BA)	Polychlorinated Biphenyl	PCB
Biological Oxygen Demand	BOD	Potassium	K
Beryllium	Be	Selenium	Se (or SE)
Boron	B	Silver	Ag (or AG)
Bromide	B–	Sulfate	SO_4 (or SO4)
Cadmium	Cd (or CD)	Tetrachloroethene	PERCL
Chemical Oxygen Demand	COD	Tetrachloroethylene (Perchloroethylene)	PERCL
Chlorine	Cl (or CHL)	Trichloroethene	TRICL
Chromium	Cr (or CR)	Trichloroethylene	TRICL
Cobalt	Co	Tin	SN
Copper	Cu (or CU)	Total Dissolved Solids	TDS
Cyanide	CN	Total Kjeldahl Nitrogen	TKN
Dissolved Oxygen	DO	Total Organic Carbon	TOC
Iron	Fe (or FE)	Total Suspended Particulate Matter	TSP
Lead	Pb (or PB)	Total Suspended Solids	TSS
Magnesium	Mg (or MG)	Total Volatile Solids	TVS
Manganese	Mn (or MN)	Uranium	U
Mercury	Hg (or HG)	Vinyl Chloride	VC
Molybdenum	Mo	Zinc	Zn (or ZN)
Nickel	Ni (or NI)		
Nitrate	NO_3		
Nitrate as Nitrogen	NO_3–N		
Nitrite as Nitrogen	NO_2–N		

Appendix C

Errata from 2000 Report

The following information was reported incorrectly in the *Savannah River Site Environmental Report for 2000* (WSRC–TR–2000–00328):

Page 29, right column, next-to-last paragraph: The reference to 110 Halon 1301 systems should have been to 112 Halon 1301 systems; the reference to 79 systems abandoned in place should have been to 80 systems abandoned in place.

Page 106, left column, second full paragraph: The reference to a highest value of 1,200 pCi/L should have been to a highest value of 1,260 pCi/L.

Page 256, seventh entry: The document number for the "SRS Data, 2001" entry should have been WSRC–TR–2000–00329.

Glossary

A

accuracy – Closeness of the result of a measurement to the true value of the quantity.

actinide – Group of elements of atomic number 89 through 103. Laboratory analysis of actinides by alpha spectrometry generally refers to the elements plutonium, americium, uranium, and curium but may also include neptunium and thorium.

activity – See radioactivity.

air flow – Rate of flow, measured by mass or volume per unit of time.

air stripping – Process used to decontaminate groundwater by pumping the water to the surface,"stripping" or evaporating the chemicals in a specially-designed tower, and pumping the cleansed water back to the environment.

aliquot – Quantity of sample being used for analysis.

alkalinity – Alkalinity is a measure of the buffering capacity of water, and since pH has a direct effect on organisms as well as an indirect effect on the toxicity of certain other pollutants in the water, the buffering capacity is important to water quality.

alpha particle – Positively charged particle emitted from the nucleus of an atom having the same charge and mass as that of a helium nucleus (two protons and two neutrons).

ambient air – Surrounding atmosphere as it exists around people, plants, and structures.

analyte – Constituent or parameter that is being analyzed.

analytical detection limit – Lowest reasonably accurate concentration of an analyte that can be detected; this value varies depending on the method, instrument, and dilution used.

aquifer – Saturated, permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients.

aquitard – Geologic unit that inhibits the flow of water.

Atomic Energy Commission – Federal agency created in 1946 to manage the development, use, and control of nuclear energy for military and civilian application. It was abolished by the Energy Reorganization Act of 1974 and succeeded by the Energy Research and Development Administration. Functions of the Energy Research and Development Administration eventually were taken over by the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission.

B

background radiation – Naturally occurring radiation, fallout, and cosmic radiation. Generally, the lowest level of radiation obtainable within the scope of an analytical measurement, i.e., a blank sample.

bailer – Container lowered into a well to remove water. The bailer is allowed to fill with water and then is removed from the well.

best management practices – Sound engineering practices that are not, however, required by regulation or by law.

beta particle – Negatively charged particle emitted from the nucleus of an atom. It has a mass and charge equal to those of an electron.

blank – Control sample that is identical, in principle, to the sample of interest, except that the substance being analyzed is absent. In such cases, the measured value or signal for the substance being analyzed is believed to be due to artifacts. Under certain circumstances, that value may be subtracted from the measured value to give a net result reflecting the amount of the substance in the sample. The Environmental Protection Agency does not permit the subtraction of blank results in Environmental Protection Agency-regulated analyses.

blind blank – Sample container of deionized water sent to a laboratory under an alias name as a quality control check.

blind replicate – In the Environmental Monitoring Section groundwater monitoring program, a second sample taken from the same well at the same time as the primary sample, assigned an alias well name, and sent to a laboratory for analysis (as an unknown to the analyst).

blind sample – Control sample of known concentration in which the expected values of the constituent are unknown to the analyst.

C

calibration – Process of applying correction factors to equate a measurement to a known standard. Generally, a documented measurement control program of charts, graphs, and data that demonstrate that an instrument is properly calibrated.

Carolina bay – Type of shallow depression commonly found on the coastal Carolina plains. Carolina bays are typically circular or oval. Some are wet or marshy, while others are dry.

Central Savannah River Area (CSRA) – Eighteen-county area in Georgia and South Carolina surrounding Augusta, Georgia. The Savannah River Site is included in the Central Savannah River Area. Counties are Richmond, Columbia, McDuffie, Burke, Emanuel, Glascock, Jenkins, Jefferson, Lincoln, Screven, Taliaferro, Warren, and Wilkes in Georgia and Aiken, Edgefield, Allendale, Barnwell, and McCormick in South Carolina.

chemical oxygen demand – Indicates the quantity of oxidizable materials present in a water and varies with water composition, concentrations of reagent, temperature, period of contact, and other factors.

chlorocarbons – Compounds of carbon and chlorine, or carbon, hydrogen, and chlorine, such as carbon tetrachloride, chloroform, tetrachloroethylene, etc. They are among the most significant and widespread environmental contaminants. Classified as hazardous wastes, chlorocarbons may have a tendency to cause detrimental effects, such as birth defects.

cleanup – Actions taken to deal with release or potential release of hazardous substances. This may mean complete removal of the substance; it also may mean stabilizing, containing, or otherwise treating the substance so that it does not affect human health or the environment.

closure – Control of a hazardous waste management facility under Resource Conservation and Recovery Act requirements.

compliance – Fulfillment of applicable requirements of a plan or schedule ordered or approved by government authority.

composite – Blending of more than one portion to make a sample for analysis.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) – This act addresses the cleanup of hazardous substances and establishes a National Priorities List of sites targeted for assessment and, if necessary, restoration (commonly known as “Superfund”).

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-reportable release – Release to the environment that exceeds reportable quantities as defined by the Comprehensive Environmental Response, Compensation, and Liability Act.

concentration – Amount of a substance contained in a unit volume or mass of a sample.

conductivity – Measure of water’s capacity to convey an electric current. This property is related to the total concentration of the ionized substances in a water and the temperature at which the measurement is made.

contamination – State of being made impure or unsuitable by contact or mixture with something unclean, bad, etc.

count – Signal that announces an ionization event within a counter; a measure of the radiation from an object or device.

counting geometry – Well-defined sample size and shape for which a counting system has been calibrated.

criteria pollutant – any of the pollutants commonly used as indices for air quality that can have a serious effect on human health and the environment, including sulfur dioxide, nitrogen dioxide, total suspended particulates, PM_{10}, carbon monoxide, ozone, gaseous fluorides, and lead.

curie – Unit of radioactivity. One curie is defined as 3.7×10^{10} (37 billion) disintegrations per second. Several fractions and multiples of the curie are commonly used:

kilocurie (kCi) – 10^3 Ci, one thousand curies; 3.7×10^{13} disintegrations per second.

millicurie (mCi) – 10^{-3} Ci, one-thousandth of a curie; 3.7×10^7 disintegrations per second.

microcurie (µCi) – 10^{-6} Ci, one-millionth of a curie; 3.7×10^4 disintegrations per second.

picocurie (pCi) – 10^{-12} Ci, one-trillionth of a curie; 0.037 disintegrations per second.

D

decay (radioactive) – Spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide, or into a different energy state of the same radionuclide.

decay time – Time taken by a quantity to decay to a stated fraction of its initial value.

deactivation – The process of placing a facility in a stable and known condition, including the removal of hazardous and radioactive materials to ensure adequate protection of the worker, public health and safety, and the environment—thereby limiting the long-term cost of surveillance and maintenance.

decommissioning – Process that takes place after deactivation and includes surveillance and maintenance, decontamination, and/or dismantlement.

decontamination – The removal or reduction of residual radioactive and hazardous materials by mechanical, chemical, or other techniques to achieve a stated objective or end condition.

deactivation and decommissioning – Program that reduces the environmental and safety risks of surplus facilities at SRS.

derived concentration guide – Concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air or inhalation), would result in either an effective dose equivalent of 0.1 rem (1 mSv) or a dose equivalent of 5 rem (50 mSv) to any tissue, including skin and lens of the eye. The guides for radionuclides in air and water are given in Department of Energy Order 5400.5.

detection limit – See analytical detection limit, lower limit of detection, minimum detectable concentration.

detector – Material or device (instrument) that is sensitive to radiation and can produce a signal suitable for measurement or analysis.

diatometer – Diatom collection equipment consisting of a series of microscope slides in a holder that is used to determine the amount of algae in a water system.

diatoms – Unicellular or colonial algae of the class Bacillariophyceae, having siliceous cell walls with two overlapping, symmetrical parts. Diatoms represent the predominant periphyton (attached algae) in most water bodies and have been shown to be reliable indicators of water quality.

disposal – Permanent or temporary transfer of Department of Energy control and custody of real property to a third party, which thereby acquires rights to control, use, or relinquish the property.

disposition – Those activities that follow completion of program mission—including, but not limited to, surveillance and maintenance, deactivation, and decommissioning.

dissolved oxygen – Desirable indicator of satisfactory water quality in terms of low residuals of biologically available organic materials. Dissolved oxygen prevents the chemical reduction and subsequent leaching of iron and manganese from sediments.

dose – Energy imparted to matter by ionizing radiation. The unit of absorbed dose is the rad, equal to 0.01 joules per kilogram in any medium.

absorbed dose – Quantity of radiation energy absorbed by an organ, divided by the organ's mass. Absorbed dose is expressed in units of rad (or gray) (1 rad=0.01Gy).

dose equivalent – Product of the absorbed dose (rad) in tissue and a quality factor. Dose equivalent is expressed in units of rem (or sievert) (1 rem=0.01 sievert).

committed dose equivalent – Calculated total dose equivalent to a tissue or organ over a 50-year period after known intake of a radionuclide into the body. Contributions from external dose are not included. Committed dose equivalent is expressed in units of rem (or sievert).

committed effective dose equivalent – Sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem (or sievert).

effective dose equivalent – Sum of the dose equivalents received by all organs or tissues of the body after each one has been multiplied by an appropriate weighting factor. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent attributable to sources external to the body.

collective dose equivalent/collective effective dose equivalent – Sums of the dose equivalents or effective dose equivalents of all individuals in an exposed population within a 50-mile (80-km) radius, and expressed in units of person-rem (or person-sievert). When the collective dose equivalent of interest is for a specific organ, the units would be organ-rem (or organ-sievert). The 50-mile distance is measured from a point located centrally with respect to major facilities or Department of Energy program activities.

dosimeter – Portable detection device for measuring the total accumulated exposure to ionizing radiation.

downgradient – In the direction of decreasing hydrostatic head.

drinking water standards – Federal primary drinking water standards, both proposed and final, as set forth by EPA.

duplicate result – Result derived by taking a portion of a primary sample and performing the identical analysis on that portion as is performed on the primary sample.

E

effluent – Any treated or untreated air emission or liquid discharge to the environment.

effluent monitoring – Collection and analysis of samples or measurements of liquid and gaseous effluents for purposes of characterizing and quantifying the release of contaminants, assessing radiation exposures of members of the public, and demonstrating compliance with applicable standards.

environmental compliance – Actions taken in accordance with government laws, regulations, orders, etc., that apply to site operations' effects on onsite and offsite natural resources and on human health; used interchangeably in this document with regulatory compliance.

environmental monitoring – Program at Savannah River Site that includes effluent monitoring and environmental surveillance with dual purpose of (1) showing compliance with federal, state, and local regulations, as well as with U.S. Department of Energy orders, and (2) monitoring any effects of site operations on onsite and offsite natural resources and on human health.

environmental restoration – Department of Energy program that directs the assessment and cleanup of inactive waste units and groundwater (remediation) contaminated as a result of nuclear-related activities.

environmental surveillance – Collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media from Department of Energy sites and their environs and the measurement of external radiation for purposes of demonstrating compliance with applicable standards, assessing radiation exposures to members of the public, and assessing effects, if any, on the local environment.

exceedance – Term used by the Environmental Protection Agency and the South Carolina Department of Health and Environmental Control that denotes a report value is more than the upper guide limit. This term is found on the Discharge Monitoring Report forms that are submitted to the Environmental Protection Agency or the South Carolina Department of Health and Environmental Control.

exposure (radiation) – Incidence of radiation on living or inanimate material by accident or intent. Background exposure is the exposure to natural background ionizing radiation. Occupational exposure is that exposure to ionizing radiation which takes place during a person's working hours. Population exposure is the exposure to the total number of persons who inhabit an area.

exposure pathway – Route that materials follow to get to the environment and then to people.

F

fallout – See worldwide fallout.

Federal Facility Agreement (FFA) – Agreement negotiated among the Department of Energy, the Environmental Protection Agency, and the South Carolina Department of Health and Environmental Control, specifying how the Savannah River Site will address contamination or potential contamination to meet regulatory requirements at the Savannah River Site waste units identified for evaluation and, if necessary, cleanup.

feral hog – Hog that has reverted to the wild state from domestication.

G

gamma ray – High-energy, short wavelength electromagnetic radiation emitted from the nucleus of an excited atom. Gamma rays are identical to X-rays except for the source of the emission.

gamma-emitter – Any nuclide that emits a gamma ray during the process of radioactive decay. Generally, the fission products produced in nuclear reactors.

gamma spectrometry – System consisting of a detector, associated electronics, and a multichannel analyzer that is used to analyze samples for gamma-emitting radionuclides.

grab sample – Sample collected instantaneously with a glass or plastic bottle placed below the water surface to collect surface water samples (also called dip samples).

H

half-life (radiological) – Time required for half of a given number of atoms of a specific radionuclide to decay. Each nuclide has a unique half-life.

heavy water – Water in which the molecules contain oxygen and deuterium, an isotope of hydrogen that is heavier than ordinary hydrogen.

hydraulic gradient – Difference in hydraulic head over a specified distance.

hydrology – Science that treats the occurrence, circulation, distribution, and properties of the waters of the earth, and their reaction with the environment.

I

in situ – In its original place. Field measurements taken without removing the sample from its origin; remediation performed while groundwater remains below the surface.

inorganic – Involving matter other than plant or animal.

instrument background – Instrument signal due to electrical noise and other interferences not attributed to the sample or blank.

ion exchange – Process in which a solution containing soluble ions is passed over a solid ion exchange column that removes the soluble ions by exchanging them with labile ions from the surface of the column. The process is reversible so that the trapped ions are removed (eluted) from the column and the column is regenerated.

irradiation – Exposure to radiation.

isotopes – Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons.

> **long-lived isotope –** Radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than three years).
>
> **short-lived isotope –** Radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is two days or less).

L

laboratory blank – Deionized water sample generated by the laboratory; a laboratory blank is analyzed with each batch of samples as an in-house check of analytical procedures. Also called an internal blank.

legacy – Anything handed down from the past; inheritance, as of nuclear waste.

lower limit of detection – Smallest concentration/amount of analyte that can be reliably detected in a sample at a 95 percent confidence level.

M

macroinvertebrates – Size-based classification used for a variety of insects and other small invertebrates; as defined by the Environmental Protection Agency, those organisms that are retained by a No. 30 (590 micron) U.S. Standard Sieve.

macrophyte – A plant that can be observed with the naked eye.

manmade radiation – Radiation from sources such as consumer products, medical procedures, and nuclear industry.

maximally exposed individual – Hypothetical individual who remains in an uncontrolled area and would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

mean relative difference – Percentage error based on statistical analysis.

mercury – Silver-white, liquid metal solidifying at –38.9 °C to form a tin-white, ductile, malleable mass. It is widely distributed in the environment and biologically is a nonessential or nonbeneficial element. Human poisoning due to this highly toxic element has been clinically recognized.

migration – Transfer or movement of a material through the air, soil, or groundwater.

minimum detectable concentration – Smallest amount or concentration of a radionuclide that can be distinguished in a sample by a given measurement system at a preselected counting time and at a given confidence level.

moderate – To reduce the excessiveness of; to act as a moderator.

moderator – Material, such as heavy water, used in a nuclear reactor to moderate or slow down neutrons from the high velocities at which they are created in the fission process.

monitoring – Process whereby the quantity and quality of factors that can affect the environment and/or human health are measured periodically in order to regulate and control potential impacts.

N

nonroutine radioactive release – Unplanned or nonscheduled release of radioactivity to the environment.

nuclide – Atom specified by its atomic weight, atomic number, and energy state. A radionuclide is a radioactive nuclide.

O

opacity – The reduction in visibility of an object or background as viewed through the diameter of a plume.

organic – Of, relating to, or derived from living organisms (plant or animal).

outcrop – Place where groundwater is discharged to the surface. Springs, swamps, and beds of streams and rivers are the outcrops of the water table.

outfall – Point of discharge (e.g., drain or pipe) of wastewater or other effluents into a ditch, pond, or river.

P

parameter – Analytical constituent; chemical compound(s) or property for which an analytical request may be submitted.

permeability – Physical property that describes the ease with which water may move through the pore spaces and cracks in a solid.

person-rem – Collective dose to a population group. For example, a dose of one rem to 10 individuals results in a collective dose of 10 person-rem.

pH – Measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH from 0–6, basic solutions have a pH > 7, and neutral solutions have a pH = 7.

piezometer – Instrument used to measure the potentiometric surface of the groundwater. Also, a well designed for this purpose.

plume – Volume of contaminated air or water originating at a point-source emission (e.g., a smokestack) or a waste source (e.g., a hazardous waste disposal site).

point source – any defined source of emission to air or water such as a stack, air vent, pipe, channel or passage to a water body.

population dose – See collective dose equivalent under dose.

process sewer – Pipe or drain, generally located underground, used to carry off process water and/or waste matter.

purge – To remove water prior to sampling, generally by pumping or bailing.

purge water – Water that has been removed prior to sampling; water that has been released to seepage basins to allow a significant part of tritium to decay before the water outcrops to surface streams and flows to the Savannah River.

Q

quality assurance (QA) – In the Environmental Monitoring System program, QA consists of the system whereby the laboratory can assure clients and other outside entities, such as government agencies and accrediting bodies, that the laboratory is generating data of proven and known quality.

quality control (QC) – In the Environmental Monitoring System program, QC refers to those operations undertaken in the laboratory to ensure that the data produced are generated within known probability limits of accuracy and precision.

R

rad – Unit of absorbed dose deposited in a volume of material.

radioactivity – Spontaneous emission of radiation, generally alpha or beta particles, or gamma rays, from the nucleus of an unstable isotope.

radioisotopes – Radioactive isotopes.

radionuclide – Unstable nuclide capable of spontaneous transformation into other nuclides by changing its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

real-time instrumentation – Operation in which programmed responses to an event are essentially simultaneous with the event itself.

reforestation – Process of planting new trees on land once forested.

regulatory compliance – Actions taken in accordance with government laws, regulations, orders, etc., that apply to site operations’ effects on onsite and offsite natural resources and on human health; used interchangeably in this document with environmental compliance.

release – Any discharge to the environment. Environment is broadly defined as any water, land, or ambient air.

rem – Unit of dose equivalent (absorbed dose in rads $\times$ the radiation quality factor). Dose equivalent is frequently reported in units of millirem (mrem) which is one-thousandth of a rem.

remediation – Assessment and cleanup of Department of Energy sites contaminated with waste as a result of past activities. See environmental restoration.

remediation design – Planning aspects of remediation, such as engineering characterization, sampling studies, data compilation, and determining a path forward for a waste site.

replicate – In the Environmental Monitoring Section groundwater monitoring program, a second sample from the same well taken at the same time as the primary sample and sent to the same laboratory for analysis.

Resource Conservation and Recovery Act (RCRA) – Federal legislation that regulates the transport, treatment, and disposal of solid and hazardous wastes. This act also requires corrective action for releases of hazardous waste at inactive waste units.

Resource Conservation and Recovery Act (RCRA) site – Solid waste management unit under Resource Conservation and Recovery Act regulation. See Resource Conservation and Recovery Act.

retention basin – Unlined basin used for emergency, temporary storage of potentially contaminated cooling water from chemical separations activities.

RFI/RI Program – RCRA Facility Investigation/Remedial Investigation Program. At the Savannah River Site, the expansion of the RFI Program to include Comprehensive Environmental Response, Compensation, and Liability Act and hazardous substance regulations.

routine radioactive release – Planned or scheduled release of radioactivity to the environment.

S

seepage basin – Excavation that receives wastewater. Insoluble materials settle out on the floor of the basin and soluble materials seep with the water through the soil column where they are removed partially by ion exchange with the soil. Construction may include dikes to prevent overflow or surface runoff.

sensitivity – Capability of methodology or instruments to discriminate between samples with differing concentrations or containing varying amounts of analyte.

settling basin – Temporary holding basin (excavation) that receives wastewater which is subsequently discharged.

site stream – Any natural stream on the Savannah River Site. Surface drainage of the site is via these streams to the Savannah River.

source – Point or object from which radiation or contamination emanates.

source check – Radioactive source with a known amount of radioactivity used to check the performance of the radiation detector instrument.

source term – Quantity of radioactivity released in a set period of time that is traceable to the starting point of an effluent stream or migration pathway.

spent nuclear fuel – Used fuel elements from reactors.

spike – Addition of a known amount of reference material containing the analyte of interest to a blank sample.

stable – Not radioactive or not easily decomposed or otherwise modified chemically.

stack – Vertical pipe or flue designed to exhaust airborne gases and suspended particulate matter.

standard deviation – Indication of the dispersion of a set of results around their average.

stormwater runoff – Surface streams that appear after precipitation.

Superfund – see Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

supernate – Portion of a liquid above settled materials in a tank or other vessel.

surface water – All water on the surface of the earth, as distinguished from groundwater.

T

tank farm – Installation of interconnected underground tanks for storage of high-level radioactive liquid wastes.

temperature – Thermal state of a body considered with its ability to communicate heat to other bodies.

thermoluminescent dosimeter (TLD) – Device used to measure external gamma radiation.

total dissolved solids – Dissolved solids and total dissolved solids are terms generally associated with freshwater systems and consist of inorganic salts, small amounts of organic matter and dissolved materials.

total phosphorus – When concentrations exceed 25 mg/L at the time of the spring turnover on a volume-weighted basis in lakes or reservoirs, it may occasionally stimulate excessive or nuisance growths of algae and other aquatic plants.

total suspended particulates – Refers to the concentration of particulates in suspension in the air irrespective of the nature, source, or size of the particulates.

transport pathway – pathway by which a released contaminant physically is transported from its point of discharge to a point of potential exposure to humans. Typical transport pathways include the atmosphere, surface water, and groundwater.

transuranic waste – Solid radioactive waste containing primarily alpha-emitting elements heavier than uranium.

trend – General drift, tendency, or pattern of a set of data plotted over time.

turbidity – Measure of the concentration of sediment or suspended particles in solution.

U

unspecified alpha and beta emissions – the unidentified alpha and beta emissions that are determined at each effluent location by subtracting the sum of the individually measured alpha-emitting (e.g., plutonium-239 and uranium-235) and beta-emitting (e.g., cesium-137 and strontium-90) radionuclides from the measured gross alpha and beta values, respectively.

V

vitrify – Change into glass.

vitrification – Process of changing into glass.

volatile organic compounds – Broad range of organic compounds, commonly halogenated, that vaporize at ambient, or relatively low, temperatures (e.g., acetone, benzene, chloroform, and methyl alcohol).

W

waste management – The Department of Energy uses this term to refer to the safe, effective management of various kinds of nonhazardous, hazardous, and radioactive waste generated on site.

waste unit – Inactive area that is known to have received contamination or had a release to the environment.

water table – Planar, underground surface beneath which earth materials, as soil or rock, are saturated with water.

weighting factor – Value used to calculate dose equivalents. It is tissue specific and represents the fraction of the total health risk resulting from uniform, whole-body irradiation that could be attributed to that particular tissue. The weighting factors used in this report are recommended by the International Commission on Radiological Protection (Publication 26).

wetlands – Lowland area, such as a marsh or swamp, inundated or saturated by surface or groundwater sufficiently to support hydrophytic vegetation typically adapted for life in saturated soils.

wind rose – Diagram in which statistical information concerning direction and speed of the wind at a location is summarized.

worldwide fallout – Radioactive debris from atmospheric weapons tests that has been deposited on the earth’s surface after being airborne and cycling around the earth.

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Units of Measure		Units of Measure	
Symbol	**Name**	**Symbol**	**Name**
Temperature		*Concentration*	
°C	degrees Centigrade	ppb	parts per billion
°F	degrees Fahrenheit	ppm	parts per million
Time			
d	day	*Rate*	
h	hour	cfs	cubic feet per second
y	year	gpm	gallons per minute
Length			
cm	centimeter	*Conductivity*	
ft	foot	µmho	micromho
in.	inch		
km	kilometer		
m	meter	*Radioactivity*	
mm	millimeter	Ci	curie
µm	micrometer	cpm	counts per minute
		mCi	millicurie
Mass		µCi	microcurie
g	gram	pCi	picocurie
kg	kilogram	Bq	becquerel
mg	milligram		
µg	microgram	*Radiation Dose*	
		mrad	millirad
Area		mrem	millirem
mi^2	square mile	Sv	sievert
ft^2	square foot	mSv	millisievert
		µSv	microsievert
Volume		R	roentgen
gal	gallon	mR	milliroentgen
L	liter	µR	microroentgen
mL	milliliter	Gy	gray

Fractions and Multiples of Units				
Multiple	**Decimal Equivalent**	**Prefix**	**Symbol**	**Report Format**
10^6	1,000,000	mega-	M	E+06
10^3	1,000	kilo-	k	E+03
10^2	100	hecto-	h	E+02
10	10	deka-	da	E+01
10^{-1}	0.1	deci-	d	E–01
10^{-2}	0.01	centi-	c	E–02
10^{-3}	0.001	milli-	m	E–03
10^{-6}	0.000001	micro-	μ	E–06
10^{-9}	0.000000001	nano-	n	E–09
10^{-12}	0.000000000001	pico-	p	E–12
10^{-15}	0.000000000000001	femto-	f	E–15
10^{-18}	0.000000000000000001	atto-	a	E–18

Conversion Table (Units of Radiation Measure)		
Current System	***Systéme International***	**Conversion**
curie (Ci)	becquerel (Bq)	1 Ci = 3.7×10^{10} Bq
rad (radiation absorbed dose)	gray (Gy)	1 rad = 0.01 Gy
rem (roentgen equivalent man)	sievert (Sv)	1 rem = 0.01 Sv

Conversion Table					
Multiply	**By**	**To Obtain**	**Multiply**	**By**	**To Obtain**
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft
mi	1.61	km	km	0.621	mi
lb	0.4536	kg	kg	2.205	lb
liq qt-U.S.	0.946	L	L	1.057	liq qt-U.S.
ft^2	0.093	m^2	m^2	10.764	ft^2
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.31	ft^3
d/m	0.450	pCi	pCi	2.22	d/m
pCi	10^{-6}	μCi	μCi	10^6	pCi
pCi/L (water)	10^{-9}	μCi/mL (water)	μCi/mL (water)	10^9	pCi/L (water)
pCi/m^3 (air)	10^{-12}	μCi/mL (air)	μCi/mL (air)	10^{12}	pCi/m^3 (air)