Front Cover — A European dark honey bee *(Apis melllifera mellifera)* pays a springtime visit to the bloom of a chicasaw plum *(Prunus angustifolia)* near SRS's L Lake. The bee, sometimes referred to as a German black bee, originally occurred from Britain to Central Europe; it was introduced to North America in colonial times. Chicasaw plum normally is quite shrubby—a head-high thicket of branches all pointing upward—and can be found in the powerline cut near the top of L Lake and in other "open" habitats, including agricultural fields that have been out of production for several years. The species, a member of the Rosaceae (or rose) family, provides excellent food for wildlife, as its drupes mature, fall to the ground, and are eaten by birds, small mammals, and deer. The fruit also is edible to humans—most frequently in sauces, pies, preserves, jams, and jellies. This year's cover photograph was taken by Al Mamatey of Savannah River Nuclear Solutions' Regulatory Integration & Environmental Services Department. The cover was designed by Eleanor Justice of the company's Records and Document Control Information Section – Information Management and Program Support Group.

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SRNS–STI–2010–00175

Savannah River Site

Environmental Report for 2009

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To Our Readers

SRS has had an extensive environmental monitoring program in place since 1951 (before site startup). In the 1950s, data generated by the onsite environmental monitoring program were reported in site documents. Beginning in 1959, data from offsite environmental surveillance activities were presented in reports issued for public dissemination. SRS reported onsite and offsite environmental monitoring activities separately until 1985, when data from both programs were merged into one public document.

The *Savannah River Site Environmental Report for 2009* (SRNS–STI–2010–00175) is an overview of effluent monitoring and environmental surveillance activities conducted on and in the vicinity of SRS from January 1 through December 31, 2009—including the site's performance against applicable standards and requirements. Details are provided on major programs such as self-assessments, the Environmental Management System (EMS), and permit compliance. Information for the 2009 report was compiled and prepared by the Regulatory Integration & Environmental Services Department of Savannah River Nuclear Solutions LLC (SRNS), the site's M&O contractor. The "SRS Environmental Monitoring Plan" (WSRC–3Q1–2–1002) and the "SRS Environmental Monitoring Program" (WSRC–3Q1–2–1100) provide complete program descriptions and document the rationale and design criteria for the monitoring program, the frequency of monitoring and analysis, the specific analytical and sampling procedures, and the quality assurance requirements.

Complete data tables are included on the CD inside the back cover of this report. The CD also features (1) an electronic version of the report; (2) an appendix of site, environmental sampling location, dose, and groundwater maps; and (3) annual (2009) reports from a number of other SRS organizations. The data tables generally are presented as unformatted Excel spreadsheets; they are not intended to be printed. However, if printing is desired, the user can modify the "Page Setup" parameters in Excel as needed. If printing of the "SRS Maps" on the CD is desired, it is recommended (to ensure clarity) that figures 1–25 be printed 8.5x11 inches and figures 26–34 be printed 36x32 inches.

The following information should aid the reader in interpreting data in this report:

- Variations in environmental report data reflect year-to-year changes in the routine monitoring program, as well as occasional difficulties in sample collection or analysis. Examples of such difficulties include adverse environmental conditions (such as flooding or drought), sampling or analytical equipment malfunctions, sample handling and transportation issues, compromise of the samples in the preparation laboratories or counting room.

- Table heading abbreviations may include the following: (1) "N" is number of observations; (2) "SampleCon" is sample concentration; (3) "SampleStd" is standard deviation; and (4) "Sig" is significance.

- Analytical results and their corresponding uncertainty terms generally are reported with up to three significant figures. This is a function of the computer software used and may imply greater accuracy in the reported results than the analyses would allow.

- Units of measure and their abbreviations are defined in the glossary (beginning on page

G-1) and in charts at the back of the report. The reported uncertainty of a single measurement reflects only the counting error—not other components of random and systematic error in the measurement process—so some results may imply a greater confidence than the determination would suggest.

- An uncertainty quoted with a mean value represents the standard deviation of the mean value. This number is calculated from the uncertainties of the individual results. For an unweighted mean value, the uncertainty is the sum of the variances for the individual values divided by the number of individual results squared. For a weighted mean value, the uncertainty is the sum of the weighted variances for the individual values divided by the square of the sum of the weights.
- All values represent the weighted average of all acceptable analyses of a sample for a particular analyte. Samples may have undergone multiple analyses for quality assurance purposes or to determine if radionuclides are present. For certain radionuclides, quantifiable concentrations may be below the minimum detectable activity of the analysis, in which case the actual concentration value is presented to satisfy DOE reporting guidelines.
- The generic term "dose," as used in the report, refers to the committed effective dose equivalent (50-year committed dose) from internal deposition of radionuclides and to the effective dose equivalent attributable to beta/gamma radiation from sources external to the body.

Report Available on Web

Readers can find the *SRS Environmental Report* on the World Wide Web at the following address: http://www.srs.gov/general/pubs/ERsum/index.html.

Contents

List of Figures

List of Tables

Acronyms and Abbreviations

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

A

ACP – Area Completion Projects

ACM – Asbestos-containing material

ALARA – As low as reasonably achievable

ANSI – American National Standards Institute

ANS – Academy of Natural Sciences

AOP – Annual Operational Plan

B

BAT – Best Available Technology

BCG – Biota concentration guide

BE – Biological Evaluation

BGN – Burial Ground North

bgs – Below ground surface

BJWSA – Beaufort-Jasper Water and Sewer Authority

BTU – British thermal unit

C

CAA – Clean Air Act

CAAA – Clean Air Act Amendments of 1990

CAB – Citizens Advisory Board

CAT – Consolidated Annual Training

CD – Compact disk

C&D – Construction and Demolition

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

CFR – Code of Federal Regulations

Ci – Curie

CMIR – Corrective Measures Implementation Report

COE – U.S. Army Corps of Engineers

CSRA – Central Savannah River Area

CWA – Clean Water Act

D

DCG – Derived concentration guide

DOE – U.S. Department of Energy

DOECAP – U.S. Department of Energy Consolidated Audit Program

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

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

DMWE – Data Management and Waste Engineering

DMR – Discharge Monitoring Report

DWS – Drinking water standards

E

EA – Environmental assessment

EEC – Environment evaluation checklist

EIS – Environmental impact statement

EM – Environmental Monitoring

EMCAP – Environmental Management Consolidated Audit Program

EML – Environmental Monitoring Lab

EMS – Environmental Management System

EO – Executive Order

EPA – U.S. Environmental Protection Agency

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

ERA – Environmental Resource Associates

ESD – Explanation of Significant Difference

ESA – Endangered Species Act

ESEC – Environmental Science Educator's Cooperative

F

FEB – Facility Evaluation Board

FFA – Federal Facility Agreement

FFCAct – Federal Facility Compliance Act

FIFRA – Federal Insecticide, Fungicide, and Rodenticide Act

FIMS – Flow injection mercury system

FONSI – Finding of no significant impact

FWS – U.S. Fish and Wildlife Service

G

GDNR – Georgia Department of Natural Resources

GET – General employee training

GNEP – Global Nuclear Energy Partnership

GSMP – Groundwater Surveillance Monitoring Program

GSA – General Separations Area

GTCC – Greater Than Class C

Gy – Gray

I

IAPCR – Interim Action Post Closure Report

ICP-AES – Inductively coupled plasma atomic emission spectrometry

ICP-MS – Inductively coupled plasma mass spectrometry

ICRP – International Commission on Radiological Protection

ISMS – Integrated Safety Management System

ISO – International Organization for Standardization

K

kg – Kilogram

L

LDR – Land disposal restrictions

LLW – Low-level radioactive waste

M

M&O – Management and Operating

MACT – Maximum achievable control technology

MAPEP – Mixed Analyte Performance Evaluation Program

mCi – Millicurie

MCL – Maximum contaminant level

MDC – Minimum detectable concentration

MFFF – Mixed Oxide Fuel Fabrication Facility

Mg/L – Milligrams per liter

mL – Milliliter

MOA – Memoranda of agreement

MOX – Mixed oxide

mrem – Millirem

mSv – Millisievert

N

NBN – No building number

NEPA – National Environmental Policy Act

NESHAP – National Emission Standards for Hazardous Air Pollutants

NHPA – National Historic Preservation Act

NOV – Notice of violation

NPDES – National Pollutant Discharge Elimination System

NRC – Nuclear Regulatory Commission

NRMP – Natural Resources Management Plan

NWP – Nationwide permit

O

ODS – Ozone-depleting substance

OFI – Opportunity for improvement

P

P2 – Pollution prevention program

PA – Performance assessment

PAR – P and R (Pond)

PCB – Polychlorinated biphenyl

PCR – Post-construction report

pCi/L – Picocuries per liter

PEIS – Programmatic environmental impact statement

PM – Particulate matter

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

POC – Point of contact

ppb – Parts per billion

ppm – Parts per million

PUREX – Plutonium Uranium Extraction Process

Q

QA – Quality assurance

QC – Quality control

R

RACR – Remedial Action Completion Report

RCRA – Resource Conservation and Recovery Act

RFI/RI – RCRA facility investigation/remedial investigation

RI&ES – Regulatory Integration and Environmental Services

RHA – Rivers and Harbors Act

RM – River mile

RMP – Risk management program

ROD – Record of decision

S

SA – Supplement analysis

SARA – Superfund Amendments and Reauthorization Act

Savannah I&D – Savannah Industrial and Domestic Water Supply Plant

SCDHEC – South Carolina Department of Health and Environmental Control

SDD – Site Deactivation and Decommissioning

SDWA – Safe Drinking Water Act

SE – Removal site evaluation

SEIS – Supplemental environmental impact statement

SES – Shealy Environmental Services, Inc.

SCE&G – South Carolina Electric and Gas

SIRIM – Site Item Reportability and Issues Management

SLA – Service level agreement

SRARP – Savannah River Archaeological Research Program

SREL – Savannah River Ecology Laboratory

S/RID – Standards/Requirements Identification Document

SRNL – Savannah River National Laboratory

SRNS – Savannah River Nuclear Solutions, LLC

SRR – Savannah River Remediation LLC

SRS – Savannah River Site

STAR – Site Tracking, Analysis, and Reporting

STP – Site Treatment Plan

SWDF – Solid Waste Disposal Facility

T

TCLP – Toxicity characteristic leaching procedure

TEAM – Transformational Energy Action Management

TEM – Transmission electron microscopy

TLD – Thermoluminescent dosimeter

TDS – Total dissolved solids

TRI – Toxic Release Inventory

TRU – Transuranic waste

TSCA – Toxic Substances Control Act

TSS – Total suspended solids

TVA – Tennessee Valley Authority

U

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

μg/L– Micrograms per liter

μg/m^3 – Micrograms per cubic meter

μS/cm – Microsieverts per centimeter

USGS – U.S. Geological Survey

UST – Underground storage tank

UTM – Universal Transverse Mercator

V

VEGP – Vogtle Electric Generating Plant

VOC – Volatile organic compound

W

WIPP – Waste Isolation Pilot Plant

W/Min – Waste minimization

WMAP – Waste Management Area Project

WP – Water pollution

WQC – Water quality certification

WS – Water supply

WSI-SRS – Wackenhut Services Incorporated–Savannah River Site

WSMS – Washington Safety Management Solutions

WSRC – Washington 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
4MB	Fourmile Branch (Four Mile Creek)
4MC	Four Mile Creek
BDC	Beaver Dam Creek
BG	Burial Ground
EAV	E-Area Vaults
FM	Four Mile
FMB	Fourmile Branch (Four Mile Creek)
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 (Augusta Lock and Dam)
PAR	"P and R" Pond
PB	Pen Branch
PMR	Patterson Mill Road
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
VEGP	Vogtle Electric Generating Plant (Plant Vogtle)

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–3A; Four Mile Creek at Road C

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

Lower Three Runs–3; Lower Three Runs at Highway 125

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 8–1

Upper Three Runs–3; Upper Three Runs at Road C

Executive Summary

The Savannah River Site Environmental Report for 2009 (SRNS–STI–2010–00175) is prepared for the U.S. Department of Energy (DOE) according to requirements of DOE Order 231.1A,"Environment, Safety and Health Reporting," and DOE Order 5400.5, "Radiation Protection of the Public and Environment."

The annual SRS Environmental Report has been produced for more than 50 years. Several hundred copies are distributed each year to government officials, universities, public libraries, environmental and civic groups, news media, and interested individuals. The report's purpose is to

- *present summary environmental data that characterize site environmental management performance*
- *confirm compliance with environmental standards and requirements*
- *highlight significant programs and efforts*

Minimal Impact

SRS maintained its record of environmental excellence in 2009, as its operations continued to result in minimal impact to the offsite public and the surrounding environment. The site's radioactive and chemical discharges to air and water were well below regulatory standards for environmental and public health protection; its air and water quality met applicable requirements; and the potential radiation dose from its discharges was less than the national dose standards.

The largest radiation dose that an offsite, hypothetical, maximally exposed individual could have received from SRS operations during 2009 was estimated to be 0.12 millirem (mrem). (An mrem is a standard unit of measure for radiation exposure.) The 2009 SRS dose is just 0.12 percent of the DOE all-pathway dose standard of 100 mrem per year, and far less than the natural average dose of about 300 mrem per year (according to Report No. 160 of the National Council of Radiation Protection and Measurements) to people in the United States. This 2009 all-pathway dose of 0.12 mrem was the same as the 2008 dose.

Extensive Monitoring; Documented Compliance

Environmental monitoring is conducted extensively within a 2,000-square-mile network extending 25 miles from SRS, with some monitoring performed as far as 100 miles from the site. The area includes neighboring cities, towns, and counties in Georgia and South Carolina. Thousands of samples of air, rainwater, surface water, drinking water, groundwater, food products, wildlife, soil, sediment, and vegetation are collected by SRS and state authorities and analyzed for the presence of radioactive and nonradioactive contaminants.

Compliance with environmental regulations and with DOE orders related to environmental protection provides assurance that onsite processes do not impact the public or the environment adversely. Such compliance is documented in this report.

SRS had a National Pollutant Discharge Elimination System (NPDES) compliance rate of 99.92 percent in 2009, with only four of the 4,989 sample analyses performed exceeding permit limits. The NPDES program protects streams, reservoirs, and other wetlands by limiting the release of nonradiological pollution into surface waters. Discharge limits are set for each facility to ensure that SRS operations do not negatively impact aquatic life or degrade water quality.

No Notices of Violation

Issued by the U.S. Environmental Protection Agency or the South Carolina Department of Health and Environmental Control, Notices of Violation (NOVs) are the procedures that allege potential violations of an organization's permits or environmental laws or regulations. SRS received no NOVs in 2009.

Introduction

CHAPTER 1

Timothy Jannik
Savannah River National Laboratory

Al Mamatey
Regulatory Integration & Environmental Services

The Savannah River Site (SRS), one of the facilities in the U.S. Department of Energy (DOE) complex, was constructed during the early 1950s to produce materials (primarily plutonium-239 and tritium) used in nuclear weapons. The site covers approximately 310 square miles in South Carolina and borders the Savannah River. Savannah River Nuclear Solutions (SRNS) assumed responsibility from Washington Savannah River Company (WSRC) for SRS Maintenance and Operations activities in August 2008. Savannah River Remediation (SRR) subsequently took over the site's Liquid Waste Operations functions from WSRC in July 2009.

Mission

SRS's mission is to fulfill its responsibilities safely and securely in the stewardship of the nation's nuclear weapons stockpile, nuclear materials, and the environment. These stewardship areas reflect current and future missions to

- meet the needs of the U.S. nuclear weapons stockpile
- store, treat, and dispose of excess nuclear materials safely and securely
- treat and dispose of legacy radioactive liquid waste from the Cold War
- clean up radioactive and chemical environmental contamination from previous site operations

SRS continued in 2009 to improve environmental quality, clean up its legacy waste sites, manage any waste produced from current operations, and plan for future operations. This included working with the South Carolina Department of Health and Environmental Control (SCDHEC), the Environmental Protection Agency (EPA), and the Nuclear Regulatory Commission to find mutually acceptable solutions for waste disposition. As part of its ongoing mission, the site will continue to address the highest-risk waste management issues by safely disposing of liquid waste and surplus nuclear materials at offsite locations, and by safely stabilizing any waste tank residue remaining on site.

Site Location, Demographics, and Environment

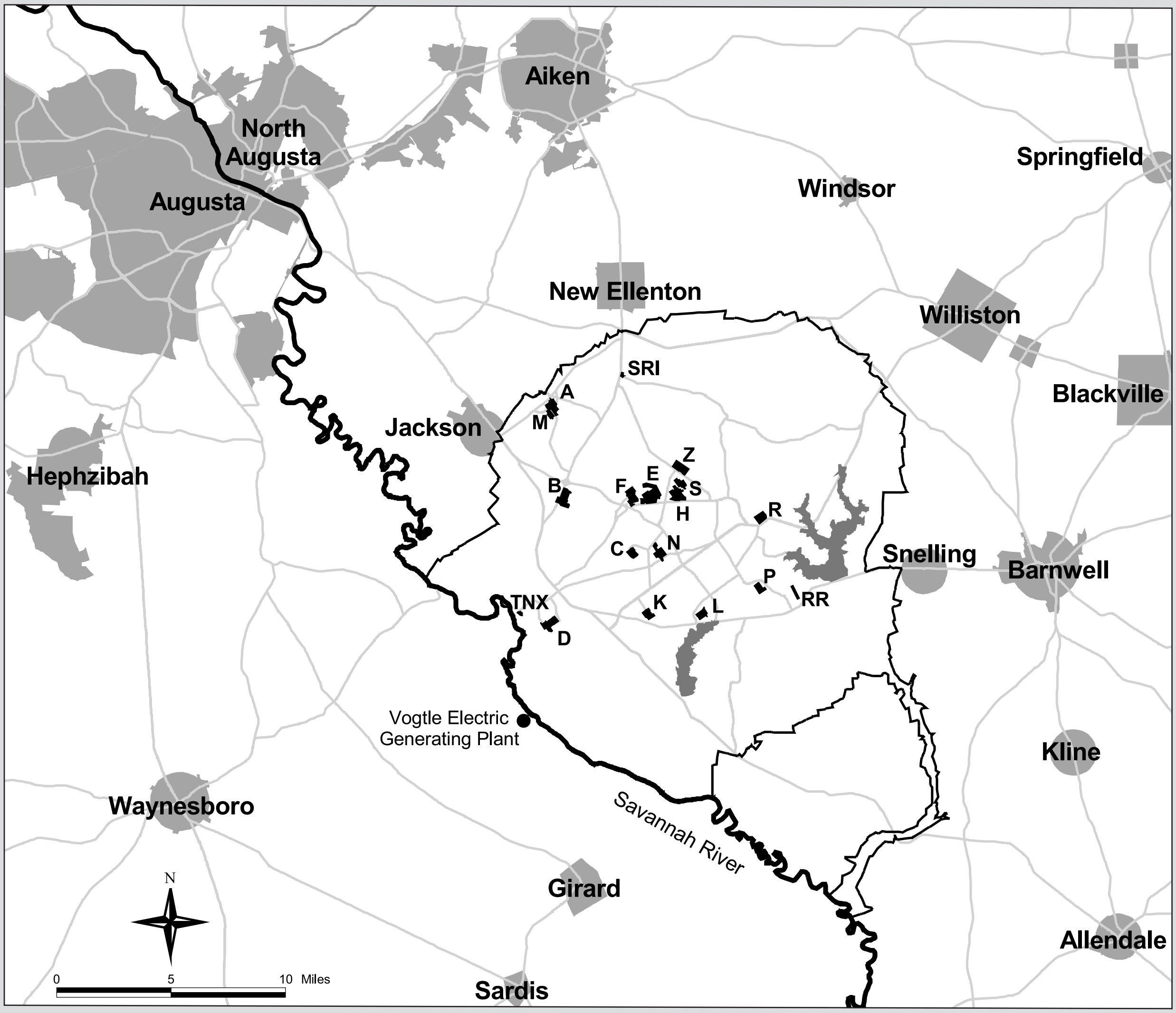
SRS covers 198,344 acres in Aiken, Allendale, and Barnwell counties of South Carolina. The site is approximately 12 miles south of Aiken, South Carolina, and 15 miles southeast of Augusta, Georgia (figure 1–1).

The average population density in the counties surrounding SRS is about 91 people per square mile, with the largest concentration in the Augusta metropolitan area. Based on 2000 U.S. Census Bureau data, the population within a 50-mile radius of the center of SRS is approximately 712,780. This translates to an average population density of about 91 people per square mile, with the largest concentration in the Augusta metropolitan area.

Water Resources

SRS is bounded on its southwestern border by the Savannah River for about 35 river miles and is approximately 160 river miles from the Atlantic Ocean.

The Savannah River is used as a drinking water supply source for some residents upstream of SRS. The nearest downriver municipal drinking water



SRNL Map

Figure 1–1 The Savannah River Site

SRS is located in South Carolina, about 12 miles south of Aiken, South Carolina, and about 15 miles southeast of Augusta, Georgia. The Savannah River flows along a portion of the site's southwestern border. The capital letters within the SRS borders identify operations areas referenced throughout this report.

source (Beaufort-Jasper Water and Sewer Authority's Purrysburg Water Treatment Plant) is located approximately 90 river miles from the site. The river also is used for commercial and sport fishing, boating, and other recreational activities. There are no known large-scale uses of the river for irrigation by farming operations downriver of the site. The groundwater flow system at SRS consists of four major aquifers. Groundwater generally migrates downward as well as laterally in recharge areas—eventually either discharging into the Savannah River and its tributaries or migrating into the deeper regional flow system. SRS groundwater is used both for processes and for drinking water.

Geology

SRS is located on the southeastern Atlantic Coastal Plain, which is part of the larger Atlantic Plain that extends south from New Jersey to Florida. The center of SRS is approximately 25 miles southeast of the geological Fall Line that separates the Coastal Plain from the Piedmont. Characterization of regional earthquake activity is dominated by the catastrophic Charleston, South Carolina, earthquake of August 31, 1886 (est. magnitude of 7.0 on the Richter scale). With nearly three centuries of available historic and contemporary seismic data, the Charleston/Summerville area remains the most seismically active region of South Carolina—and the most significant seismogenic region affecting SRS. Ongoing studies by University of South Carolina seismologists suggest a recurrence interval of 500–600 years for magnitude 7.0 or greater earthquakes (similar to the 1886 event) near Charleston. Earthquake activity occurring within the upper Coastal Plain of South Carolina, where the majority of SRS is located, is best characterized by occasional small shallow events associated with strain release near small-scale faults and intrusives. Levels of seismic activity within this region are very low, with magnitudes or sizes generally less than or equal to 3.0

Land and Forest Resources

About 90 percent of SRS land area consists of natural forests and managed pine plantations, which are planted, maintained, and harvested by the U.S. Department of Agriculture Forest Service–Savannah River. The site contains portions of three forest types: Oak-Hickory-Pine, Southern Mixed, and Southern Floodplain. More than 370 Carolina bays exist on SRS. These unique wetlands provide important habitat and refuge for many plants and animals.

Animal and Plant Life

The majority of SRS is undeveloped; only about 10 percent of the total land area is developed or used for industrial facilities. The remainder is maintained in healthy, diverse ecosystems. About 260 species of birds, 60 species of reptiles, 40 species of amphibians, 85 species of freshwater fish, and 50 species of mammals have been identified at SRS. The site also is home to an estimated 950 species of plants.

Primary Site Activities

Liquid Waste Operations

SRS continued to manage its Liquid Waste Operations facilities in support of the integrated high-activity waste removal program in 2009. This work included operation of the Defense Waste Processing Facility, the Saltstone Production and Disposal Facilities, the F-Area and H-Area tank farms, and the Actinide Removal Process/Modular Caustic Side Solvent Extraction Unit salt processing facility.

A detailed description of the site's 2009 Liquid Waste Operations activities can be found on the CD accompanying this report.

Separations

In the past, the SRS separations facilities processed special nuclear materials and spent fuel from site reactors to produce materials for nuclear weapons and isotopes for medical and National Aeronautics and Space Administration applications. The end of the Cold War in 1991 brought a shift in the mission of these facilities to stabilization of nuclear materials from onsite and offsite sources for safe storage or disposition. F Canyon, one of the site's two primary separations facilities, was deactivated in 2006. The other facility, H Canyon, continues to operate, and an important part of its mission is the conversion of weapons-usable, highly enriched uranium to low-enriched uranium for use in the manufacture of commercial reactor fuel, a key function of the nation's nuclear nonproliferation program.

Spent Nuclear Fuel Storage

SRS's spent nuclear fuel facilities store fuel elements from a variety of foreign and domestic reactors. The mission of the spent nuclear fuel program is to cost-effectively eliminate the hazards associated with legacy spent nuclear fuel—from research reactors around the world—by receiving, stabilizing, and dispositioning the fuels in a safe and environmentally sound manner.

Tritium Processing

SRS tritium facilities are designed and operated to supply and process tritium, a radioactive form of hydrogen gas that is a vital component of nuclear weapons. These facilities are part of the National Nuclear Security Administration's Defense Programs operations at SRS.

Waste Management

SRS manages

- the large volumes of radiological and nonradiological waste created by previous operations of the nuclear reactors and their support facilities
- newly generated waste created by ongoing site operations

Although the primary focus is on safely managing the radioactive liquid waste, the site also must handle, store, treat, dispose of, and minimize solid waste resulting from past, ongoing, and future operations. Solid waste includes hazardous, low-level, mixed, sanitary, and transuranic wastes. More information about radioactive liquid and solid wastes is included on the CD housed inside the back cover of this report.

Area Completion Projects

Past operations at SRS have released hazardous constituents and substances to soil and groundwater at numerous waste sites, with contamination levels exceeding regulatory thresholds.

The mission of Area Completion Projects (ACP) personnel is to protect human health and the environment by meeting all applicable regulatory requirements while safely deactivating and decommissioning contaminated facilities and remediating soils and groundwater. Completing the cleanup of legacy waste at contaminated waste sites and removing obsolete facilities helps consolidate ongoing site operations and free up SRS areas for future missions. The use of streamlined cleanup strategies enables ACP to accelerate work and reduce overall lifecycle costs.

The approach for soil and groundwater cleanup is to mitigate the source of the contamination and to monitor and, if needed, remediate contamination that already has migrated from the source. The approach for facility deactivation is to bring facilities to a safe and stable condition, in part by de-energizing facility systems. Following deactivation, the excess administrative, radiological, and nuclear facilities are decommissioned—by demolition or by placement into an in situ end state in which part of the facility remains.

Cleanup decisions are reached through implementation of a core team process with EPA Region 4 and SCDHEC. In reaching such decisions, input from the public and stakeholders (such as the Citizens Advisory Board) is solicited and considered.

Numerous technologies have been pioneered to increase the effectiveness of ACP's remediation efforts and to reduce hazardous risk across the site. ACP utilizes a Green Remediation approach to reduce greenhouse gas emissions and other negative environmental impacts that might occur during characterization or remediation of hazardous waste sites. Green Remediation is the practice of (1) considering all the environmental effects of remedy implementation and (2) incorporating options to minimize the environmental footprints of cleanup actions. Natural remedies used at SRS include phytoremediation (augmented natural vegetative processes), bioremediation (augmented naturally occurring microbial processes), and natural remediation (natural processes to address contamination). These technologies are proving to be a cost-efficient means of reducing risk to human health and the environment, and have been successful in expediting cleanups.

More information about ACP's 2009 operations is included on the CD accompanying this report.

Effluent Monitoring and Environmental Surveilance

SRS sampling locations, sample media, sampling frequency, and types of analysis are selected based on environmental regulations, exposure pathways, public concerns, and measurement capabilities. The selections also reflect the site's commitment to (1) safety; (2) protecting human health; (3) reducing the risks associated with past, present, and future operations; (4) improving cost effectiveness, and (5) meeting regulatory requirements.

Releases

Releases to the environment of radioactive and nonradioactive materials come from legacy contamination as well as from ongoing site operations. For instance, shallow contaminated groundwater—a legacy—flows slowly toward onsite streams and swamps and into the Savannah River. In ongoing site operations, releases occur during the processing of nuclear materials.

Meeting certain regulations, such as the Safe Drinking Water Act and the Clean Air Act, requires that releases of radioactive materials from site facilities be limited to very small fractions of the amount handled. The site follows an optimization philosophy that emissions will be kept as low as reasonably achievable (ALARA).

Pathways

The routes that contaminants can follow to enter the environment and then reach people are known as exposure pathways. A person potentially can be exposed when he or she breathes the air, consumes locally produced foods and milk, drinks water from the Savannah River, eats fish caught from the river, or uses the river for recreational activities such as boating, swimming, etc.

One way to determine if contaminants from the site have reached the environment is through environmental monitoring. The site gathers thousands of air, water, soil, sediment, food, vegetation, and animal samples each year. The samples are analyzed for potential contaminants released from site operations, and the potential radiation exposure to the public is assessed. Samples are taken at the points where materials are released from (1) the facilities (effluent monitoring) and (2) the environment itself (environmental surveillance). SCDHEC and the Georgia Department of Natural Resources also have programs in place to monitor the environment in and around SRS.

Research and Development

The Savannah River National Laboratory (SRNL)—the site's applied research and development laboratory—creates, tests, and implements solutions to SRS's technological challenges. Other environmental research is conducted at SRS by the following organizations:

- *Savannah River Ecology Laboratory (SREL)* – More information can be obtained by contacting SREL at 803–725–2472 or by viewing the laboratory's website at http://www.uga.edu/srel. Also, SREL's technical progress report for 2009 is included on the CD accompanying this document.

- *U.S. Department of Agriculture Forest Service–Savannah River (USFS–SR)* – More information can be obtained by contacting USFS–SR at 803–725–0006 or 803–725–0237 or by viewing the USFS–SR website at http://www.srs.gov/general/srfs/srfs.htm. Also, USFS–SR's 2009 report is included on the CD accompanying this document.

- *Savannah River Archaeological Research Program (SRARP)* – More information can be obtained by contacting SRARP at 803–725–3724, or by viewing the SRARP website at http://www.srarp.org

Environmental Management System

CHAPTER 2

Michael E. Roper
Regulatory Integration & Environmental Services

Compliance with environmental statutory and other legal regulatory requirements is a fundamental responsibility of all federal agencies. In 2009, SRS continued to meet or exceed performance expectations with respect to the management of environmental protection media (air, water, waste programs, etc.).

This chapter focuses on the integration of numerous environmental requirements mandated by existing statutes, regulations, and policies as implemented through the Environmental Management System (EMS). All contractor requirements mandated by U.S. Department of Energy (DOE) Order 450.1A, "Environmental Protection Program," are appropriately considered in the site's Integrated Safety Management System (ISMS) structure.

A management system is a tool established by an organization to manage its operations and activities in the pursuit of its policies and goals. In the case of the EMS, it is not a stand-alone environmental program or a data management program. When properly implemented, this management system enables SRS to clearly identify and establish environmental goals, develop and implement plans to meet the goals, determine measurable progress toward the goals, and take steps to ensure continuous improvement.

Executive Order (EO) 13423, "Strengthening Federal Environmental, Energy, and Transportation Management," was signed by President Bush January 24, 2007. This order directs each federal agency to use an EMS as the management framework to implement, manage, measure, and continually improve upon sustainable environmental, energy, and transportation practices. EO 13423 mandates that the EMS shall include corresponding federal agency-specific objectives and targets to meet goals in the areas listed below.

- Energy Efficiency and Reduction of Greenhouse Gas Emissions
- Use of Renewable Energy
- Water Conservation
- Fleet Management
- Construction and Renovation of High-Performance Buildings
- Electronics Stewardship and Purchasing
- Reduction in the Use of Toxic and Hazardous Chemicals and Materials
- Acquisition of Environmentally Preferable Goods
- Pollution and Waste Prevention and Recycling

For DOE, the promulgation of EO 13423 resulted in the revision of DOE Order 450.1A, which was released June 4, 2008. The revision mandated a formal "declaration of conformance" to the EMS requirements no later than June 30, 2009. Savannah River Nuclear Solution (SRNS) personnel initiated activities—including the establishment of supporting environmental, energy, and transportation management objectives and targets—that resulted in the "declaration" requirement being satisfied June 12, 2009.

EO 13514 ("Federal Leadership in Environmental, Energy, and Economic Performance") was signed in October 2009. Although it has not yet resulted in revisions of any DOE order(s), it is being evaluated for potential enhancements to the EMS.

SRS EMS Implementation

DOE Order 450.1A requires an organization to develop an environmental policy, create plans to implement the policy, implement the plans, check progress and take corrective actions, and review the system annually to ensure its adequacy and effectiveness. An annual revision of the SRS Environmental Policy Letter was published to more clearly integrate requirements from DOE Orders 450.1A and 430.2B, "Departmental Energy, Renewable Energy, and Transportation Management." Sitewide endorsement of the policy was reflected by the signatures of senior management from DOE, the primary contractors, and tenant organizations. DOE Order 450.1A includes a requirement that in the initial year of implementation (2009) and every third year thereafter, an independent external audit must be performed to ensure compliance with the Order and conformance with the 17 elements of the International Organization for Standardization (ISO) 14001 Standard, "Environmental Management System." The external audit of SRS's EMS—conducted April 28 to May 1, 2009—concluded that the EMS conformed with both the order and the ISO standard. This conclusion became the basis for the "declaration of conformance" mentioned earlier.

Significant SRS contributions initiated and/or completed within the EMS during 2009 include the following:

- In accordance with the requirements of DOE Order 450.1A, an audit of the EMS was conducted by a qualified outside party. The audit culminated in a "declaration of conformance" June 23. Along with five noteworthy practices identified, a formal corrective action plan was developed to address one minor nonconformance, three opportunities for improvement, and two observations. All corrective actions were entered into the site commitment tracking system. One action remains open and is scheduled for completion by March 2010.

- A self-assessment was conducted on the EMS program—using lines of inquiry derived from DOE Order 450.1A and ISO Standard 14001 (among others)—to validate issues/concerns indicated by the external audit. In reinforcing the audit findings, the self-assessment identified the need for increasing senior management engagement with the EMS process. As such, procedural revisions were implemented to more clearly define process and expectations with respect to roles, responsibilities, and activities associated with management reviews.

- Revised both the EMS implementing procedure and description manual to include (1) the establishment of site-specific targets to achieve sustainable environmental stewardship, energy, and transportation goals, (2) the incorporation of EMS elements into the Integrated Safety Management System (ISMS), (3) addressing assessments/audits and the identification of root causes of noncompliance, and (4) a formal third-party audit that culminated in a "declaration of conformance."

- Established an intranet website as a repository for pertinent program documents, including the formal declaration of conformance, communications with internal customers and external agencies, and applicable procedures, as well as records of briefings and audits/assessments.

- Initiated a progressive review process using various SRS environmental management programs, including the Senior Environmental Management Council (SEMC – a body of senior environmental managers representing all site primary contractor and tenant organizations).

The chapter sections that follow describe the 17 elements that demonstrate SRS implementation of DOE Order 450.1A, which requires the EMS to reflect the elements and framework in the ISO 14001 Standard.

Environmental Policy

The SRS Environmental Policy is a statement of the site's intention to implement sound stewardship practices that are protective of the air, water, land, and other natural cultural resources impacted by SRS operations. The objective of this policy is to establish a consistent sitewide approach to environmental protection through the implementation of an EMS as integrated within the site's comprehensive ISMS. The SRS EMS provides for the systematic planning, integrated execution, and evaluation of site activities for (1) public health and environmental protection, (2) pollution prevention (P2) and waste minimization, (3) compliance with applicable environmental protection requirements, and (4) continuous improvement of the EMS.

The SRS Environmental Policy document in effect through FY 2010 is included on the CD accompanying this report. The policy is updated, published, and communicated throughout the site annually. Additionally, it is posted routinely to the externally accessible SRS website to foster additional communication with, and awareness by, the surrounding community.

Environmental Aspects and Impacts

Determining environmental aspects (elements of activities, products, processes, and services that could have a significant impact on the environment) is critical to the EMS process. It equates to analyzing hazards via the ISMS review protocol. Identifying the SRS environmental aspects is not the end of the process. Work activities, whether routine or unusual, must consider whether these aspects are a potential part of the work activity. This leads to the development and implementation of controls necessary to mitigate the potential that the action will adversely affect the environment. Environmental aspects (as well as goals and targets) are reviewed during EMS status meetings with the SEMC and senior management to keep the aspects current. SRS has determined that the following aspects of its operations have the potential to affect the environment:

- Air pollutants
- Asset management (including procurement of environmentally preferable goods and chemical and electronics management)
- Biological hazards
- Building performance and sustainable design
- Cultural/historical resource disturbance
- Ecological research
- Energy conservation (including energy efficiency, renewable energy, and alternative fuels)
- Environmental remediation development, demonstration, and deployment
- Nanomaterials
- Pollution prevention/waste minimization
- Solid waste management (including hazardous, nonhazardous, sanitary, nonradiological, radiological, and mixed)
- Storage of hazardous, mixed, or radioactive materials or wastes in tanks (underground and above ground)
- Transportation (fleet) management
- Water pollution and conservation
- Wildlife and habitat management

Legal and Other Requirements

Regulatory and DOE requirements for environmental programs are included in the site's Standards/Requirements Identification Document(S/RID), Functional Area (FA) 20 – Environmental Protection. The purpose of FA 20 is to address environmental, safety, and health technical and programmatic requirements related to environmental protection activities undertaken by contractors on behalf of DOE at SRS. Sources include DOE Order 5400.5 ("Radiation Protection of the Public and Environment"), DOE Order 450.1A, DOE Order 451.1B ("National Environmental Policy Act Compliance Program"), applicable Codes of Federal Regulations, and State of South Carolina pertinent directives. The environmental protection S/RID functional area includes activities required to protect the environment and the health of the public and workers. The scope of the S/RID addresses ten major elements:

- Environmental protection
- Environmental policy management
- Permits
- Environmental monitoring, surveillance and inspections
- Environmental control standards
- Pollution prevention
- Record keeping, reports, and notifications
- Key Interfaces
- Major sources of environmental requirements and standards; and
- Documents and references.

Objectives, Targets, and Programs

The EMS pursues and measures continual improvement in performance by establishing and maintaining documented environmental objectives and targets that counterbalance SRS activities having actual or potentially significant environmental impacts. Objectives and targets are established to 1) achieve full compliance with applicable environmental requirements, 2) devote resources to specific pollution prevention initiatives, and 3) ensure responsible stewardship of natural and historical resources at SRS.

In accordance with the requirements of DOE Order 450.1A, environmental objectives and targets are established, implemented, and maintained consistent with and in support of the following DOE environmental objectives:

- Increase energy efficiency and reduce greenhouse gases (GHG)
- Increase use of renewable energy
- Increase water conservation
- Increase procurement of environmentally preferred products (EPP)
- Increase pollution prevention initiatives
- Incorporate sustainable building standards
- Increase petroleum conservation
- Practice affirmative life-cycle management of electronics
- Increase alternative fuel use
- Practice effective use of environmentally friendly options in the exercise of transportation (fleet) management

The enhancement goals and targets for each of these objectives are developed and endorsed by senior management responsible for each of the functional areas associated with the objectives. Once approved, responsibility for the achievement of the goals and targets resides with that organization. Respective lead-points-of-contact (POCs) are designated and execution timelines are established and tracked. Annual targets and corresponding metrics reflective of progress are posted to the internal EMS website and are otherwise available upon request.

For FY09, seven specific objectives and targets encompassing nine environmental aspects were established. All objectives and targets were directly related to the "leadership goals" and "TEAM Initiatives" defined in DOE Order 430.2B ("Departmental Energy, Renewable Energy, and Transportation Management"). The targets for each objective defined in the order were met or exceeded through FY09 relative to the baseline year. A table on the CD housed inside the back cover of this report provides a summary of the objectives and targets, the actions taken, and the progress/success.

Additional references defining SRS goals and objectives include

SRS FY2010 Executable Plan for Energy Efficiency, Renewable Energy, and Transportation Management – Revision 0, dated December 2009, contains detailed information specifically related to requirements and objectives delineated in DOE Order 430.2B.

Pollution Prevention (P2) Program – The SRS P2 program is addressed by and documented in the site's Environmental Compliance Manual (3Q), Procedure 6.11 ("Pollution Prevention Program"), with specific annual reduction goals agreed upon by the M&O contractor and DOE–SR.

Natural Resources Management Plan (NRMP) – The USFS–SR uses the NRMP to provide strategic guidance for SRS natural resource programs, and furthers the mission of SRS by helping to ensure responsible stewardship of the environmental resources at SRS.

WSI–SRS Annual Operational Plan (AOP) – The AOP identifies each task to be performed by Wackenhut Services, Inc. (WSI–SRS) with respect to major operations or programs defined by DOE–SR. Because of security requirments, the WSI–SRS AOP is not available publicly; however, information about it can be obtained by contacting the manager of SI's Contracts and Resources Management Department at 803–952–7565.

Resources, Roles, and Responsibilities

All SRS employees have specific roles and responsibilities in key areas, including environmental protection. Environmental and waste management technical support personnel assist site line organizations with developing and meeting their environmental responsibilities. Additional detailed information relative to resources, roles, responsibilities, and authority as they relate to the SRS EMS is contained within Manual 3Q, Procedure 13.5, "EMS Implementation," and Procedure 18.1, "Site Environmental Protection"; Policy Manual 1–01, MP 4.1, "Environmental Assurance"; and "EMS Description Manual" (G–TM–G–00001), as well as within facility-specific implementing and operations procedures.

Competence, Training, and Awareness

The purpose of SRS environmental training programs is to ensure that personnel whose actions could have environmental consequences are properly trained and made aware of their responsibilities to protect the environment, workers, and the public. EMS requirements have been provided to employees whose responsibilities include environmental protection and regulatory compliance. All employees are responsible for supporting and complying with EMS programs and processes. This includes compliance with legal requirements, an understanding of pollution prevention/waste minimization techniques, and the need to continuously improve operating practices to enhance and protect the site's workers and environment—and the public. This line management responsibility is accomplished primarily through the activities of environmental compliance groups assigned to each organization.

SRNS's environmental training curriculum ensures that personnel are trained and aware of environmental responsibilities, including reporting instances of environmental noncompliance. The curriculum includes job-specific training to develop operational-level competencies and/or subject matter expertise; initial General Employee Training, including environmental responsibilities required of all employees, subcontractors, and vendors; and Consolidated Annual Training to provide annual refresher training on environmental responsibilities. Training program requirements are documented in Manual 4B, "Training and Qualification Program Manual"; in Manual 3Q, Procedure 13.5, and in "EMS Description Manual."

Communication

SRS continues to improve internal and external communications on environmental issues. Many policies and procedures guide communications at SRS, ranging from the general site policy to forms and techniques addressed in facility-specific procedures. Additionally, SRS solicits input from interested parties such as community members, activists, elected officials, and regulators. The SRS Citizen's Advisory Board provides advice and recommendations to DOE on environmental compliance, remediation, waste management, facility decommissioning, and related issues. Ex-officio members from DOE, the U.S. Environmental Protection Agency (EPA) Region 4, the South Carolina Department of Health and Environmental Control (SCDHEC), and the Georgia Department of Natural Resources participate in board activities. At the core of the communication and community involvement programs are the SRS EMS Policy and the SRS Federal Facility Agreement Community Involvement Plan. The ultimate goal of environmental communication is to improve the site's overall environmental performance.

Additional forums for the dissemination of information associated with environment issues include the

- *Senior Environmental Managers Committee (SEMC)* – comprised of senior-level environmental managers from all of the SRS contractors. Information is shared via the SEMC on environmental concerns, regulatory matters, SRS operational issues, and upcoming changes to improve the SRS environmental compliance program.

- *Environmental Quality Management Division (EQMD)* – DOE's Savannah River Operations Office (DOE–SR) conducts a periodic meeting of the SRS contractors along with the DOE environmental staff to discuss issues relevant to environmental protection and compliance. These discussions provide a forum for DOE to provide regulatory direction and expectations to the site contractors as well as receive updates on the status of environmental/regulatory issues.

- *SRS Regulatory Integration Team (SRIT)* – DOE–SR, EPA Region 4, and SCDHEC have formed the SRIT to effectively implement the regulatory integration process at SRS. The

SRIT identifies issues that are cross-cutting and require high-level agency agreement so that actions can be taken consistently across multiple programs. The SRIT commissions Integrated Project Teams (IPTs); designates a team lead; defines the overall scope, objective, and deliverables; and provides guidance to facilitate issue resolutions or to build upon opportunities.

- *Challenges, Opportunities, and Resolution (COR) Team* – The COR team consists of regulatory compliance representatives from each SRNS organization and major contractors that work on site. The COR team discusses emerging compliance or implementation challenges and opportunities, and develops and coordinates resolution of challenges via IPTs. EQMD personnel are briefed biweekly on COR activities.
- *Environmental Compliance Authorities* – ECAs are trained environmental professionals dedicated to specific projects and facilities at SRS. The ECAs assist projects in identifying potential environmental issues and solutions and provide regulatory updates and guidance to program personnel.
- *SRS Online Electronic Bulletin* – The SRS Online Electronic Bulletin is an electronic communications tool used by SRS management. The bulletin is used by RI&ES to provide (1) timely information to employees on environmental matters, such as how to report spills and other issues, and (2) the communication of responsibilities protection of the environment.
- *SRS Operating Experience Program* – The SRS Operating Experience Program implements a systematic review of the operating experiences (e.g., lessons learned) at SRS facilities, similar DOE complex facilities, and commercial nuclear industry facilities for the purpose of preventing events and eliminating recurring events.

Many site- and facility-specific policies and procedures guide and enable environmental communications at SRS. These range from general site policy declaration and dissemination to an intranet web-based newsletter to various group forums (prejob briefings, workplace meetings, monthly safety meetings, etc.) and formal and informal intervention and instructional techniques (Behavior Based Safety observations, on-the-job training, "management by walking around," etc.). Additionally, an intranet website is dedicated to facilitating the dissemination of EMS-related information. Posted to the site's externally accessible website is the "EMS Description Manual," which documents how the EMS is implemented across the site in accordance with DOE Order 450.1A.

Documentation

EMS documentation includes, but is not limited to

- the environmental policy
- objectives and targets
- description of the EMS scope
- description of the main elements of the EMS and their interaction and reference to related documents
- records determined by organizations to be necessary to ensure the effective planning, operation, and control of processes related to the organizations' significant environmental aspects

Site and/or facility-specific implementing procedures and/or work packages define what documents are to be retained for historical purposes to meet programmatic and statutory requirements.

SRS source documents used by various organizations, contractors, and tenant activities to manage their EMS-associated documents include, but are not limited to, the following:

- SRS Environmental Policy
- Manual 3Q, "Environmental Compliance Manual"
- "SRS Environmental Management System Manual," G–TM–G–0001
- SRM 300.1.1B, Chapter 1, Section 1.2, "DOE–SR Functions, Responsibilities, and Authorities Procedure"
- SREL Environmental Management Program Description
- "WSI–SR Environmental Management System Implementation Plan," WSI 1–05

Operational Control

The EMS operational control element helps ensure that controls are in place to implement environmental policy-related activities of regulatory compliance, pollution prevention, and continuous improvement by SRS management. Consistent with its policy, objectives, and targets, operations and activities are identified, planned, and executed to ensure that they are carried out within appropriate controls, thereby eliminating or mitigating adverse impacts and enhancing beneficial impacts.

Rigorous work control practices include the following:

- establishing, implementing, and maintaining control of situations where their absence could lead to deviation from the environmental policy, objectives, and targets
- stipulating acceptable operating criteria
- ensuring that significant environmental aspects are considered in decisions related to goods and services, and are communicated to suppliers and subcontractors

Operational controls are implemented through multiple rigorous processes documented in the 2S Manual, “Conduct of Operations”; 1Y Manual, “Conduct of Maintenance”; 8Q Manual “Employee Safety Manual”; and 11B Manual, “Subcontractor Management Manual.” The Assisted Hazards Analysis and the Environmental Evaluation Checklist (EEC) are among the site processes that support implementation of the EMS.

Emergency Preparedness and Response

Emergency plans are established, implemented and maintained as documented in Manual SCD–7, SRS Emergency Plan (and other references, including those specified below.) The SCD–7 manual contains procedures to facilitate the identification of emergency situations and accidents with the potential to impact the environment, and provides definitions of appropriate responses and reporting criteria. It further defines (or provides guidance as to) how organizations can prevent and/or mitigate potential adverse scenarios.

These procedures are reviewed and revised periodically to address lessons learned and operating experience gained. They also provide the basis for periodic testing of the procedures to maintain requisite skills.

SRS emergency plans and programs include occurrences categorized as environmental emergencies. Procedures and documents that guide the Emergency Preparedness Process are as follows:

- Manual 1–01 (“Management Policies”), 4.12, “Emergency Preparedness”
- Manual SCD–7, “Savannah River Site Emergency Plan” (includes drills and exercises)
- Manual 9B, “Site Item Reportability and Issues Management (SIRIM)”
- Central Services Works Engineering Spill Response Team procedures
- USFS–SR Emergency Response and Evacuation Plan and Emergency Spill Procedure
- WSI–SRS Procedure 1–6816, “Emergency Management Plan”
- SREL Safety Manual, chapter 2, “Medical and Emergency Procedures”
- “SREL Occurrence Reporting Procedures” (EHS–94–0001)
- Resource Conservation and Recovery Act Part B Permit, Volume I, General Information, Section G, Contingency Plan.
- Memoranda of agreement (MOAs) and service level agreements (SLAs)

Monitoring and Measurement

Monitoring and measurement means that the key characteristics of SRS operations are monitored regularly. This includes effluent monitoring (radiological and nonradiological), compliance monitoring, performance monitoring, and equipment/facility monitoring (e.g., calibration of instruments).

References include the following:

- Manual 3Q1–2, (Plans and Procedures), Vol. 1, Section 1000, Procedure 1002, "SRS Environmental Monitoring Plan"
- Manual 3Q1–2 (Plans and Procedures), Vol. 1, Section 1000, Procedure 1100, "SRS Environmental Monitoring Program"
- WSRC–ESH–EMS–94–0129, "SRS EM Corrective Action Plan"
- "Environmental Geochemistry Group Operating Handbook," July 1996
- USFS–SR Post-Burn Evaluations
- USFS–SR Biological Evaluations
- Manual SCD–4, "Assessment Performance Objectives and Criteria"
- Manual 3Q, "Environmental Compliance Manual"
- Manual 1Q (Quality Assurance), 12–1, "Control of Measuring and Test Equipment"
- Manual 1Q, Procedure 12–2, "Control of Installed Process Instrumentation"
- Manual 1Q, Procedure 15–1, "Control of Nonconforming Items"
- Manual 1–01, Procedure 5.35, "Corrective Action Program"
- Annual SRS Environmental Report
- USFS–SR Accomplishment Reports
- Individual Agency and Divisional Performance Indicators
- WSI–SRS Consolidated Assessment Schedule

Evaluation of Compliance

Specific environmental legislation and regulations are evaluated and assessed on a program- or facility-specific basis. SRS has established a process for periodically evaluating its compliance with relevant environmental regulations. This process is primarily captured in three site documents: (1) the Standards/Requirements Identification Document (S/RID), (2) the Source and Compliance Document (SCD–4), and (3) the Assessment Manual (12Q). The procedure often is integrated into an organization's environmental, safety, and health inspection process, which is performed in a prioritized fashion by a team of experts—including one on environmental regulatory issues. Periodically, environmental support organizations conduct regulatory assessments in particular topical areas to verify the compliance status of multiple organizations throughout SRS. Finally, external regulatory agencies and/or technical experts may conduct independent audits of compliance.

Legal and Other Requirements

EMS includes procedural mechanisms for identifying laws, regulations, DOE Orders, and other requirements. Proposed laws and regulations are monitored by the RI&ES Department via routine review of federal and state registers performed by subject matter experts for analysis and impact determinations. Identified regulatory and DOE requirements for environmental programs are included in the applicable S/RID. The environmental functional area within the S/RID addresses activities required to protect the environment and the health of the public and workers, ensuring compliance with applicable standards, laws, and regulations, as well as with DOE orders and directives. The S/RID scope addresses environmental protection, environmental policy management, permitting, environmental monitoring, surveillance and inspections, environmental control standards, pollution prevention, record keeping, reports and notifications, key interfaces, and documents and references. Applicable references: S/RID for M&O is SRNS–RP–2008–00086–020–M&O; S/RID for LWO is WSRC–RP–94–1268–020–LWO.

Compliance Evaluations

Consistent with Manual 12Q, "Assessment Manual," a self-assessment plan is published annually to evaluate environmental regulatory compliance. It has the flexibility to make during-the-year adjustments as operational concerns surface. Records documenting results of the periodic evaluations are retained in accordance with regulatory direction and records management programs.

The conduct of scheduled self-assessments is captured and tracked in the organizational integrated schedule, and all action items generated by that evaluation process are entered into Site Tracking, Analysis, and Reporting system (STAR). Similarly, audits and inspections conducted by external regulators (i.e., EPA, SCDHEC, and DOE) are captured in the integrated schedule, and the resulting corrective actions are tracked to completion in STAR.

Corrective Actions

In accordance with Manual 1–01, Procedure 5.35, "Corrective Action Program," and Manual 1B, Procedure 4.23, "Corrective Action Program," identified opportunities for improvement (OFI), observations, and findings are entered into STAR, where they are monitored routinely for progress and completion by multiple levels of management. As an example, an OFI identified during the external audit of the EMS identified the need to improve the process whereby environmental aspects are identified and evaluated, significance determinations are made, and necessary adjustments to processes/programs/procedures are implemented. This subsequently was captured in STAR, and is being tracked to completion.

Nonconformance; Corrective and Preventive Actions

Nonconformance and corrective and preventive actions include EMS nonconformance as a part of the site's quality assurance (QA) program. The application of QA procedures, therefore, supports the total EMS. For example, use of the nonconformance report form applies to environment-related equipment, instruments, facilities, and procedures. Also, instances of "nonconformance" identified by assessments and evaluations are recorded and dispositioned according to established procedures, utilizing the following resources:

- Quality Assurance Management Plan
- SRM 226.1.1C, Integrated Performance Assurance Manual, Section 8, "Corrective Action Processing and Closure Verification"
- Manual 1–01, Prodecure 5.35, "Corrective Action Program"
- Manual 12Q (Assessment Manual), Procedure FEB–1, "Facility Evaluation Board"
- Manual 1Q, "Quality Assurance Manual"
- WSI–SRS Procedure 1–3700, "Improvement/Corrective Action Management Program"
- USFS–SR Handbook, 6309.11, "Contract Administration"
- "Evaluation and Cleanup of SREL Research Sites" (A–98–0002)

Control of Records and Documents

The identification, maintenance, and disposition of environmental records and documents are required by the SRS EMS. The site's records management program incorporates environmental records for these purposes. Specific documentation for programmatic environmental activities is addressed in department-level procedures. For example, Regulatory Integration and Environmental Services (RI&ES) maintains records of correspondence with regulatory agencies. Environmental training records are maintained by the line organization requiring and conducting the training as well as by the site Training Department. EECs completed by facilities for specific activities are forwarded to and maintained by the site M&O contractor. Among the various records and documents management procedures in use at SRS are the following:

- DOE Order 1324.5A, "Records Management Program"
- Manual 1Q, Quality Assurance Manual, QAP 5–1, "Instructions, Procedures, and Drawings"
- Manual 1Q, Quality Assurance Manual, QAP 6–1, "Document Control"
- Manual 1Q, Procedure 17–1, "Quality Assurance Records"
- Manual 1B (Management Requirements and Procedures), Procedure 3.11, "WSRC Document and Correspondence Numbering System"
- Manual 1B, Procedure 3.31, "Records Management"
- Manual 1B, Procedure 3.32, "Document Control"
- WSRC IM–93–0060, "Sitewide Records Inventory and Disposition Schedule (RIDS)," Section

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- Savannah River Implementing Plan (SRIP) 200, Chapter 241.1, "Records Management Program"
- WSI–SRS Procedure 1–1507, "Records Management Requirements"
- U.S. Forest Service Handbook, 6209.11, "Records Management"
- ESH 94–0033, "SREL Environmental Management Plan"

Internal Audits

SRS audits are incorporated into the DOE and contractor assessment programs to verify that the site's EMS is functioning as intended. Environmental assessments include performance objectives and criteria for management system review. For example, Source and Compliance Document 4 (SCD–4) Functional Area 07 contains the performance objectives and criteria for the self-assessment of environmental management and technical/compliance requirements.

SRS utilizes a Facility Evaluation Board (FEB) to conduct independent performance-based assessments of site programs to satisfy contractual and regulatory obligations. The independent assessment program periodically conducts performance-based assessments of facilities/projects, support departments, and SRS programs. Other activities for which oversight of environment, safety, health, radiological controls, or quality assurance is required also are assessed.

The M&O's Office of Contractor Assurance prepares the annual FEB schedule for the M&O president. Determination of facility assessment scheduling considers, but is not limited to, the following criteria:

- Hazard level, including (1) radiological categories 1, 2, or 3 and (2) industrial (inherent facility safety and health hazards)
- Facility risk, as defined by the facility's authorization basis documentation
- Operational status (shutdown, standby, operating, startup test mode, or closure)
- Number and frequency of reportable occurrences during the previous 12 months, including type, root-cause factors, and status of action items
- Type of last assessment
- Time since last assessment
- Grade from last FEB evaluation
- Regulatory-driven assessment frequencies
- Requests for evaluation by site management

Management Review

The SRS EMS Policy requires periodic evaluations of the effectiveness of the EMS. Guidelines are intended to keep the management review focused on continuous improvement. Oversight of SRS's annual EMS review is the responsibility of DOE–SR's EQMD.

- A formal external audit was conducted during the period April 28–May 1, 2009. The scope of the audit was to determine whether the EMS conforms to the requirements of DOE Order 450.1A, and had been properly implemented and maintained. The audit team determined that the EMS was in conformance, enabling the initial "declaration of conformance" required by DOE Order 450.1A. Information derived from the audit was reported to senior management.
- A formal internal assessment was conducted in accordance with the M&O contractors' assessment program to (among other items) validate the findings, observations, and opportunities for improvement identified by the external audit. Planning and execution for conduct of the assessment was the responsibility of the EMS coordinator in cooperation with EQMD. Coordination of assessment objectives included defining scope, developing evaluation criteria, and discussing methods to be used for completing the assessment. The assessment was completed, with results reported to and approved by senior management. Corrective actions were documented in STAR, and (with the exception of one item scheduled for completion by March 31, 2010) all corrective actions have been implemented.

Senior management reviews the EMS to ensure its continuing suitability, adequacy, and effectiveness.

Reviews include assessing (1) opportunities for improvement and (2) the need for changes to the EMS. Records of the management reviews are retained in accordance with procedures, as previously addressed. Minutes from the reviews are available on the EMS intranet website.

For Further Information Should additional information be required relative to this chapter, contact Michael Roper at michael.roper@srs.gov.

Environmental Compliance

CHAPTER 3

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Regulatory Integration & Environmental Services

It is the policy of the U.S. Department of Energy (DOE) that all activities at the Savannah River Site (SRS) will be carried out in full compliance with applicable federal, state, and local environmental laws and regulations, and with DOE orders, notices, directives, policies, and guidance. Compliance with environmental regulations and with DOE orders related to environmental protection is a critical part of the operations at SRS.

The purpose of this chapter is to report the status of SRS compliance with these various statutes and programmatic documents. Some key regulations with which SRS must comply, and the compliance status of each, are listed in table 3–1.

This chapter also provides information on Notices of Violation (NOVs) issued by the U.S. Environmental Protection Agency (EPA) or the South Carolina Department of Health and Environmental Control (SCDHEC). NOVs are the procedures that allege violations of an organization's permits, or of environmental laws or regulations. SRS received no NOVs in 2009.

Compliance Activities

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) was passed in 1976 to address solid and hazardous waste management. The law covers such wastes as spent solvents, batteries, and many other discarded substances potentially harmful to human health and the environment. Amendments to RCRA regulate nonhazardous solid waste, underground storage tanks (USTs) and solid waste management units (units that historically contained or managed solid waste).

Hazardous waste generators, including SRS, must follow specific requirements for handling these wastes.

Underground Storage Tanks

The 19 USTs at SRS that contain petroleum products, as defined by the Comprehensive Environmental Response, Compensation, and Liability Act (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. SCDHEC's 2009 inspection and audit found all 19 tanks to be in compliance, marking seven straight years without a violation.

Land Disposal Restrictions

The 1984 RCRA amendments established Land Disposal Restrictions (LDRs) to minimize the threat of hazardous constituents migrating to groundwater sources. The same restrictions apply to mixed (hazardous and radioactive) waste.

Federal Facility Compliance Act

The Federal Facility Compliance Act (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. A Site Treatment Plan (STP) (WSRC–TR–94–0608) consent order (95–22–HW, as amended) was obtained and implemented in 1995, as required by the FFCAct. A Statement of Mutual Understanding for Cleanup Credits was executed by SCDHEC in October 2003, allowing SRS to earn credits for certain accelerated cleanup

Table 3–1
Laws/Regulations Applicable to SRS

Legislation	What It Requires	Program In Compliance
RCRA Resource Conservation and Recovery Act (1976)	The management of hazardous and nonhazardous solid wastes and of underground storage tanks containing hazardous substances and petroleum products	✓
FFCAct Federal Facility Compliance Act (1992)	The development by DOE of schedules for mixed waste treatment to meet LDR requirements	✓
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	✓
EPCRA Emergency Planning and Community Right-to-Know Act (1986)	The reporting of SRS hazardous substances (and their releases) to EPA, state emergency commissions, and local planning units	✓
NEPA National Environmental Policy Act (1969)	The evaluation of the potential environmental impacts of proposed federal activities and alternatives	✓
SDWA Safe Drinking Water Act (1974)	The protection of public drinking water	✓
CWA Clean Water Act (1977)	The regulation of liquid discharges at outfalls (e.g., drains or pipes) that carry effluents to streams (NPDES, Section 402); regulation of dredge and fill of U.S. waters (Section 404) and associated water quality for those activities (WQC, Section 401).	✓
RHA Rivers and Harbors Act of 1899, Section 10	The regulation of construction over and obstruction of navigable waters of the U.S.	✓
FIFRA Federal Insecticide, Fungicide, and Rodenticide Act (1947)	The regulation of restricted-use pesticides through a state-administered certification program	✓
CAA (NESHAP) Clean Air Act (1970), (National Emission Standards for Hazardous Air Pollutants)	The establishment of air quality standards for criteria pollutants, such as sulfur dioxide and particulate matter, and hazardous air emissions, such as radionuclides and benzene	✓
TSCA Toxic Substances Control Act (1976)	The regulation of PCBs, radon, asbestos, and lead used in sensitive populations, as well as evaluation and notification to EPA of new chemicals and significant new uses of existing chemicals	✓
ESA Endangered Species Act (1973)	The protection of critically imperiled species from extinction	✓
NHPA National Historic Preservation Act (1966)	The preservation of historical and archaeological sites	✓

actions. Credits then can be applied to the STP commitment schedules. SRS submitted to SCDHEC an annual update to the approved STP in November 2009 (SRNS–TR–2008–00101, Rev 1) that identified changes in mixed waste treatment and inventory. Changes in the 2009 STP update include

- updating the commitment summary for the new fiscal year
- updating the status of the following waste streams: SR–W001, radiologically contaminated solvents; –W008, separations area sample receipts from Savannah River National Laboratory (SRNL); –W009, silver-coated packing material; –W060, tritiated water with mercury; –W064, investigation-derived waste (IDW) - soils/sludges/slurries; –W065, IDW monitoring well purge/development water; –W066, IDW debris; –W067, IDW personal protective equipment; and –W092, Battelle Columbus Site transuranic (TRU) mixed waste.
- updating the characterization and shipment status for SR–W045, plutonium uranium extraction process (PUREX) organic waste
- changing SR–W060 from onsite treatment to offsite treatment
- revising the salt processing facility information
- revising the current cumulative inventory

Also documented in the 2009 update is SRS's completion of 1,037 TRU waste shipments (as of September 1) to the DOE's Waste Isolation Pilot Plant (WIPP) in New Mexico.

STP updates will continue to be produced annually unless provisions of the consent order are modified.

Liquid Radioactive Waste Tank Closure

The primary regulatory goal of the waste tank closure program at SRS's F-Area and H-Area liquid radioactive waste tank farms is to close the tank systems under the Federal Facility Agreement (FFA) and SCDHEC regulations, which establish requirements for the remediation of tank system(s) that are removed from service. Under these requirements, Tanks 17 and 20 in the F-Area Tank farm were closed in 1997.

Waste removal from tanks 18F and 19F was completed in 2009 using an enhanced mechanical cleaning technology known as the "Sand Mantis." Presentations were made to DOE, SCDHEC, and EPA as part of an SRS request to discontinue waste removal in both tanks. All three parties gave permission to cease waste removal activities. Operation of the Actinide Removal Process/Modular Caustic-Side Solvent Extraction Unit and use of Tank 21H for salt batch preparations were instrumental in supporting waste removal activities.

Waste Minimization/Pollution Prevention (WMin/P2) Program

2009 Program Results and Highlights The SRS Pollution Prevention/Waste Minimization (P2/WMin) Program continued to achieve significant results in 2009. All required site waste generators demonstrated active participation in the program through documented pollution avoidance and/or direct mission support activities for site recycling. Site employees' P2 awareness was increased through online articles and both general employee and job-specific training.

The WMin/P2 Program met all DOE and regulatory agency reporting requirements. Program accomplishments during 2009 included the following:

- Documentation of 24 P2 projects resulting in a DOE–SR-approved FY09 avoidance of 655 cubic meters of hazardous and radioactive waste. Site contractors exceeded their FY09 waste avoidance performance goal of 507 cubic meters by 29 percent. Annual cost avoidance resulting from the documented P2 projects was $25.5 million.
- Two National DOE *E*Star Awards, both of which were forwarded to next-tier competitions. Winning EStar nominations were *SRS Deploys New Gasket Removal and Replacement Tool* (which also claimed a "White House Closing the Circle" Honorable Mention award) and SRS *Bio-Mass Steam Plant Team.* SRS presented information about these projects to DOE Complex environmental representatives on a DOE Environmental Sustainability conference call to share lessons learned.

SRS participates in EPA voluntary P2 programs by maintaining its EPA Waste Wise and EPA National Partnership for Environmental Priorities memberships. The site continued its participation in the

Federal Electronic Reuse and Recycle Campaign, and reported 186,653 pounds of electronics recycled and reused for the FY09 campaign period.

SRS recycled 39 percent (931 metric tons) of its routine (office-type) sanitary waste stream using the North Augusta Material Recovery Facility and Three Rivers Regional Landfill services. This exceeded the 35-percent SRS routine sanitary waste recycling goal established for 2009.

Pollution prevention support was provided to DOE–HQ program offices in 2009. The P2 Program sponsored one employee to attend the June 16–17 Federal Executive Environmental Sustainability Workshop, which included a separate DOE–HQ P2 Planning Workshop June 18; both were held in Bethesda, Maryland.

The SRS pollution prevention team supported P2 awareness in 2009 on site and in the local community, as follows:

- Onsite awareness was increased through online articles and general employee and job-specific training.
- The P2 Program provided voluntary support for the North Augusta Kids Earth Day event, which hosted more than 30 separate exhibits to educate and share with the 2,000-plus attendees.
- The P2 Program provided voluntary support for the Environmental Science Educator's Cooperative (ESEC). The ESEC ECOMEET is a hands-on environmental competition for middle school students. The program also supported ESEC CSRA Electronics Recycle Days, and the Environmental Teacher of the Year Award events—both held in Augusta, Georgia.
- Solid Waste Engineering personnel, representing the P2 Program, completed a presentation on SRS Solid Waste Management and Reduction Programs at the Savannah River Subcontractor Safety Forum in Aiken as part of an Environmental Management System (EMS) topical area.

Comprehensive Environmental Response, Compensation, and Liability Act

SRS was placed on the National Priority List in December 1989, under the legislative authority of CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). In accordance with Section 120 of CERCLA, DOE, EPA Region 4, and SCDHEC entered into the FFA, which became effective August 16, 1993, and which directs the comprehensive environmental remediation of the site.

SRS has 515 waste units in the Area Completion Projects program, including RCRA/CERCLA units, Site Evaluation Areas, and facilities covered under the SRS RCRA permit. At the beginning of FY09, 373 units were complete or in the remediation phase (360 complete and 13 in the remediation phase). At the end of FY09, 374 units were complete or in the remediation phase (368 complete and six in remediation). A summary of the FY09 FFA milestones follows.

RCRA Facility Investigation/Remedial Investigation (RFI/RI) field starts were initiated for the following units:

- Savannah River Floodplain Swamp Integrator Operable Unit (including Beaver Dam Creek and D-Area Ash Basin Wetlands) Second Phase II
- Fourmile Branch Integrator Operable Unit (including the Unnamed Tributary of Fourmile Branch South of C-Area) Third Phase II

Remedial Actions were initiated at the following units:

- C-Area Burning/Rubble Pit (131–C) and Old C-Area Burning/Rubble Pit - no building number (NBN)
- M-Area Operable Unit

Remedial actions were completed and Post-Construction Reports (PCRs) or Post-Construction Reports/Corrective Measures Implementation Report/Remedial Action Completion Reports (PCR/CMIR/RACRs) submitted for the following units:

- R-Area Reactor Seepage Basins (904–57G, –58G, –59G, –60G, –103G, and –104G) and Overflow Basin (108–4R)
- A-Area Burning/Rubble Pits (731–A, –1A), A-Area Rubble Pit (731–2A), and Miscellaneous Chemical Basin/Metals Burning Pit (731–41A, –5A) [included the A-Area Ash Pile (788–2A)]

No Interim Action Post-Construction Reports (IAPCRs) were submitted in FY09.

A Removal Action Report was issued for the following unit:

- Miscellaneous Rubble Pile #2 (NBN)

Records of Decision (RODs) were submitted for the following units in FY08:

- E-Area Low-Level Waste Facility, 643–26E (Slit Trench Disposal Units 1 and 2) Interim Action
- Early Construction and Operational Disposal Sites (L–1, N–2, P–2, and R–1A, –1B, –1C)
- C-, K-, L-, and R-Reactor Complexes Early Action

RODs were approved and issued for the following units:

- P-Area Operable Unit Early Action
- M-Area Operable Unit

Explanations of Significant Differences (ESDs) were submitted for the following units:

- M-Area Operable Unit
- P Area Operable Unit Early Action

An ESD was issued for the following unit:

- M-Area Operable Unit

The Third Five-Year Remedy Review Report was issued in FY09.

Section X ("Site Evaluations") of the FFA requires SRS to submit Removal Site Evaluation (SE) reports to EPA and SCDHEC for (1) those areas with potential or known releases of hazardous substances not identified before the effective date of the agreement, and (2) those areas listed in appendix G.I of the agreement.

SRS submitted one Remedial SE report:

- Remedial Site Evaluation Report for the Sandblast Area CMB–001 (NBN) (Comment Responses)

SRS submitted eight Removal SE reports, as follows:

- 489–D Coal Pile Runoff Basin, D–006 Outfall, and 484–10D Waste Oil Facility at the D-Area Operable Unit
- Volatile Organic Compound (VOC)-Contaminated Soil at the Bubble Tower Subunit at the D-Area Operable Unit
- Tritium-Contaminated Soil and Concrete at the Moderator Processing Subunit at the D-Area Operable Unit
- P-Area Process Sewer Lines as Abandoned (NBN) Subunit at the P-Area Operable Unit
- R-Reactor Building Complex (105–R)
- R-Reactor Area Cask Car Railroad Tracks as Abandoned (NBN)
- Asphalt Floor Tile Piles at Gunsite 012 Operable Unit
- Heavy Water Components Test Reactor (HWCTR) (770–U)

The FFA requires submittal of an annual removal action report describing all removal actions performed during the previous fiscal year, by January 1 of each year. SRS submitted the report December 15, 2009, to EPA and SCDHEC. The FY09 report described 12 active removal action areas and 25 maintenance activities.

A listing of all 515 waste units at SRS can be found in appendices C ("RCRA/CERCLA Units List") and G ("Site Evaluation List") of the FFA.

Emergency Planning and Community Right-to-Know Act

The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 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 EPCRA-mandated Toxic Chemical Release Inventory report to include source reduction and recycling activities.

Executive Order 12856

Executive Order 12856, "Federal Compliance with

Right-to-Know Laws and Pollution Prevention Requirements," requires that all federal facilities comply with right-to-know laws and pollution prevention requirements. SRS complies with the applicable reporting requirements for EPCRA, as indicated in table 3–2, and the site incorporates the toxic chemicals on the Toxic Release Inventory Report into its pollution prevention efforts.

Chemical Inventory Report (Tier II)

Under Section 312 of EPCRA, SRS completes an annual Tier II Chemical 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 Release Inventory (TRI) Report (Form R)

Under Section 313 ("Toxic Chemical Release Reporting") of EPCRA, SRS must file an annual Toxic Release Inventory (TRI) report by July 1 for the previous year. SRS calculates chemical releases to the environment for each regulated chemical that exceeds its established threshold value and (in addition to other inventory data sets) reports the release values to EPA on Form R of the report. Threshold values are those quantities of regulated chemicals (as defined by EPCRA Section 313) above which additional reporting is required using the TRI Report – Form R.

Form R for 2008 was submitted electronically to EPA July 1, 2009. SRS reported the following chemicals that exceeded their thresholds: barium, chlorine, chromium, copper, fluorine, formic acid, hydrochloric acid, lead, manganese, mercury, nickel, nitrate, nitric acid, sodium nitrite, sulfuric acid, and zinc. (NOTE: The term "exceeded" in an EPCRA context does not indicate a violation. Per EPA regulations, SARA chemical limits are established, and reporting requirements are based on these threshold values.) Specific details, including release amounts and detailed information about toxic release inventory reporting, can be viewed on the EPA website at www.epa.gov/tri/tridata.

During preparation of the 2007 SRS TRI Report Form R in 2008, a substantially higher than normal nitrate release value was traced to a data transcription error that occurred during preparation of the 2000 report. Corrective actions were developed in 2008, and appropriate documentation—including a voluntary self-disclosure—was submitted to EPA, which had not responded to the submittals by the end of 2009.

Table 3–2
SRS Reporting Requirements under "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements" (Executive Order 12856)

EPCRA Citation	Activity Regulated	Reported in 2009
302–303	Planning Notification	NA[a]
304	Extremely Hazardous Substances Release Notification	NA[a]
311–312	Material Safety Data Sheet / Chemical Inventory	Yes
313	Toxic Release Inventory Reporting	Yes

[a] Did not exceed reporting threshold

National Environmental Policy Act

The National Environmental Policy Act (NEPA) is the federal government's basic charter for assuring the protection and wise use of the "human environment" by federal agencies. NEPA's procedures require that federal agencies identify and consider the potential environmental consequences of their proposed actions early in the planning process so they can make informed, environmentally sound decisions regarding project design and implementation. The NEPA process at SRS is initiated by completing an Environmental Evaluation Checklist (EEC). The EEC is used to characterize the proposed action, identify any potential environmental concerns, and determine which level of NEPA review (if any) will be required [i.e., categorical exclusion determination

(CX), environmental assessment (EA), or environmental impact statement (EIS)]. A total of 412 SRS-related NEPA reviews were conducted in 2009 (see table 3–3). In November 2009, SRS began to post CX determinations on the SRS external (public) website in support of DOE's effort to facilitate NEPA process transparency and openness. By the end of the year, SRS had posted 63 CX determinations on the website. The following is a listing of major NEPA reviews conducted during 2009, some of which are scheduled to be completed in 2010:

- *Surplus Plutonium Disposition Supplemental EIS (DOE/EIS–0283–S2)* – OE has announced its intent to modify the scope of this ongoing Supplemental EIS (SEIS) and to conduct additional public scoping. DOE issued its original Notice of Intent (NOI) on March 28, 2007. The originally stated preferred alternative for the disposition of surplus plutonium was to construct and operate a vitrification facility at SRS. Over the interim, DOE has continued to evaluate alternatives for plutonium disposition, and now is pursuing a project to combine the functions of the planned Pit Disassembly and Conversion Facility (PDCF) and the Plutonium Preparation Project (PuP) and install and operate the required equipment to disassemble pits and convert plutonium metals to oxides in an existing building in SRS's K-Area. Additionally, DOE has determined that some of the surplus plutonium could be disposed of at its WIPP facility. Also, since the Surplus Plutonium Disposition EIS was prepared in 1999, the contract with Duke Energy Company to irradiate mixed oxide (MOX) fuel in its reactors has been terminated, and DOE and the Tennessee Valley Authority (TVA) are evaluating selected TVA reactors for possible use of MOX fuel. A summary of all the alternatives DOE will evaluate in the SEIS follows: (1) PDCF Baseline – DOE would construct and operate a stand-alone PDCF facility in F-Area; (2) PuP Baseline – DOE would construct and operate the equipment required to prepare nonpit plutonium for either H-Canyon processing or as feed material for the MOX Fuel Fabrication Facility (MFFF); (3) Combination Project in K-Area – DOE would construct and operate a facility with combined PDCF and PuP capabilities in K-Area; (4) H-Canyon – DOE would use the H-Canyon to process surplus plutonium for disposal; (5) Vitrification – DOE would install a vitrification facility with can-in-canister capability in K-Area; (6) WIPP – DOE would prepare nonpit plutonium that could not be utilized as MFFF feed material for disposal at WIPP; (7) MFFF feed – PuP capabilities would be used to prepare some additional surplus nonpit plutonium as feed for the MFFF; and (8) DOE will evaluate the impacts of constructing any reactor facility modifications necessary to accommodate MOX fuel operation at TVA reactor locations.

- *Surplus Plutonium Disposition Supplemental EIS (DOE/EIS–0283–S2) Interim Action Determination* – DOE has determined that (2) the impacts of processing up to 420 kg of plutonium materials in H-Canyon for vitrification at DWPF are covered by the Interim Management of Nuclear Materials EIS, and (3) this action would not bias its selection of disposition alternatives in the SEIS process.

- *Programmatic EIS for Disposition of Scrap Metals (DOE/EIS–0327)* – At the end of 2009,

Table 3–3
Summary of SRS-Related NEPA Reviews in 2009

Type of NEPA Review	Number
Categorical Exclusion Determinations	203
"All No" EEC Determinations[a]	189
Actions Tiered to Previous NEPA Reviews	13
Environmental Impact Statements[b]	3
Supplement Analysis[c]	1
Interim Action	1
Revised FONSI	1
Environmental Assessments[d]	1
Total SRS-Related NEPA Reviews	**412**

[a] Proposed actions that require no further NEPA review

[b] DOE/EIS–0283–S2 (in progress); DOE/EIS–0375 (in progress); DOE/EIS–0396 (cancelled in 2009); DOE/EIS–0423 (in progress); DOE/EIS–0327 (schedule uncertain)

[c] SA for SRS Spent Nucleaur Fuel Management FEIS (DOE/EIS–0279) (in progress)

the draft PEIS had not been issued, and the schedule was uncertain.

- *EIS for the Disposal of Greater-Than-Class-C Low-Level Radioactive Waste (GTCC LLW) (DOE/EIS–0375)* – In this EIS, DOE will evaluate the impacts of disposing GTCC LLW in a geologic repository, in intermediate-depth boreholes, or in enhanced near-surfaced disposal facilities. Candidate DOE sites being considered at the end of 2009 for these disposal facilities included SRS, Idaho National Laboratory, Los Alamos National Laboratory, WIPP, Nevada Test Site, Oak Ridge, Hanford, and Yucca Mountain. DOE also will consider generic commercial disposal of GTCC LLW at arid and humid locations. Disposal alternatives being considered for SRS include an intermediate-depth borehole facility and an enhanced near-surface facility. Publication of the draft and final EISs is expected in June 2010 and June 2011, respectively.

- *Programmatic EIS for the Global Nuclear Energy Partnership (GNEP) Technology Demonstration Program (DOE/EIS–0396)* – Cancelled in 2009 because DOE no longer is pursuing domestic commercial reprocessing

- *Supplement Analysis (SA): SRS Spent Nuclear Fuel Management FEIS (DOE/EIS–0279)* – In this SA, DOE is reviewing the continued use of H-Canyon to process spent nuclear fuel that DOE had decided to manage using the melt-and-dilute process. No projected approval dates had been established for the SA or amended ROD by the end of 2009.

- *Environmental Assessment for the Proposed Use of SRS Lands for Military Training (DOE/EA–1606)* – In this EA, DOE will evaluate the potential impacts associated with the proposed use of SRS lands for military training by the U.S. Department of Defense (e.g., U.S. Army). Publication of the draft and final EA are expected in May and September 2010, respectively.

- *Revised Finding of No Significant Impact (FONSI): EA for the Natural Fluctuation of Water Level in Par Pond and Reduced Water flow in Steel Creek below L-Lake at the SRS (DOE/EA–1070)* – This revised FONSI reduces the required flow from L-Lake into Steel Creek and from PAR Pond into Lower Three Runs from 10.0 cubic feet per second (cfs) to 4.5 cfs and 5 cfs, respectively. DOE approved the revised FONSI January 29, 2009.

- *EIS for the Storage and Management of Elemental Mercury (DOE/EIS-0423)* – As directed by the Mercury Export Ban Act of 2008, DOE will evaluate seven sites (including SRS) for the long-term storage of elemental mercury. A scoping meeting was held in North Augusta, South Carolina, July 30, 2009. The draft and final EIS documents are expected in first and third quarters, respectively, of 2010.

Safe Drinking Water Act

The federal Safe Drinking Water Act (SDWA) was enacted in 1974 to protect public drinking water supplies. SRS domestic water is supplied by groundwater sources. The A-Area, D-Area, and K-Area systems are actively regulated by SCDHEC, while the remaining smaller water systems receive a reduced level of regulatory oversight.

Samples are collected and analyzed periodically by SRS and SCDHEC to ensure that all site domestic water systems meet SCDHEC and EPA bacteriological and chemical drinking water quality standards. All samples collected in 2009 met these standards.

The water systems in D-Area and K-Area also were sampled under the state Lead and Copper Rule in 2009. These systems were in compliance with the SCDHEC action levels for lead and copper in the 90th percentile.

Clean Water Act

National Pollutant Discharge Elimination System

The Clean Water Act (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 effluents into streams, reservoirs, and wetlands.

SRS had four NPDES permits in 2009 (table 3–4):

- Two permits for industrial wastewater discharges (SC0047431, which covered the D-Area Powerhouse, and SC0000175, which covered the remainder of the site)

- Two general permits for stormwater discharges (SCR000000 for industrial and SCR100000 for construction)

The site also had one no-discharge permit for land applications (ND0072125).

More information about SRS's NPDES permits can be found in chapter 4, "Effluent Monitoring."

The results of monitoring for compliance with the industrial wastewater discharge permit at SRS were reported to SCDHEC in the site's monthly discharge monitoring reports, as required by the permit.

SCDHEC generally conducts an unscheduled "NPDES 3560 Compliance Sampling Inspection" of the site's permitted outfalls annually; however, no such inspection was performed in 2009.

The outfalls covered by the industrial stormwater permit (SCR000000) were reevaluated in 2007. This resulted in the development of a new sampling plan implemented in 2008. No new issues were identified in 2009. Results of stormwater outfall sampling appear in an effluent monitoring data table on the CD housed inside the back cover of this report.

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 2009.

SRS has an agreement with SCDHEC to report petroleum product discharges of 25 gallons or more to the environment. No such incidents occurred at the site in 2009.

Notices of Violation (CWA)

SRS received no NOVs under the CWA in 2009. Only four out of 4,989 sample analyses (includes flow measurements and no-flow designations) performed during 2009 exceeded permit limits—a 99.92-percent compliance rate. The four exceptions were as follows.

- A permit exception occurred February 2 at Outfall A–11 because of an elevated pH level.
- An invalid result attributed to contaminated contract laboratory dilution water was reported July 2 for the BOD sample at Outfall TH–1(H–16). This is considered an isolated event.
- On November 8 and 9, the daily maximum water temperature difference value at Outfall D–01 exceeded the limits due to defective temperature monitoring equipment. SRS activated a temperature mediation plan immediately and replaced the defective equipment.

Dredge and Fill; Rivers and Harbors

The CWA, Section 404, "Dredge and Fill Permitting," as amended, and the Rivers and Harbors Act (RHA) of 1899, Sections 9 and 10, "Construction Over and Obstruction of Navigable Waters of the United States," protect U.S. waters from dredging/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 and 40 CFR.

In 2009, SRS had four open permits under the Nationwide Permits (NWPs) program (general permits under Section 404), and one permit open under the RHA of 1899, Section 10, as follows:

- Dam construction on an unnamed tributary to Fourmile Branch for the Mixed Waste Management Facility Groundwater Interim Measures project was completed in 2000 under NWP 38, "Hazardous Waste Cleanup." However, mitigation for the impact to wetlands was still pending in 2009 and must be addressed before the permit can be considered closed. The SRS Maintenance and Operations (M&O) contractor, Savannah River Nuclear Solutions, LLC (SRNS), has requested approval from DOE to use wetland mitigation bank credits to satisfy the mitigation issue and close the permit.
- Installation of characterization wells in the wetlands near Joyce Branch and Mill Creek was covered under NWP 5, "Scientific Measurement Devices." The wells will be used to investigate the groundwater in wetlands adjacent to Joyce Branch and Mill Creek near R-Area. The project was completed in December 2008

- A minor discharge of material for research purposes was authorized in May 2008 under NWP 18, "Minor Discharges. The material was placed in Steel Creek below the S.C. Highway 125 bridge and used by SRNL as part of a remediation research project evaluating active caps in streams to remediate contaminants. An active cap is one that actively binds or sequesters contaminants—as opposed to a passive cap, which simply covers contaminants. The cap in this research project consisted of combinations of apatite, sand, organoclay, and a sugar-based polymer. Research continued in 2009, and the permit for this project remains open.

- SRS initiated a project during 2009 to dredge sediments out of the 681–3G and 681–5G pumphouse canals to allow for better flow to the water intake of each pumphouse. On March 24, an RHA of 1899 Section 10 permit, (SAC–2008–1156) was obtained from the U.S. Army Corps of Engineers (COE) to allow the dredging work to begin. Both canals were successfully dredged and returned to their original design. The project complied with the Section 10 permit and was completed in June 2009. The permit remains open until March 31, 2014, to allow for additional maintenance dredging as required.

Water Quality Certification

Section 401, "Water Quality Certification," of the CWA is administered by SCDHEC to ensure the maintenance of water quality during dredge-and-fill projects. On December 4, 2008, a water quality certification (WQC), P/N 2008–1156–6IJ, was issued to Washington Savannah River Company for the sediment dredging project of 681–3G and 681–5G pumphouse canals. This certification was transferred to Savannah River Nuclear Solutions January 14, 2009. The WQC was a prerequisite for the Section 10 permit that the COE required for this project. The WQC remains in effect for this project until December 4, 2011.

Construction in Navigable Waters

SCDHEC Regulation 19–450, "Permit for Construction in Navigable Waters," protects South Carolina's navigable waters. The only state navigable waters at SRS are Upper Three Runs Creek (through the entire site), Lower Three Runs Creek (upstream to the base of the PAR Pond Dam), and the Savannah River (along the site's southwestern border).

A navigable waters permit (P/N 2008–1156–6IJ) was issued to Washington Savannah River Company December 4, 2008, for the sediment dredging project of the 681–3G and 681–5G pumphouse canals. The permit—transferred to Savannah River Nuclear Solutions January 14, 2009—was issued by SCDHEC simultaneously with the WQC, and remains in effect for this project until December 4, 2011.

Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act regulates the application of restricted-use pesticides (RUPs) at SRS through a state-administered certification program. The site complies with these requirements through Procedure 8.1, "Federal Insecticide, Fungicide, and Rodenticide Act Compliance for Use of Pesticides," of the Environmental Compliance Manual (3Q). Extensive revisions of the procedure have been incorporated in recent years to improve the efficiency of the site pesticide-application approval process.

According to the SRS Pesticide Activity Report Database, 1,212 pounds of solid pesticides, 233 gallons of liquid or aerosol pesticides, and 291 one-ounce pieces of rodenticide (totaling 18.2 pounds) were applied at SRS during 2009. All pesticides used in 2009 were "unrestricted," meaning that they were lower-toxicity, commercially available grades of pesticide compared to RUPs.

Clean Air Act

Regulation and Delegation

The Clean Air Act (CAA) and the Clean Air Act Amendments (CAAA) of 1990 provide the basis for protecting and maintaining air quality. Though EPA still maintains overall authority for the control of air pollution, regulatory authority for all types of emission sources has been delegated to SCDHEC. Therefore, SCDHEC must ensure that its air pollution regulations are at least as stringent as the federal requirements. This is accomplished through SCDHEC Regulation 61–62, "Air Pollution Control Regulations and Standards." The various CAAA

Titles covered by these SCDHEC regulations are discussed below.

Title V Operating Permit Program

Under the CAA, and as defined in federal regulations, SRS is classified as a "major source" and, as such, falls under the CAAA Part 70 Operating Permit Program. On February 19, 2003, SCDHEC's Bureau of Air Quality issued SRS its Part 70 Air Quality Permit (TV–0080–0041), with an effective date of April 1, 2003, and an expiration date of March 31, 2008. SRS submitted a permit application renewal September 18, 2007, as required by SC R61–62.70. The site expected to receive the new Part 70 Air Permit in 2008; however, due to prioritization issues with SCDHEC, renewal of the permit has been delayed until 2010—and the initial permit has been extended. Until SCDHEC renews the permit, SRS will continue to operate in accordance with requirements of the extended permit.

The Part 70 Air Quality Permit regulates both radioactive and nonradioactive toxic and criteria pollutant emissions from approximately 22 nonexempt emission units, with each emission unit having specific emission limits, operating conditions, and monitoring and reporting requirements. The permit also contains a listing, known as the Insignificant-Activities List, identifying approximately 500 SRS sources that are exempt based on insignificant emission levels, or on equipment size or type.

The renewed Title V permit for the D-Area Powerhouse (TV–0300–0036) was issued to SRS May 15, 2007, with an effective date of July 1, 2007, and an expiration date of June 30, 2012. In 2007, DOE–SR proposed replacement of the existing D-Area Powerhouse boilers with two new biomass cogeneration boilers more closely aligned with current and future steam demands. This proposed action would allow for decommissioning of the existing D-Area Powerhouse prior to its current Title V permit expiring June 30, 2012. SCDHEC issued construction permit No. 0080–0144CA November 12, 2008 for a new biomass-fired cogeneration plant to be located at SRS. Construction of the plant officially got under way with a groundbreaking ceremony November 30, 2009.

SCDHEC issued no revisions to the SRS Part 70 Air Quality Permit (TV–0080–0041) in 2009. Three revisions to the 484–D Powerhouse Part 70 Air Quality Permit (TV–0300–0036) were issued by SCDHEC in 2009 to incorporate two administrative changes and one minor modification to remove insignificant activities.

The Mixed Oxide Fuel Fabrication Facility (MFFF)—a part of the SRS Nuclear Nonproliferation Program—was issued an air construction permit (0080–0139CA) August 22, 2006. Construction of the MFFF, which began August 1, 2007, continued throughout 2009.

Compliance with the SRS Part 70 Air Quality Permit conditions last was evaluated by SCDHEC September 15, 2009, as part of an Air Compliance Inspection. For results of the evaluation, refer to the "Assessments/Inspections" section of this chapter, beginning on page 3–17.

Notices of Violation (CAA)

No NOVs were issued to SRS under the CAA in 2009. SCDHEC had issued a Notice of Alleged Violation (NOAV) to the site June 11, 2008, concerning a particulate matter (PM) exceedance related to the biennial stack test of the site's A-Area Boiler #2 conducted February 20 of that year. During a presentation to SCDHEC, SRS provided evidence that (1) the boiler was operating within limits required by the permit, (2) the issuance of the NOAV by SCDHEC was not legally supportable, and (3) the only exceedance occurred during testing. SCDHEC agreed there was credible evidence that the boiler test was conducted at an operating level much higher than normal operating conditions, and agreed to include in any order language that SRS did not admit a violation. The parties continued to negotiate settlement of the dispute in 2008, and subsequently signed a consent order (09–002A), which included a $6,500 fine, in January 2009.

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.

NESHAP Radionuclide Program The current list of 187 hazardous air pollutants includes all radionuclides as a single item. Regulation of these pollutants has been delegated to SCDHEC; however, EPA Region 4 continues to regulate some aspects of NESHAP radionuclides.

NESHAP Radionuclide Program Subpart H of 40 CFR 61 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 4 signed a Federal Facility Compliance Agreement (FFCA) October 31, 1991, providing a schedule to bring SRS's emissions monitoring into compliance with regulatory requirements. The FFCA was officially closed—and the site declared compliant—by EPA Region 4 May 10, 1995. Subpart H was revised by EPA September 9, 2002, with an effective date of January 1, 2003. This revision added inspection requirements for existing SRS sources and allowed the use of ANSI N13.1–1999 for establishing monitoring requirements. SRS is performing all required inspections, has monitoring systems compliant with the regulation, and remains in compliance with Subpart H of 40 CFR 61.

During 2009, the maximally exposed individual effective dose equivalent, calculated using the NESHAP-required CAP88 computer code, was estimated to be 0.04 mrem (0.0004 mSv), which is 0.4 percent of the 10 mrem per year (0.10 mSv per year) EPA standard (chapter 6, "Potential Radiation Doses").

SRS compliance with 40 CFR 61, Subpart H ("National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities") last was evaluated by SCDHEC in June 2008 as part of a Title V radiological NESHAP inspection. SCDHEC did not conduct a Subpart H inspection at SRS in 2009.

NESHAP Nonradionuclide Program SRS uses many chemicals identified as toxic or hazardous air pollutants, but most of them 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 original 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 (MACT) standards.

On September 13, 2004, EPA finalized a MACT rule that applied to the coal-fired steam boilers at the 784–A and 484–D powerhouse facilities. The rule, "National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters" (Boiler MACT), had a compliance date of September 13, 2007, and required facilities to meet more stringent emissions limits dealing with PM, mercury, and hydrogen chloride emissions. During 2006, 484–D Powerhouse Facility personnel prepared to conduct the necessary testing during the 2007–2008 timeframe to demonstrate compliance with the new emission limits without the significant expenditure of capital funds. In June 2006, a MACT extension request was submitted to SCDHEC's Bureau of Air Quality requesting a one-year extension from the September 2007 compliance date so SRS could replace the aging A-Area boilers with a smaller wood-fired boiler and an oil-fired boiler capable of meeting the lower MACT emission limits. That compliance extension request was approved by SCDHEC September 5, 2006. Then, on July 30, 2007, the U.S. Court of Appeals for the District of Columbia vacated the Boiler MACT, thereby leaving it up to each state to enforce the rule. The State of South Carolina—one of the few states that elected to proceed with implementation of the rule—decided to give all facilities in the state a one-year extension until September 12, 2008, to comply. In May 2008, SCDHEC provided an additional 24 months—until September 13, 2010—for the facilities to comply.

NESHAP Asbestos Abatement Program SRS began its asbestos abatement program in 1988 and continues to manage asbestos-containing material (ACM) by "best management practices." Site compliance in asbestos abatement, as well as demolitions, falls under SCDHEC and federal regulations, including South Carolina Regulations 61–86.1 ("Standards of Performance for Asbestos Projects") and 40 CFR 61, Subpart M ("National Emission Standards for Hazardous Air Pollutants – Asbestos"). Procedure 4.14 ("Asbestos Management Program") of SRS Environmental Compliance Manual 3Q provides site personnel and contractors applicable guidelines to ensure compliance with state and federal requirements.

SCDHEC finalized extensive revisions to R. 61–86.1 during 2008. The change that most affected SRS was a requirement that mandated a follow-up analysis of suspect ACM using transmission electron microscopy (TEM) of at least one of three bulk samples should all three samples test negative for the presence of asbestos when using customary polarized light microscopy (PLM). Regulatory Integration and

Environmental Services (RI&ES) personnel secured a laboratory to perform the TEM analyses, thus enabling the site to comply with the new requirement. Procedure 4.14 was revised in 2009 to reflect the TEM requirement.

SRS personnel removed and disposed of an estimated 33.75 square feet and 630 linear feet of friable (regulated) ACM during 2009. SRS personnel also removed an estimated 9,846.75 square feet, 673 linear feet, and 1cubic foot of nonfriable (unregulated) ACM.

Radiologically-contaminated asbestos waste was disposed of at the SRS E-Area low-level vaults, engineered trenches, and slit trenches, which are authorized by SCDHEC as asbestos waste disposal sites. Nonradiological asbestos waste was disposed of at the Three Rivers Solid Waste Authority Landfill and the construction and demolition (C&D) debris Landfill (632–G), both of which also are SCDHEC-approved asbestos waste landfills.

Accidental Release Prevention Program

Under Title III of the CAAA, EPA established a program for the prevention of accidental releases of large quantities of hazardous chemicals. As outlined in Section 112(r), any facility that maintains specific hazardous or extremely hazardous chemicals in quantities above specified threshold values must develop a risk management program (RMP). The RMP establishes methods that will be used for the containment and mitigation of large chemical spills.

SRS maintains hazardous and extremely hazardous chemical inventories below the threshold value. This cost-effective approach minimizes the regulatory burden of 112(r) but does not eliminate any liability associated with the general duty clause, as stated in 112(r)(1). No reportable 112(r)-related hazardous or extremely hazardous chemical releases occurred at SRS in 2009.

Ozone-Depleting Substances

The CAAA of 1990 mandated significant new air quality standards for the protection of stratospheric ozone. These initiatives directly impacted operations, maintenance, and recordkeeping activities related to ozone depleting substances (ODS) at SRS. First, the CAAA Title V operating permit program (TV–0080–0041, Condition 4.B.6) requires that SRS comply with the standards for recycling and emissions reduction pursuant to 40 CFR 82. The permit specifies compliance with the requirements of Subpart B ("Servicing of Motor Vehicle Air Conditioners"), Subpart E ("The Labeling of Products Using Ozone-Depleting Substances"), and Subpart G ("Significant New Alternatives Policy Program"). Accordingly, all large (greater than or equal to 50-pound charge) heating, ventilation, and air conditioning/chiller systems leak repair data are reported monthly. Incidental discharges from refrigerant sources at SRS during 2009 totaled 392 pounds.

Additionally, the Title V operating permit also specifies that SRS comply with the requirements of halon emissions reduction and recycling found in 40 CFR 82, Subpart H ("Halon Emissions Reduction"). Halon is used as a fire suppression agent; therefore, the SRS Fire Department (SRSFD) is responsible for providing halon fire suppression equipment at the site. SRSFD personnel maintain and recharge halon-containing equipment, and manage the national halon repository (Savannah River Halon Repository). Halon is maintained at this repository to support existing missions at SRS for the life of the missions. The repository also maintains halon supplies for other sites in the DOE complex.

According to the SRS Halon Management Plan (F–ESR–G–00120, November 16, 2005), all halon systems in service at SRS are scheduled to remain in service for the life of SRS's existing missions. As missions cease, halon will be recovered, recycled, and stored at the SRS repository in support of continuing missions. When stored halon exceeds the amount needed for support of SRS and other DOE sites, the excess is shipped to the U.S. Department of Defense (DOD), or offered to the General Services Administration as excess. SRS continues to phase out its use of halon as part of an overall goal to eliminate halon use in the United States.

The SRSFD details the total halon inventory at SRS in its annual "Halon Report" to DOE. As of December 31, 2009, there was approximately 55,264 pounds on site, including 19,407 pounds in 85 installed fire suppression systems, and 8,590 pounds of unprocessed Halon stored in original containers. The balance, 27,267 pounds of Halon, has been processed and is stored on site in 1-ton bulk containers. The 2009 total represents a significant decrease from the 2008 total of 71,167 pounds. The reduction is attributable to a large shipment of halon to DOD in

December 2009. In addition, to the SRS inventory, halon totaling 34,790 pounds was maintained in the national halon repository at SRS.

Air Emissions Inventory

SCDHEC Regulation 61–62.1, Section III ("Emissions Inventory"), requires compilation of an air emissions inventory to locate all sources of air pollution and to define and characterize the various types and amounts of pollutants. To demonstrate compliance, SRS personnel in 1993 conducted the initial comprehensive air emissions inventory, which identified approximately 5,300 radiological and nonradiological air emission sources. Source operating data and calculated emissions from 1990 were used initially to establish the SRS baseline emissions and to provide data for air dispersion modeling. In 2006, a rerun of the air dispersion modeling accompanied the site's Title V permit renewal application. This modeling was required to demonstrate sitewide compliance with Regulation 61–62.5, Standards No. 2 ("Ambient Air Quality Standards") and No. 8 ("Toxic Air Pollutants").

Regulation 61–62.1, Section III, which was revised in August 2005, requires that air emissions inventory data be updated and recorded annually but reported to SCDHEC on a specific reporting frequency—either an annual cycle for "Type A" sources or a 3-year cycle for "Type B" and "Nonattainment Area" sources—based on "minimum reporting thresholds." The threshold values depend on the actual tons per year of specific criteria pollutants.

SRS, under Title V Permit TV–0080–0041, is classified as a Type B source, required to report only every third year, thus reducing the cost burden associated with annual emissions inventories for sources with moderate emission rates. However, the acquired D-Area Powerhouse (co-located at SRS), under Title V Permit TV–0080–0044, is a Type A source that must report actual emissions annually. Both facilities ("SRS" and "D-Area Powerhouse") compiled and reported CY 2008 emissions to SCDHEC by March 31, 2009, as required. CY 2009 emissions, on the other hand, must be submitted to SCDHEC by March 31, 2010, only for the Powerhouse (as a Type A source with an annual requirement).

During 2009, the site collected CY08 operating data for permitted and other significant sources in accordance with SRS procedures and guidelines. Because data collection for all SRS sources begins in January for the preceding year, and requires up to 6 months to complete, the 2009 site environmental report contains emissions data for CY08. These data were used to generate the site's Title V Permit renewal application. Compilation of 2009 data will be completed in 2010 and documented in the SRS Environmental Report for 2010.

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 record keeping are mandated for new chemicals and for any chemical that may present a substantial risk of injury to human health or the environment.

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 site policies.

The site's 2008 PCB document log was completed in full compliance with 40 CFR 761, and the 2008 annual report of onsite PCB disposal activities was submitted to EPA Region 4 in July 2009, meeting applicable requirements. The disposal of nonradioactive PCBs routinely generated at SRS is conducted at EPA-approved facilities within the regulatory period. For some 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.

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 critical habitats on which such species depend.

Several threatened and endangered species exist at SRS, including the wood stork, the red-cockaded woodpecker, the shortnose sturgeon, the pondberry, and the smooth purple coneflower. Although the bald eagle is no longer on the endangered species list, it is still protected under the Bald and Golden Eagle Protection Act. Programs are in place to enhance the habitat and survival of such species.

In 2009, as part of the Natural Resource Management Plan, the USDA Forest Service–Savannah River (USFS–SR) developed five biological evaluations (BEs), four of which were conducted for timber-related activities. The one nontimber BE was for the Advanced Tactical Training Area facility expansion. This project was reviewed and determined by the U.S. Fish and Wildlife Service (FWS) to be an informal consultation with no adverse impact to the red-cockaded woodpecker because it did not adversely impact active or recruitment foraging areas or population goals for the bird. The four timber-related BEs—Steel Creek watershed, PAR Pond West watershed, the windstorm in Timber Compartment 21, and tree mortality related to a prescribed burn in Timber Compartment 55—were evaluated by the FWS and considered to have no adverse impacts on the threatened and endangered species.

National Historic Preservation Act

The National Historic Preservation Act (NHPA) of 1966, Section 106, governs archaeological and historical resources. SRS ensures that it is in compliance with the NHPA through several processes. The Cold War Programmatic Agreement and the SRS Cold War Built Environment Cultural Resource Management Plan are in place and being implemented. The site's artifact selection team—which includes DOE, Savannah River Nuclear Solutions, LLC, (SRNS), and the University of South Carolina's Savannah River Archaeological Research Program (SRARP)—meets monthly and is responsible for overseeing the selection, collection, and curation of Cold War-era artifacts from buildings prior to decommissioning and demolition activities.

SRS also helps ensure that it remains in compliance with NHPA through its Site Use Program. All locations being considered for activities such as construction are evaluated by SRARP personnel to ensure that archaeological or historic sites are not impacted. Reviews of timber compartment prescriptions include surveying for archaeological resources and documenting areas of importance with regard to historic and prehistoric significance.

The following information is summarized from the Annual Review of Cultural Resources Investigations by the Savannah River Archaeological Research Program, Fiscal Year 2009, Savannah River Archaeological Research Program, South Carolina Institute of Archaeology and Anthropology, University of South Carolina, October 2009.

SRARP personnel reviewed 51 site-use permit application packages during FY09, of which 42 proposed land modifications resulted in the need to survey 144 acres (7.1 percent) of the total survey coverage for FY09. The remaining site-use packages were found to have no activities of significant impact in terms of the NHPA. SRARP personnel also surveyed 1,880 acres (92.9 percent) of the total survey area coverage in 2009 in support of onsite forestry activities. Sixty-seven surveys were conducted in FY09, totaling 2,024 acres and consisting of 42 Site-Use Application Surveys and 25 Timber Compartment Prescription Surveys. During these surveys a total of 3,723 shovel test pits were dug of which 523 had positive results. These investigations identified 39 new archaeological sites—and resulted in revisits to 19 previously recorded sites for cultural resources management within the 2,024 acres.

In compliance with NHPA, artifacts recovered through daily compliance activities and the analysis of artifacts recovered must be curated. SRARP curated 7,002 artifacts during FY09. Of these curated artifacts, 2006 were from compliance related excavations; 2,690 from site 38AK469 (Flamingo Bay site); and 2,306 from site 38AK11 (Lawton Site).

Floodplains and Wetlands

Under 10 CFR 1022 ("Compliance with Floodplains and Wetlands Environmental Review Requirements"), DOE establishes policies and procedures for implementing its 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. No floodplains/wetlands assessments were performed in 2009.

Executive Order 11988

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 SRNS, DOE–SR, the USFS–SR, and the Savannah River Ecology Laboratory (SREL), as well as by professionals from other organizations.

Executive Order 11990

Executive Order 11990 ("Protection of Wetlands") was established to mitigate adverse impacts to wetlands caused by destruction and modification, 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 from SRNL, SREL, and RI&ES—review site-use applications to ensure that proposed projects do not impact wetlands.

Environmental Release Response and Reporting

Response to Unplanned Releases

RI&ES personnel respond to unplanned environmental releases, both radiological and nonradiological, upon request by area operations personnel. No unplanned environmental releases occurred at SRS in 2009 that required the sampling and analytical services of RI&ES.

Occurrences Reported to Regulatory Agencies

Federally permitted releases comply with legally enforceable licenses, permits, regulations, or orders. If a nonpermitted release to the environment of a reportable (or greater) quantity of a hazardous substance (including radionuclides) occurs, CERCLA requires notification of the National Response Center. Reportable quantities—not to be confused with threshold values, as defined by EPCRA Section 313—are those quantities of a hazardous substance greater than or equal to values specified in table 302.4 ("Designation of Hazardous Substances") of 40 CFR 302 ("Designation, Reportable Quantities, and Notification").

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 has been reinforced with liability provisions in the CERCLA National Contingency Plan. SRS has had no CERCLA-reportable releases since 1999.

No notifications required by CERCLA or SCDHEC Memoranda of Understanding had to be made by SRS during 2009. One SCDHEC-required notification was made regarding a November 10 sewage spill of greater than 500 gallons at 607–68G collection station (due to faulty underground wiring that has been corrected). The site recorded and cleaned up the following spills that did not require reporting under CERCLA or to SCDHEC: 31 chemical, one radioactive wastewater, four sewage, and 97 petroleum products.

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 at SRS in 2009.

Site Item Reportability and Issues Management Program

The Site Item Reportability and Issues Management (SIRIM) program, mandated by DOE Order 232.1A ("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."

Of the 127 SIRIM-reportable events in 2009, none involved allegations of violations, and one—the November 10 sewage spill described earlier—was categorized as environmental.

Assessments/Inspections

The SRS environmental program is overseen by a number of organizations, both outside and within the DOE complex. In 2009, the site's environmental appraisal program again consisted of self and independent assessments. The program ensures the recognition of noteworthy practices, the identification of performance deficiencies, and the initiation and tracking of associated corrective actions until they are satisfactorily completed. The primary objectives of the assessment program are to ensure compliance with regulatory requirements and to foster continuous improvement. The program—an integral part of the site's Integrated Safety Management System—supports the SRS EMS, which continues to meet the standards of International Organization for Standardization Standard 14001. (ISO 14000 is a family of voluntary environmental management standards and guidelines.) The Site Tracking, Analysis, and Reporting (STAR) is a database used for scheduling self-assessments as well as documenting results and any issues or concerns identified, tracking corrective actions to closure, and trending accumulated data for process improvement. DOE–SR's Environmental Quality Management Division conducted 94 assessments on SRNS and SRR environmental programs during 2009.

SRNS also conducted several environmental program-level assessments in 2009. The self-assessment titles, the environmental topical areas (in parentheses), and brief summaries are as follows:

- *NEPA* - *Categorical Exclusions* - *Compliance With the National Environmental Policy Act(NEPA)* – This self-assessment was conducted July 1–30. The objective was to evaluate the use of "all no" EECs at SRS and the level of NEPA compliance achieved by implementing organizations. The overall level of use of "all no" EECs by the site organizations surveyed was minimal, but the level of NEPA compliance achieved by implementing organizations was good. The assessment identified six opportunities for improvement (OFIs) to address observations. Corrective actions for the observations were identified and initiated, and are in progress or completed.

- *Liquid Effluents (Radiological* - *Surface Water Quality)* – This self-assessment was conducted July 14–31. The purpose was to review the SRS Radiological Liquid Effluent Monitoring Program to ensure that SRNS's program basis conforms to applicable DOE orders and site procedures. The assessment—which included data, document, and procedure reviews, and interviews of environmental monitoring personnel—identified two document items to be updated and five OFIs for database enhancements. Corrective actions for the observations were identified and initiated, and are in progress or completed.

- *Calculations* - *Radiation Dose Evaluations (Environmental Radiation Protection Dose)* – This self-assessment was conducted September 15–October 29. The purpose was to review SRS's dose calculation program to ensure conformance with applicable DOE orders and standards. The primary focus of the assessment was to ensure that the environmental dosimetry used at SRS is technically defensible, accurate, and current, that doses to the public have not exceeded DOE regulations, and that all potential pathways are considered. This assessment includes document reviews, interviews, and data review. Indirectly, the assessment examined the relationship between environmental dosimetry and other program elements, such as the environmental monitoring radiological effluent and surveillance programs. The results showed that SRS's program for dose calculations meets the requirements defined in federal regulations and in DOE orders. The SRS staff members responsible for dose calculations were found to be sufficiently knowledgeable and qualified. Dose calculations are performed with standard calculating models required or recommended in the regulations. Modifications of standard models are documented and approved for use by appropriate authorities. Five OFIs were identified. Corrective actions for the observations were identified and initiated, and are in progress or completed.

- *Emissions from Motor Vehicles (Air Quality Protection)* – This self-assessment was conducted December 4–14. The purpose was to review the adequacy and effectiveness of contractor policies, procedures, and programs in meeting federally mandated requirements for ride-sharing activities and the reduction of motor vehicle emissions. Procedures/policies reviewed involved minimizing emissions to the atmosphere from motor vehicles and from gasoline storage and dispensing operations. Applicable regulations, orders, and plans include 40CFR80.22 ("Regulations of Fuel and Fuel Additives, Controls and Prohibitions"), Executive Order 13423 ("Strengthening Federal Environmental, Energy, and Transportation Management"), and the "U.S. Department of Energy Savannah River Site Strategic Plan," May 2009. The assessment identified one OFI to address an observation. A corrective action for the observation was identified, initiated, and completed.

- *Environmental Surveillance* - *Radiological Air Environmental Surveillance Program (Air Quality Protection)* – This self-assessment was conducted August 10–September 4. The purpose was to verify that program-specific information is included in the SRS Environmental Monitoring Plan (EMP) to address required radiological air surveillance monitoring, sampling, analysis, and reporting needs. Results indicated the radionuclide ambient air sampling program at SRS is well documented, but the EMP is due for an update. The quality assurance aspects of the program appear to be adequate and are being implemented appropriately. During the field walkdown, sample collection was observed. The collection activities were procedurally correct. Four OFIs were identified. Corrective actions for the observations were identified and initiated, and are in progress or completed.

- *Facility Permitting* - *Protection of Drinking Water Sources (Domestic Water Quality)* – This self-assessment was conducted October 1–15. The purpose was to verify that the health and safety of site employees is protected by providing drinking water that meets all federal and state regulatory requirements and engineering design standards. Construction and/or operating permits are obtained from SCDHEC or SRNS (as appropriate) prior to initiating any construction, expansion, or modification of drinking water wells or of treatment or distribution systems or facilities. Permits are obtained or issued on an as-needed basis. Generally, the domestic water systems were found to be in excellent condition and in compliance with state Primary Drinking Water Regulations. Personnel associated with the operation and maintenance of the systems were adequately trained to perform all necessary functions to maintain compliance. No programmatic findings were identified against this program self-assessment element during the evaluation.

- *Facility Operations and Maintenance* - *Protection of Drinking Water Sources (Domestic Water Quality)* – This self-assessment was conducted October 1–19. The purpose was to verify that the health and safety of site employees is protected by providing drinking water that meets all federal and state regulatory requirements and engineering design standards. Generally, the domestic water systems are in excellent condition and are being operated in compliance with the state Primary Drinking Water Regulations. Personnel associated with the operation and maintenance of the site's domestic water systems are adequately trained to perform all necessary functions to maintain compliance. No programmatic findings were identified against this program self-assessment element during the evaluation.

- *Operator Certification* - *Protection of Drinking Water Sources (Domestic Water Quality)* – This self-assessment was conducted October 13–19. The purpose was to determine the adequacy and effectiveness of applicable programs, policies, and procedures to ensure compliance with domestic water operator certification requirements. The assessment involved interviews with the personnel responsible for the operator certification program, and a review of the training records, program policies, and procedures. Also, in conjunction with this assessment, an inspection of the site's domestic water facilities and a review of associated records and logs were performed. These activities indicated that the personnel responsible for operating and maintaining the site's domestic water systems are adequately trained to perform all necessary functions to maintain compliance. Generally, the operator certification program was found to be extremely well-organized, and all aspects of the regulations and procedures followed. Time and cost-saving measures have been implemented to ensure that training requirements can be met easily. No programmatic findings were identified against this program self-assessment element during the evaluation.

- *Effectiveness Evaluation of Environmental Protection Program via Transition Readiness Review (TRR) (Management Discretion)* – This self-assessment was conducted February 24–March 31. The purpose was to measure how well the transition of SRS's M&O functions to SRNS is progressing, to determine the transformation's overall effectiveness, and to ensure that changes in RI&ES's organizational structure had been communicated and that both staff and customers are cognizant of the changes. The scope of this assessment included reviews of organizational documents, meeting documents, and initiatives, as well as interviews of 28 RI&ES and DOE Environmental Quality Management Division staff members to assess the effectiveness of the changes. Because no minimum requirements were identified in the scope of this assessment, no findings were generated as a result of the review. Concern was expressed with respect to the lack of depth and succession planning. Some positives noted in terms of personnel understanding the changes and of customers recognizing the changes in organizational structure. Eleven OFIs were identified. Corrective actions for the observations were identified and initiated, and are in progress or completed.

- *Environmental Protection Programs* - *Organizational Structure (Environmental Management Functions)* – This self-assessment, conducted February 10–June 30, evaluated the programmatic implementation of the site's EMS. The purpose was to provide assurance that SRNS and Savannah River Remediation LLC (SRR), the site's Liquid Waste Operations contractor, and subcontractor organizations apply the principles and specific requirements of DOE Order 450.1A, "Environmental Protection Program." This order mandates the implementation of an EMS, which ensures sound stewardship practices that protect air, water, land, and other natural and cultural resources impacted by DOE operations. The assessment provides the basis for ensuring that site activities meet or exceed compliance with applicable environmental, public health, and resource protection requirements. Results indicated the organizational structure at SRS was established in such a manner that the functions, responsibilities, and authorities for environmental protection programs are clearly defined. Both oversight roles and line management responsibilities are accommodated. In general, the RI&ES management team has a keen understanding of EMS policies, procedures, and practices. Existing goals and targets are defined for functional areas. The assessment identified one OFI to address multiple observations. One corrective action for the observations was identified, initiated, and completed.

- *Health and Safety* - *Release Reporting (Releases)* – This self-assessment was conducted May 5–29. The purpose was to verify that a program is in place to discover, characterize, and report—within required time frames of the laws and regulations—environmental releases of hazardous substances that are reportable to the federal or state government. Interviews indicated that policies and procedures were in place for reporting and responding to hazardous-substance releases. Other site contractors' staff members appeared knowledgeable and also had appropriate procedures and policies in place. The assessment identified three OFIs to address observations. Corrective actions for the observations were identified and initiated, and are in progress or completed.

- *Laboratory Certification* - *Protection of Drinking Water Sources (Domestic Water Quality)* – This self-assessment was conducted November 16–December 30. The scope of the activity involved evaluating the SRNS laboratory certification program against the state Environmental Laboratory Certification Program. All SRNS certified laboratories were included in this assessment. Results indicated that the laboratory certification program appears to be sound. Most of the professionals involved have been associated with the program for several years, so there is a great deal of undocumented tribal knowledge. It is believed that the program can be enhanced by procedural changes that capture some of this information. One finding resulted from this assessment, and four OFIs were identified. Corrective actions for the finding and observations were identified and initiated, and are in progress or completed.

- *D-Area Clean Water Act (Domestic Water Quality)* – This self-assessment was conducted March 24–May 15. The scope of the activity involved evaluating D-Area compliance with the CWA based on implementation of related SRNS policies, programs, and procedures. The assessment was conducted primarily with several teams of two assessors. Consequently, several trips were made to the D-Area Powerhouse. Several documents were reviewed, and many

Table 3–4
SRS Construction and Operating Permits, 2005–2009

Type of Permit	Number of Permits				
	2005	**2006**	**2007**	**2008**	**2009**
Air	1	3[a]	5[a]	5	5
U.S. Army Corps of Engineers – Section 10, Rivers & Harbors Act of 1899	0	0	0	0	1
U.S. Army Corps of Engineers Nationwide Permit	4	5	5	4	2
Domestic Water	207	207	207	170	170
Industrial Wastewater	63	70	70	70	70
NPDES Discharge	1	2	2	2	2
NPDES No Discharge	1	1	1	1	1
NPDES Stormwater	2	2	2	2	2
Construction Stormwater Grading Permit	13	9	10	11	24
RCRA Hazardous Waste	1	1	1	1	1
RCRA Solid Waste[b]	4	3	4	4	4
RCRA Underground Storage Tank	7	7	7	7	7
Sanitary Wastewater	106	106	106	98	89
SCDHEC 401	0	0	1	0	1
SCDHEC Navigable Waters	0	0	1	0	1
Underground Injection Control	21	14	14	15	13
Totals	**431**	**430**	**436**	**390**	**393**

[a] These numbers were revised to include the Mixed Oxide Fuel Fabrication Facility construction permit received in 2006.

[b] The Saltstone Disposal Facility's landfill permit covers all the Saltstone disposal vaults and cells.

people were interviewed. A key theme identified was that D-Area did not appear to be completely integrated with the rest of the SRNS M&O functions. Procedures are several generations old; most of the staff consists of subcontractors; and facility personnel generally do not rely on the 3Q manual procedures to implement environmental programs. However, the facility has a limited remaining life. Agreements to start construction of a replacement facility were nearing resolution at the time the assessment was nearing conclusion. Ten OFIs were identified. Corrective actions for the observations were identified and initiated, and are in progress or completed.

SCDHEC and EPA personnel conducted external inspections and audits of the SRS environmental program for regulatory compliance. Agency representatives performed several comprehensive compliance inspections and audits in 2009, as follows:

- *RCRA Compliance Evaluation Inspection* – The RCRA compliance evaluation inspection was conducted by SCDHEC (EPA also represented) June 15–19. A September 18 SCDHEC letter noted, "All deficiencies were corrected during the inspection or prior to issuing this report."

- *Annual Underground Storage Tank Inspection* – SCDHEC inspected the site's USTs September 9. All were found to be in compliance with applicable regulations for the seventh straight year

- *632–G C&D Landfill, 288–F Ash Landfill, and 488–4D Ash Landfill Inspections* – SCDHEC conducted routine (at least every other month) inspections of the 632–G C&D, the 288–F Ash, and the 488–4D Ash landfills; the facilities were found to be satisfactory, with no observed deficiencies.

- *Z-Area Saltstone Solid Waste Landfill Inspections* – Saltstone Disposal Facility inspections continued to be completed on a weekly basis. Moisture areas continued to be observed on the walls of the facility's Vault 4, and were reported to SCDHEC in accordance with the facility's contingency plan. (NOTE: "Moisture areas" are areas on the external walls of the facility's cells that appear damp due to a combination of saltstone shrinkage from curing, bleeding, and process water accumulation at the inner cell walls, and from hydrostatic pressure that causes the water to weep through preexisting construction cracks. Such moisture areas are not areas of free-flowing liquid. Moisture areas on vault walls may indicate the presence of radiological contamination.) SRR facility personnel inspected the vault areas daily and communicated the discovery of any new moisture areas to SCDHEC, per the facility contingency plan. SCDHEC performed onsite weekly inspections of Vault 4 for observation of existing and potentially new moisture areas. SCDHEC inspectors detailed the results of their inspections in the Saltstone Disposal Facility Vault 4 Inspection Checklist. SCDHEC has not mandated any additional actions other than continuous monitoring of Vault 4 via the aforementioned inspections. No further actions are pending.

- *Interim Sanitary Landfill* – SCDHEC personnel conducted an annual post-closure inspection of the Interim Sanitary Landfill September 29, and the landfill was found to be satisfactory, with no observed deficiencies.

- *Groundwater Comprehensive Monitoring Evaluation* – SCDHEC conducted an unannounced RCRA inspection of SRS's groundwater program May 18–20. No deficiencies or permit violations were cited.

- *Site and D-Area Air Compliance Audit* – SCDHEC's Bureau of Air Quality conducted an air compliance audit September 15. The purpose was to verify that SRS and the D-Area Powerhouse were in compliance with applicable regulations, including monitoring, reporting, and recordkeeping requirements contained in both Part 70 Air Quality Permits. No violations or findings were identified during this inspection.

Environmental Training

The SRS environmental training program identifies training needs and appropriate training settings to teach job-specific skills that protect the employee and the environment, in addition to satisfying regulatory training requirements. This process ensures that personnel whose actions could have environmental consequences are properly trained and made aware of their responsibilities to protect the environment, workers, and the public. General environmental awareness training is provided to all employees of SRS via initial General Employee Training (GET) which subsequently is reinforced annually through Consolidated Annual Training (CAT). Specialized training opportunities are developed by and offered through a centralized training organization that relies heavily upon the functional-area subject matter expertise within the environmental organization for the development of environmental and waste management curricula. Regularly scheduled classes in this program cover such topics as Environmental Laws and Regulations, the Hazardous Waste Worker, Hazardous and Radiological Waste Characterization, Management of Polychlorinated Biphenyls, and the Environmental Compliance Authority course. A self-taught Environmental Laws and Regulations course—available for technical personnel–is updated annually by environmental subject matter experts. More than 60 environmental program-related training courses are listed in the site training database, and individual organizations schedule and perform other facility-specific, environment-related training to ensure that operations and maintenance personnel, as well as environmental professionals, have the knowledge and skills to perform work safely and in a manner that protects the environment in and around SRS.

Environmental Permits

SRS had 393 construction and operating permits in 2009 that specified operating levels for each permitted source. Table 3–4 summarizes the permits held by the site during the past 5 years. These numbers reflect only permits obtained by SRNS for itself and for other SRS contractors that requested assistance in obtaining permits. The numbers include some permits that were voided or closed during 2009.

Editor's 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 and their organizations 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 4

Effluent Monitoring

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Effluent monitoring at the Savannah River Site (SRS) is conducted to demonstrate compliance with applicable standards and regulations. Site effluent monitoring activities are divided into radiological and nonradiological programs. The monitoring is conducted by the Environmental Monitoring Services group of the site's Regulatory Integration & Environmental Services organization—following specific sampling and analytical procedures .that can be found in sections 1101–1111 of the Savannah River Site Environmental Monitoring Program, WSRC–3Q1–2, Volume 1, Revision 4, [SRS EM Program, 2002a]. A summary of data results is presented in this chapter; more complete data can be found in tables on the CD housed inside the back cover of this report.

Radiological Monitoring

Radiological effluent monitoring results are a major component in determining compliance with applicable dose standards. SRS environmental 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.

Unspecified alpha and beta releases (the measured gross activity minus the identified individual radionuclides) in airborne and liquid releases are large contributors—on a percentage basis—to offsite doses, especially for the airborne pathway from diffuse and fugitive releases (see definitions below).

The unspecified alpha and beta releases are listed separately in the effluent release tables. They conservatively include naturally occurring radionuclides such as uranium, thorium, and potassium-40, as well as small amounts of unidentified manmade radionuclides. For dose calculations, the unspecified alpha releases were assigned the plutonium-239 dose factor, and the unspecified beta releases were assigned the strontium-90 dose factor (chapter 6, "Potential Radiation Doses").

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, 2002a].

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

One effluent sampling change occurred in 2009: The sampling frequency at R-Area Reactor was changed from biweekly to monthly in July.

Diffuse and Fugitive Sources

Estimates of radionuclide releases from unmonitored diffuse and fugitive sources are calculated on an annual basis and are included in the SRS radioactive release totals. A diffuse source is defined as an area source, such as a pond or disposal area. A fugitive source is defined as an undesignated localized source, such as an open tank or naturally ventilated building.

Diffuse and fugitive releases are calculated using

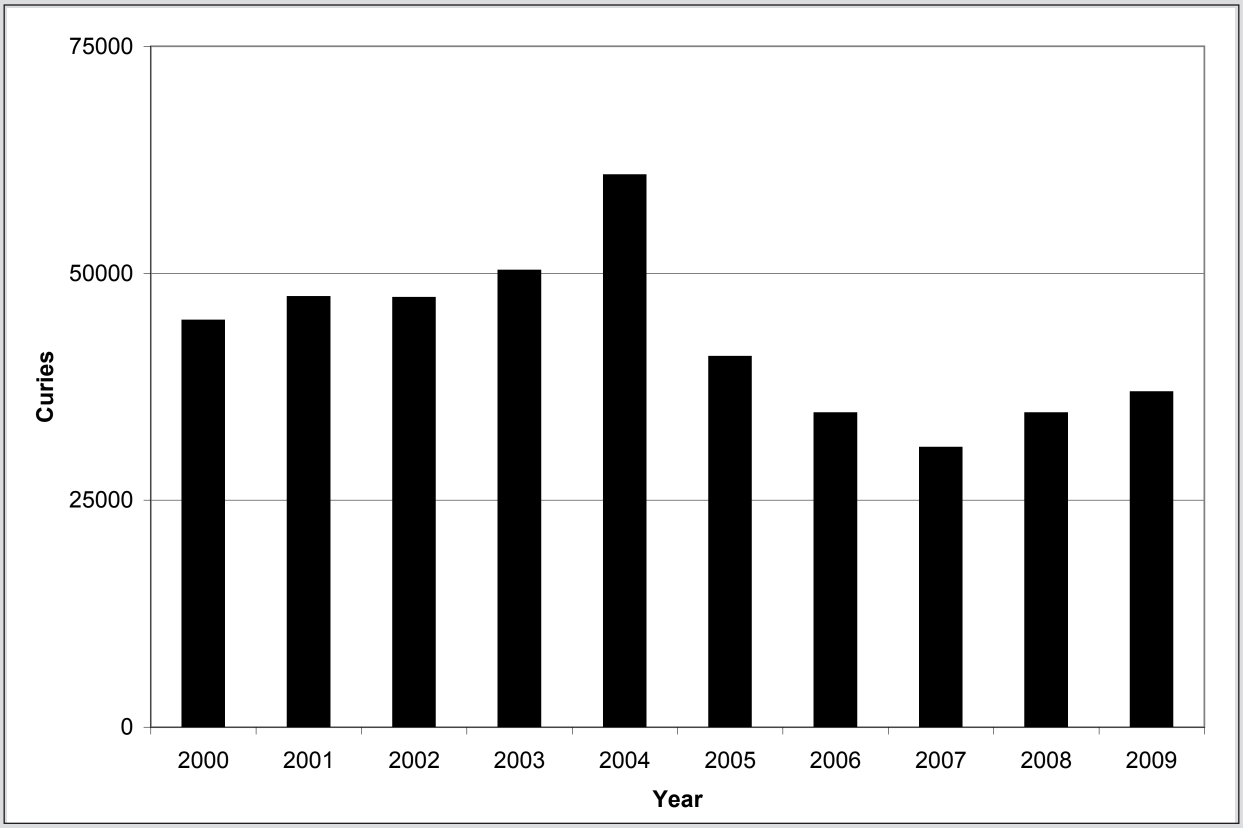

Figure 4–1 Ten-Year History of SRS Annual Atmospheric Tritium Releases

the U.S. Environmental Protection Agency's (EPA's) recommended methods [EPA, 2002a]. Because these methods employ conservative assumptions, they generally lead to overestimates of actual emissions. Though these releases are not monitored at their source, onsite and offsite environmental monitoring stations are in place to quantify unexpectedly large diffuse and fugitive releases (chapter 5, "Environmental Surveillance").

Monitoring Results Summary

The total amount of radioactive material released to the environment is quantified by using (1) data obtained from continuously monitored airborne effluent release points and (2) estimates of diffuse and fugitive sources.

Tritium Tritium in elemental and oxide forms accounted for more than 99 percent of the total radioactivity released to the atmosphere from SRS operations in 2009, when about 36,900 Ci of tritium were released from the site—compared to about 34,600 Ci in 2008. Most of the releases came from the site's tritium facilities.

During the past 10 years, because of changes in the site's missions and the beginning of operations at the Replacement Tritium Facility, the amount of tritium released from SRS has fluctuated but has remained less than 75,000 Ci per year (figure 4–1).

Comparison of Average Concentrations in Airborne Emissions to DOE Derived Concentration Guides Average concentrations of radionuclides in airborne emissions are calculated by dividing the amount of each radionuclide released annually from each stack by the respective yearly stack-flow volumes. 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," as a screening method to determine if existing effluent treatment systems are proper and effective. The 2008 atmospheric effluent annual-average concentrations, their comparisons against the DOE DCGs, and the quantities of radionuclides released are provided, by discharge point, on the CD accompanying this report.

DCGs are used as reference concentrations for conducting environmental protection programs at all DOE sites. DCGs are applicable at the point of discharge (prior to dilution or dispersion) under conditions of continuous exposure.

Most of the SRS radiological stacks/facilities release small quantities of radionuclides at concentrations below the DOE DCGs. However, tritium (in the oxide form) from the reactor (K-Area and L-Area main stacks) and tritium facilities was emitted in 2009 at concentration levels above the DCGs. Also, plutonium-239 exceeded the DCG at the F-Area Main Stack during this time. The offsite dose from all atmospheric releases, however, remained well below the DOE and EPA annual atmospheric pathway dose standard of 10 mrem (0.1 mSv), as discussed in chapter 6.

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, 2002a].

Depending on the processes involved, liquid effluents also may be monitored with real-time instrumentation to ensure that releases are managed within established limits. Because the instruments have limited detection sensitivity, online monitoring systems are not used to quantify SRS liquid radioactive releases at their current low levels. Instead, samples are collected for more sensitive laboratory analysis.

Monitoring Results Summary

Data from continuously monitored liquid effluent discharge points are used in conjunction with site seepage basin and Solid Waste Disposal Facility (SWDF) migration release estimates to quantify the total radioactive material released to the Savannah River from SRS operations. SRS liquid radioactive releases for 2009 are shown by source on the CD accompanying this report. These data are a major component in the determination of offsite dose consequences from SRS operations.

Direct Discharges of Liquid Effluent 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 the radioactivity discharged in SRS liquid effluents. The total amount of tritium released directly from process areas—i.e., reactor, separations, Effluent Treatment Facility (ETF)—to site streams during 2009 was 238Ci. Direct releases of tritium to site streams for the years 2000–2009 are shown in figure 4–2.

Operations at D-Area and TNX were discontinued in 2000 and 2001, respectively. A-Area releases represent only a small percentage of the total direct releases of tritium to site streams. The reactor area releases include the overflows from PAR Pond and L Lake.

Migration/transport of radionuclides from site seepage basins and SWDF are discussed in chapter 5.

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 SWDF migration discharges. The DOE order lists DCG values for most radionuclides.

DCGs are applicable at the point of discharge from the effluent conduit to the environment (prior to dilution or dispersion). According to DOE Order 5400.5, exceedance of the DCGs at any discharge point may require an investigation of "best available technology" (BAT) waste treatment for the liquid effluents. Tritium in liquid effluents is specifically excluded from BAT 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. The 2009 liquid effluent annual-average concentrations, their comparisons against the DOE DCGs, and the quantities of radionuclides released are provided—by discharge point—on the CD accompanying this report.

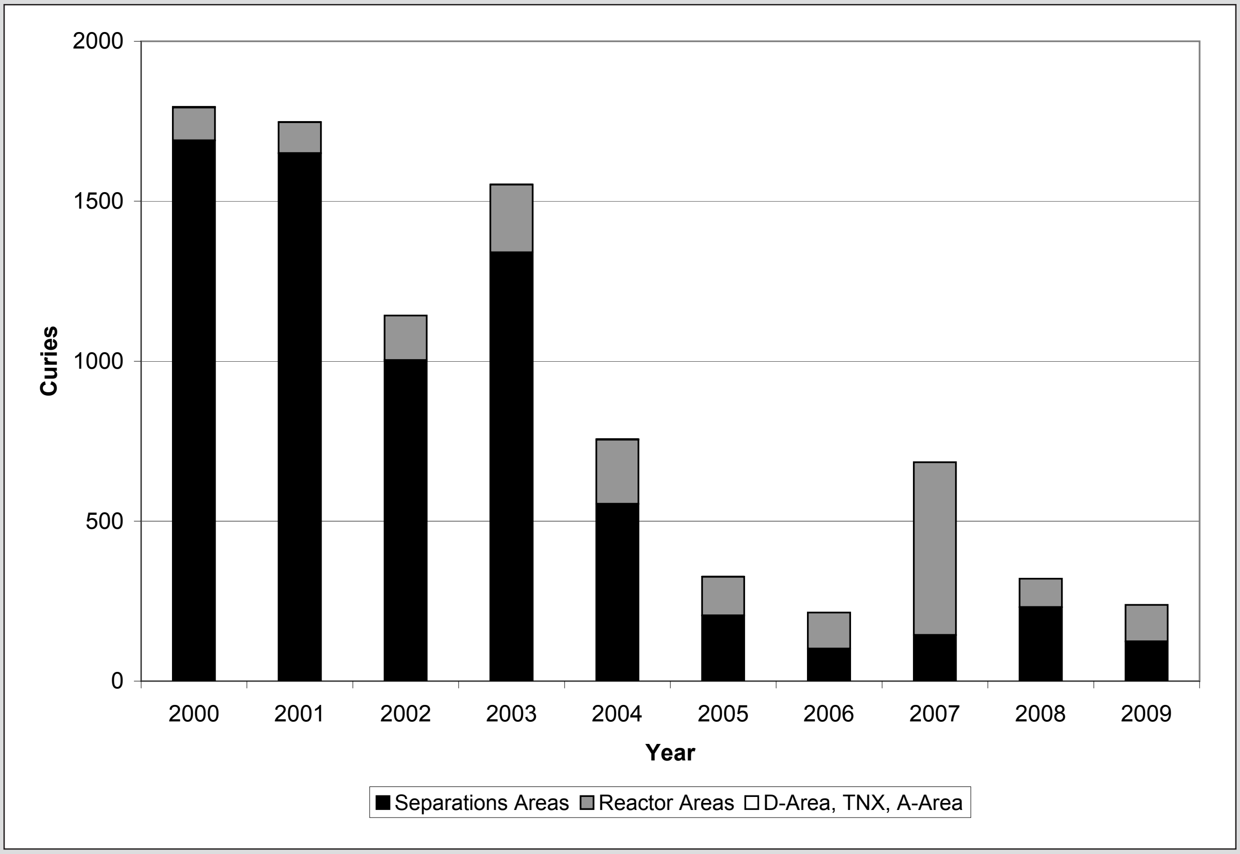

Figure 4–2 Ten-Year History of Direct Releases of Tritium to SRS Streams

The data show that ETF Outfall U3R–2A at the Road C discharge point exceeded the DCG guide for 12-month-average tritium concentrations again during 2009. However, as noted previously, DOE Order 5400.5 specifically exempts tritium from BAT waste treatment investigation requirements. This is because there is no practical technology available for removing tritium from dilute liquid waste streams.

No other liquid discharge points exceeded the DOE DCGs during 2009.

Nonradiological Monitoring

Airborne Emissions

The South Carolina Department of Health and Environmental Control (SCDHEC) regulates both radioactive and nonradioactive criteria and toxic air pollutant emissions from SRS sources. Each source of air emissions is permitted or exempted by SCDHEC on the SRS Part 70 Air Quality Permit (issued in 2003), with specific limitations and monitoring requirements identified. This section will cover only nonradioactive emissions.

The bases for the limitations and monitoring requirements specified in the Part 70 Air Quality Permit 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 industries, processes, or equipment. However, some standards govern all sources for criteria pollutants, 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," of this report. The SCDHEC air standards for toxic air pollutants can be found at http://www.scdhec.gov/environment/baq/docs/regs/.

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 (1) 10 micrometers and (2) 2.5 micrometers, volatile organic compounds (VOCs), and toxic air pollutants. With the issuance of the Part 70 Air Quality Permit, SRS has several continuous and periodic monitoring requirements; only the most significant are discussed below.

The primary method of source monitoring at SRS is the annual air emissions inventory. Actual emissions from SRS sources are determined during this inventory from standard calculations using source operating parameters, such as hours of operation, process throughput, and emission factors provided in the EPA "Compilation of Air Pollution Emission Factors," AP–42. Many of the processes at SRS, however, are unique sources requiring nonstandard, complex calculations. The hourly and total actual annual emissions for each source then can be compared against their respective permit limitations.

At the SRS A-Area and D-Area Powerhouses, airborne emission specialists under contract to SRS perform stack compliance tests every two years. The tests include sampling of boiler exhaust gases to determine particulate matter, sulfur dioxide, and visible opacity emissions. The permit for the A-Area Powerhouse also requires a weekly sample and laboratory analysis of coal for sulfur content, and a daily visible-emissions inspection to verify compliance with opacity standards.

For the package steam generating boilers in K-Area, fuel oil-fired water heaters in B-Area, and diesel-powered equipment, compliance with sulfur dioxide standards is determined by analysis of the fuel oil purchased from the offsite vendor. Sulfur content of the fuel oil must be below 0.05 percent—and must be certified by the fuel supply vendor and reported to SCDHEC semiannually.

The monitoring of SRS diesel-powered equipment includes tracking fuel oil consumption monthly and calculating a 12-month rolling total for determining permit compliance with a site consumption limit.

SRS has several soil vapor extraction units and two air strippers that are sources of toxic air pollutants and VOCs. These units must be sampled monthly for VOC concentrations, and the total VOC emissions must be calculated for comparison against a 12-month rolling limit. The VOC emissions then are reported to SCDHEC on a quarterly basis.

Several SRS sources have pollutant control devices—such as multiclone dust collectors, electrostatic precipitators, baghouse dust collectors, or condensers—whose parameters must be monitored continuously or whenever the system is operated. The operating parameters must be recorded and compared against specific operating ranges.

Compliance by all SRS permitted sources is evaluated during annual compliance inspections by the local SCDHEC district air manager. The inspections include a review of each permit condition; i.e., daily monitoring readings, equipment calibrations, control device inspections, etc. SCDHEC performed an air compliance inspection September 15, 2009 and found no instances of noncompliance.

Monitoring Results Summary

In 2009, operating data were compiled and emissions calculated for 2008 operations for all site air emission sources. Because this process, which begins in January, requires up to six months to complete, this report provides a comprehensive examination of total 2008 emissions, with only limited discussion of available 2009 monitoring results for specific sources. Refer to the "Toxic Air Pollutant Emissions (2006–2008)" table on the CD accompanying this report for a list of the 2008 estimated emissions.

The 2008 total SCDHEC Standard 2 emission estimates for all SRS permitted sources, as determined by the air emissions inventory conducted in 2009, are provided in table 4–1. A review of the calculated emissions for each source for calendar year 2008 determined that SRS sources had operated in compliance with permitted emission rates. Some toxic air pollutants (e.g., benzene) regulated by SCDHEC also are, by nature, VOCs. As such, the total for VOCs in table 4–1 includes toxic air pollutant emissions.

Three power plants with nine overfeed stoker-fed coal-fired boilers are maintained by Savannah River Nuclear Solutions (SRNS) at SRS. The location, number of boilers, and capacity of each boiler for these plants are listed in table 4–2.

Table 4–1
SRS Estimated SCDHEC Standard 2 Pollutant Air Emissions, 2006–2008

Pollutant Name	Actual Emissions (Tons/Year)		
	2006	2007	2008
Sulfur dioxide (SO_x)	5.10E+03	4.25E+03	4.07E+03
Total particulate matter (PM)	5.04E+02	4.17E+02	4.59E+02
Particulate matter <10 micrometers (PM_{10})	3.82E+02	2.45E+02	3.13E+02
Particulate matter <2.5 micrometers ($PM_{2.5}$)	3.19E+02	2.20E+02	2.65E+02
Carbon monoxide (CO)	7.83E+01	7.62E+01	6.73E+02
Ozone (volatile organic compounds)	1.69E+01	1.61E+01	6.53E+01
Gaseous fluorides (as hydrogen fluoride)[a]	1.42E+01	1.27E+01	1.22E+01
Nitrogen dioxide (NO_x)	3.15E+03	2.63E+03	1.89E+03
Lead (lead components)	7.60E-02	1.91E-02	2.67E-02

To replace the aging A-Area coal-fired boilers, SRS began construction of a biomass boiler and an oil-fired backup boiler in October 2007. Known as the 784–7A Steam Facility, those two boilers are substantially smaller and burn cleaner than the two coal-fired boilers they replaced. The biomass boilers produce significantly less particulate matter, sulfur dioxide, and nitrogen dioxide emissions than the two coal-fired boilers. The biomass boiler and backup oil-fired boiler began operations in August 2008.

SRNS assumed operational responsibility for the D-Area Powerhouse (484–D) in February 2006 from South Carolina Electric and Gas (SCE&G), which had operated the facility for DOE under a separate contract since 1995. The D-Area Powerhouse has four coal-fired boilers—each on a biennial stack test schedule required by its Part 70 Air Quality Permit. During 2009, D-Area Powerhouse boilers D#1, D#3, and D#4 were source tested. The results for boilers D#1, D#3, and D#4 are shown in table 4–3. This boiler's particulate matter, sulfur dioxide, and visible emissions were found to be in compliance with its permitted limit.

The three H-Area Powerhouse boilers have not operated since 2000–2001.

SRS also operates one package steam generating boiler in K-Area fired by No. 2 fuel oil. The percent of sulfur in the fuel oil must be vendor certified semiannually to ensure that the fuel meets permit specifications; the certification was documented twice during 2009. SRS submitted a request to SCDHEC February 26 to remove a second K-Area package steam generating boiler from the site's Part 70 Air Quality Permit. This unit no longer is operational.

The total diesel fuel consumption for portable air compressors, generators, emergency cooling water pumps, and fire water pumps was found to be well below the SRS limit for the entire reporting period. As reported to SCDHEC during 2009, the calculated annual VOC emissions were well below the permit limit for each unit. .

Table 4–2
SRS Power Plant Boiler Capacities

Location	Number of Boilers	Capacity[a] (Btu/hr)
A-Area	2	40.7E+06
D-Area	4	396.0E+06

[a] Capacity indicated is for *each* boiler.

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 is conducted as required as part of the Title V and construction permitting process. Additional information about ambient-air-quality regulations at the site can be found in appendix A of this report.

Liquid Discharges

Description of Monitoring Program

SRS monitors nonradioactive liquid discharges 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 in place for discharges to the waters of the United States and South Carolina. These permits establish the 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 can be found in the individual permits, which are available to the public through SCDHEC's Freedom of Information office at 803–898–3882.

Table 4–3
2009 Boiler Stack Test Results[a]

Boiler	Pollutant	Emission Rates lb/10^6 Btu	Emission Rates lb/hr
C-Area Boiler #1	Particulates[b]	0.068	26.5
	Sulfur dioxide[b]	0.95	371.9
	Opacity[c]	Avg. 12.5%	
D-Area Boiler #2[d]			
D-Area Boiler #3	Particulates[b]	0.206	64.7
	Sulfur dioxide[b]	0.97	264.7
	Opacity[c]	Avg. 6.5%	
D-Area Boiler #4	Particulates[b]	0.176	81.6
	Sulfur dioxide[b]	0.91	499.3
	Opacity[c]	Avg. 11.0%	

[a] Boiler #1 source test January 14, 2009; Boiler #3 source test June 24, 2009; Boiler #4 source test January 15, 2009.
[b] The compliance level is 0.6 lb/million BTU for particulates, based on source tests using EPA Methods 1–5, and 3.5 lb/million BTU for sulfur dioxide, based on representative samples of sulfur heat value of coal consumed during the source tests.
[c] Opacity limit 40%
[d] Not stack tested during 2009

In 2009, SRS discharged water into site streams under three NPDES permits: two for industrial wastewater, SC0047431 (covers D-Area) and SC0000175 (covers remainder of site), and one for stormwater runoff—SCR000000 (industrial discharge). A fourth 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 2009.

SRS submitted a permit application in 2006 for each of nine individual stormwater outfalls for which the average of any four consecutive analyses exceeded the proposed EPA Multisector General Permit benchmarks. These outfalls are expected to be covered under the upcoming new Industrial Stormwater General Permit rather than the individual permits.

Permit ND0072125 is a "no discharge" permit regulating the land application of biosolids (dried sludge) from onsite sanitary wastewater treatment facilities. There were no applications of sludge at SRS in 2009. An application was submitted to SCDHEC in August 2009 for a 10-year renewal of the permit, which expires in 2010. Renewing the permit is expected to be more cost effective than developing a new sludge land application site.

NPDES samples are collected 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.

Monitoring Results Summary

SRS reports industrial wastewater analytical results to SCDHEC through a monthly discharge monitoring report (EPA Form 3320–1). Four out of approximately 4,989 sample analyses (includes flow measurements and no-flow designations) performed during 2009 exceeded permit limits. This resulted in a 99.92-percent compliance rate. None of the four permit exceptions resulted in a Notice of Violation by SCDHEC. Details related to the four exceptions appear in table 4–4. A complete presentation of the NPDES data, with the exceptions noted, can be found on the CD accompanying this report.

In 2009, 16 stormwater outfalls were scheduled for compliance sampling. All samples were obtained as scheduled. In addition to compliance sampling, special grab sampling was conducted at four outfalls to aid in evaluating compliance with the proposed general permit. Complete stormwater data can be found on the CD accompanying this report.

Table 4–4
2009 Exceptions to SCDHEC-Issued NPDES Permit Liquid Discharge Limits at SRS[a]

Company	Outfall	Date(s)	Parameter	Possible Cause(s)	Corrective Actions
SRNS	A–11	February 2	pH (max) Value: 9.8 su[b] Limit: 8.5 su[b]	Rainwater released from a sump associated with a caustic tank	No discharge of sump contents without first verifying that the pH meets outfall limits.
SRR	TH–1 (H–16)	July 2	BOD (invalid result) Value: < 2.0 mg/L Limit: 20 avg., 40 max mg/L	Contaminated contract laboratory dilution water	Isolated event
SRNS	D–01	November 8	Water Temperature Difference (daily max) Value: 12.7° F Limit: 10.8° F	Defective temperature monitoring equipment	Water temperature mediation plan immediately activated; followed by replacement of defective equipment
SRNS	D–01	November 9	Water Temperature Difference (daily max) Value: 11.0° F Limit: 10.8° F	Defective temperature monitoring equipment	Water temperature mediation plan immediately activated; followed by replacement of defective equipment

[a] SRS's compliance rate for 2009 was 99.92 percent.
[b] su = standard units

Environmental Surveillance

CHAPTER 5

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Environmental surveillance at the Savannah River Site (SRS) is designed to survey and quantify any effects that routine and nonroutine operations could have on the site and on the surrounding area and population. Site surveillance activities are divided into radiological and nonradiological programs.

As part of SRS's radiological surveillance program, routine surveillance of all applicable radiation exposure pathways is performed on all environmental media (air, rain, surface water, soil, sediment, vegetation, drinking water, food products, and wildlife) that could lead to a measurable annual dose above background at and beyond the site boundary. Nonradioactive environmental surveillance at SRS involves the sampling and analysis of surface water, drinking water, sediment, groundwater, and fish. Results from the analyses of surface water, drinking water, sediment, and fish are discussed in this chapter. A description of the groundwater monitoring program analysis results can be found in chapter 7, "Groundwater."

The Regulatory Integration & Environmental Services Department's Environmental Monitoring (EM) section performs surveillance activities for SRS. The Savannah River also is monitored by other groups, including the South Carolina Department of Health and Environmental Control (SCDHEC), the Georgia Department of Natural Resources, Georgia Power Company's Vogtle Electric Generating Plant (operating in Georgia), and the City of Savannah, Georgia. A complete description of the EM surveillance program, including sample collection and analytical procedures, can be found in section 1105 of the Savannah River Site Environmental Monitoring Program, WSRC–3Q1–2, Volume 1, Revision 4 [SRS EM Program, 2002a]. Brief summaries of analytical results are presented in this chapter; complete data sets can be found in tables on the CD housed inside the back cover of this report.

Radiological Surveillance

Air

Description of Surveillance Program

EM maintains a network of 15 sampling stations in and around SRS to monitor the concentration of tritium and radioactive particulate matter in the air.

Surveillance Results Summary

Except for tritium, no specific radionuclides were routinely detectable at the site perimeter in 2009. Both onsite and offsite radioactivity concentrations were similar to levels observed in previous years (see expanded discussion in paragraphs that follow).

Average gross alpha and gross beta results from 2009 were-similar to those of 2008, and are consistent with historical results in demonstrating long-term variability.

No 2009 samples contained detectable amounts of the manmade gamma-emitting radionuclide cesium-137. Historically, only a small number of air samples have contained detectable cesium-137 activity.

During 2009, detectable levels of uranium-234 were observed in 12 of 15 air samples, and detectable levels of uranium-238 were observed in 13 of 15 air samples; however, no detectable levels of uranium-235 were observed in any of the 2009 samples. These results are similar to those observed in 2008 and previous years. Uranium is naturally occurring in soil, and therefore expected to be present in low concentrations on some particulate filters. By weight, natural uranium is 99-percent uranium-238, 0.72-percent uranium-235, and 0.0055-percent uranium-234. However, by radioactivity, natural uranium is 48.9-percent uranium-234, 48.9-percent uranium-238, and 2.2-percent uranium-235. Because the analytical method quantifies the radioactivity, uranium-234 and -238 are sometimes detected when uranium-235 is not. Aside from uranium, alpha-emitting radionuclide activity was observed in nine air samples from four locations—three locations along the site perimeter and one at the 25-mile radius. The site perimeter locations revealed corresponding increases in plutonium-238, plutonium-239, and americium-241 during the same timeframe, which is consistent with the true presence of plutonium. Generally, these concentrations were consistent with historical results. For the remaining locations, all alpha-emitting isotopes were below detection levels. One 2009 strontium-89,90 result was above the minimum detectable concentration (MDC)—consistent with results since 2007, when the laboratory implemented a more sensitive analytical protocol. The dose consequences are explained in more detail in chapter 6 ("Potential Radiation Doses").

Tritium-in-air results for 2009 were similar to—but generally lower than—those observed in 2008, and were consistent with the long-term variability of historical results. The Burial Ground North (BGN) tritium-in-air results were slightly higher than those observed in 2008. As in previous years, the BGN location showed average and maximum concentrations significantly higher than those observed at other locations. BGN concentrations are expected to be higher and more variable because of the location's proximity to both the tritium facilities and the phytoremediation project near the center of the site, and are influenced by operations at these facilities. All tritium-in-air samples from the center of the site contained detectable levels of tritium. As expected, tritium concentrations generally decreased with increasing distance from the tritium facilities.

Rainwater

Description of Surveillance Program

SRS maintains a network of 15 rainwater sampling sites as part of the air surveillance program. These stations are used to measure deposition of radioactive materials.

Surveillance Results Summary

No detectable manmade gamma-emitting radionuclides were observed in rainwater samples during 2009.

Gross alpha and gross beta results from 2009 were consistent with those of 2008. In 2009, the average gross alpha and gross beta results generally were slightly higher than in 2008. Annual average gross alpha and gross beta concentrations, as well as individual sample results, are consistent with historical results, which demonstrate long-term variability.

Detectable levels of uranium-234 and uranium-238 were present in most samples. Uranium is naturally occurring in soil, and therefore expected to be present at low concentrations in some deposition samples. Both uranium-234 and uranium-238 results were higher at the D-Area perimeter location than at the other site perimeter locations; they also were higher at the BGN (onsite) location. This likely is attributable to the increased airborne particulate matter (dust) is present at these locations because of vehicle traffic on nearby dirt roads and fields. Plutonium-238 was observed in eight samples (four from the site perimeter and four from the 25-mile location). Americium-241 was observed in four samples from the site perimeter. The average concentrations of plutonium-238 and americium-241 were well below the drinking water standard. All other actinides, as well as strontium-89,90, either were below detection levels or were present in only a small number of samples (<3 percent) in 2009.

As in previous years, tritium-in-rain values were highest near the center of the site. All samples from the center of the site contained detectable tritium. This is consistent with the H-Area effluent release points that routinely release tritium. Beyond the center of the site, tritium was detected in 37 samples—31 from the site perimeter locations, five from the 25-mile locations, and one from the 100-mile location. As with tritium in air, concentrations generally decreased as distance from the effluent release points increased..

Gamma Radiation

Description of Surveillance Program

Ambient dose rates from gamma radiation exposures in and around SRS are monitored by a system of thermoluminescent dosimeters (TLDs).

Surveillance Results Summary

Ambient dose rates 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 radiation exposure levels. In 2009, ambient dose rates varied between 55 and 152 mrem per year. The 2009 exposure rates were based on a calendar year timeframe (January through December); in the past, they were based on a fiscal year timeframe (October through September).

In general, the 2009 ambient gamma radiation monitoring results indicated dose rates lower than those observed at the same locations in 2008. The average annual dose rate was 80 mrem in 2009, compared to 87 mrem in 2008; 51 locations showed lower exposure, and three locations showed higher exposure. The BGN (onsite) location showed elevated dose rates for the second, third, and fourth quarters of 2009. However, these results generally are consistent with previously published historical results, and indicate that no significant difference in average annual dose rates is observed between monitoring networks—except in the case of population centers. Ambient dose rates in population centers are slightly elevated compared to the other monitoring networks—as expected—because of factors such as buildings and roadways, which emit small amounts of radiation.

Stormwater Basins

Description of Surveillance Program

Stormwater accumulating in site stormwater basins is monitored monthly because of potential contamination. In 2009, monitoring was conducted at six E-Area basins, as well as at the Z-Area Basin and F-Area Pond 400.

Surveillance Results Summary

There are no active discharges to site stormwater basins. The primary contributor is rainwater runoff. Rain events did not supply enough water to the E–06 basin for sampling purposes in 2009. The highest mean tritium concentration was measured in the E–05 basin, and was consistent with historical results—although 40 percent lower than the highest mean tritium concentration at the same location in 2008. No cobalt-60 or curium-244 was detected in any of the basins. Fission products, as well as some actinides, were observed in the basins. Technetium-99 was detected in all locations, with uranium-234, uranium-238, and plutonium-238 the primary actinides. Gross alpha and gross beta activity was detected in all the basins, and the concentrations were compared to those of previous years to identify any trends. The 2009 values were consistent with historical data.

Streams

Description of Surveillance Program

Continuous surveillance monitoring of SRS streams is utilized downstream of several process areas to detect and quantify levels of radioactivity in effluents transported to the Savannah River. The five primary streams are Upper Three Runs, Fourmile Branch, Pen Branch, Steel Creek, and Lower Three Runs. The frequency and types of analyses performed on each sample are based on potential quantity and types of radionuclides likely to be present at the sampling location.

Surveillance Results Summary

Detectable concentrations of tritium, the predominant radionuclide detected above background levels in SRS streams, were observed at least once at all stream locations in 2009, except at Upper Three Runs-1A (the stream control point). Overall, tritium releases to SRS streams were slightly higher in 2009 than in 2008, but the concentrations remain consistent with long-term tritium levels.

Cesium-137 was detected in three of the five major SRS streams—Fourmile Branch, Pen Branch, and Steel Creek. Gross alpha and gross beta activity was detected in all streams, but concentrations were consistent with levels of recent years. Other radionuclides were observed at locations throughout the site, but were consistent with the source of the material, and exhibited variations similar to those of previous years. No significant trends were observed in 2009 when compared to recent years.

Seepage Basin and Solid Waste Disposal Facility Radionuclide Migration

To incorporate the migration of radioactivity to site streams into total radioactive release quantities, EM personnel continued to monitor and quantify the migration of radioactivity from site seepage basins and

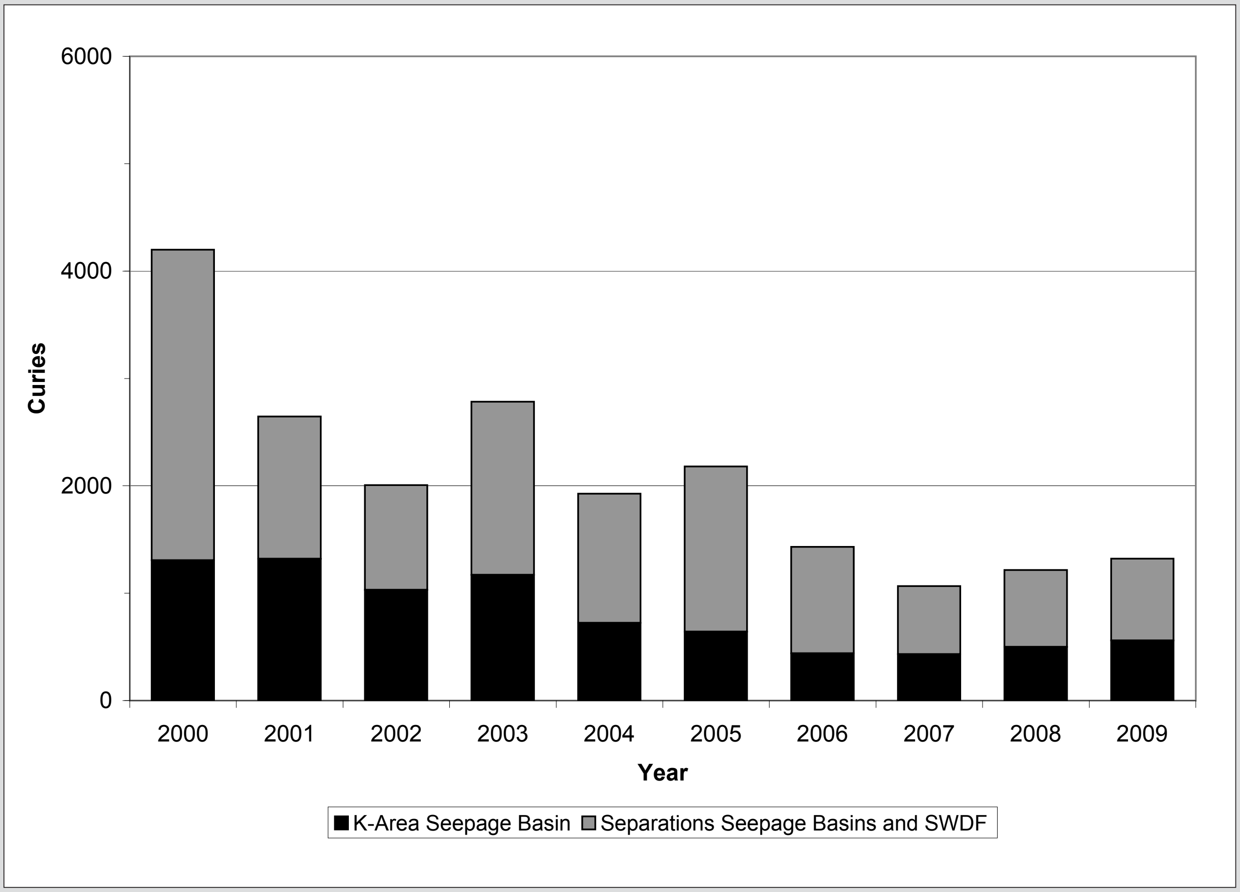

Figure 5–1 Tritium from SRS Seepage Basins and SWDF to Site Streams, 2000–2009

the Solid Waste Disposal Facility (SWDF) in 2009 as part of its stream surveillance program. Tritium, strontium-89,90, technetium-99, iodine-129, and cesium-137 were detected in migration releases.

Figure 5–1 is a graphical representation of releases of tritium via migration to site streams for the years 2000–2009. As can be seen in the figure, migration releases of tritium generally have declined the past 10 years, with year-to-year variability caused mainly by the amount of annual rainfall. During 2009, the total quantity of tritium migrating from site seepage basins and SWDF was 1,321 Ci.

Radioactivity previously deposited in the F-Area and H-Area seepage basins and SWDF continues to migrate through the groundwater and to outcrop into Fourmile Branch and Upper Three Runs. Because of their proximity, migration from the SWDF cannot be distinguished from migration from a part of H-Area Basin 4. Measured migration of tritium into Fourmile Branch in 2009 occurred as follows:

- from F-Area seepage basins, 27 Ci—a 62-percent decrease from the 2008 total of 71 Ci
- from SDWF and a part of H-Area seepage basin 4, 532 Ci—a 7.9-percent increase from the 2008 total of 493 Ci
- from H-Area seepage basins 1, 2, 3, and most of 4, 135 Ci—a 3-percent increase from the 2008 total of 131 Ci

The measured migration from the north side of SWDF and the General Separations Area (GSA) into Upper Three Runs in 2009 was 68 Ci, compared with the 2008 total of 20 Ci—a fluctuation consistent with historical results. (The GSA is in the central part of SRS and contains all waste disposal facilities, chemical separations facilities, and associated high-level waste storage facilities, along with numerous other sources of radioactive material.)

The total amount of strontium-89,90 entering Fourmile Branch from the GSA seepage basins and SWDF during 2009 was estimated to be 36.28 mCi. Migration releases of strontium-89,90 vary from year to year but have remained below 100 mCi the past 7 years.

In 2009, 19.29 mCi of technetium-99, 35.50 mCi of iodine-129, and 68.9 mCi of cesium-137 were estimated to have migrated into Fourmile Branch.

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 annually in Pen Branch. The 2009 migration total of 559 Ci represents a relatively slight (11.8-percent) increase from the 500 Ci recorded in 2008.

C-Area, L-Area, and P-Area Seepage Basins Liquid purges from the C-Area, L-Area, and P-Area disassembly basins were released periodically to their respective seepage basins from the 1950s until 1970. Migration releases from these basins are accounted for in the stream transport totals (see "Tritium Transport in Streams" section of this chapter).

Migration of Actinides in Streams

Migration into site streams of the actinides uranium, plutonium, americium, and curium no longer is quantified because of the actinides' historically low levels. However, the streams are sampled and analyzed annually for the presence of these actinides. The resulting concentrations are compared to those of previous years to identify any trends. Overall, values for 2009 were consistent with historical data, and generally remained at or below the analytical detection limit.

Savannah River

Description of Surveillance Program

Continuous surveillance is performed along the Savannah River at locations above and below SRS, including a location at which liquid discharges from Georgia Power Company's Vogtle Electric Generating Plant (VEGP) enter the river.

Surveillance Results Summary

Based on curies released, tritium is the predominant radionuclide detected above background levels in the Savannah River. The combined SRS and VEGP tritium releases (weekly composites) at River Mile (RM) 118.8 decreased in 2009, with levels again well below the drinking water standard. No gamma emitters were detected. Detectable gross alpha and gross beta activity was observed at all river sampling locations, and was consistent with long-term gross alpha and gross beta levels in the river, with one exception. A higher-than-expected gross beta result was observed in June at River Mile 150.4, located next to VEGP. Because of the analytical method used (ion exchange resin), excess sample water was not available for a rerun to verify the result, which is believed to have been caused by a laboratory error. The corresponding gross alpha result was within the normal range.

In addition to the weekly composite samples referenced above, SRS collects annual grab samples to provide a more comprehensive suite of radionuclides. Uranium-234 and uranium-238 were quantified in all these grab samples in 2009. Annual grab sampling also detected technetium-99 at River Mile 150.4.

Tritium Transport in Streams

Tritium is introduced into SRS streams and the Savannah River from former production areas on site. Because of the mobility of tritium in water and the quantities 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:

- total direct tritium releases, including releases from (1) facility effluent discharges and (2) measured migration of tritium from site seepage basins and SWDF migration (direct releases)
- tritium transport in SRS streams, measured at the last sampling point before entry into the Savannah River (stream transport)
- tritium transport in the Savannah River, measured downriver of SRS (near RM 118.8) after subtraction of any measured contribution above the site (river transport)

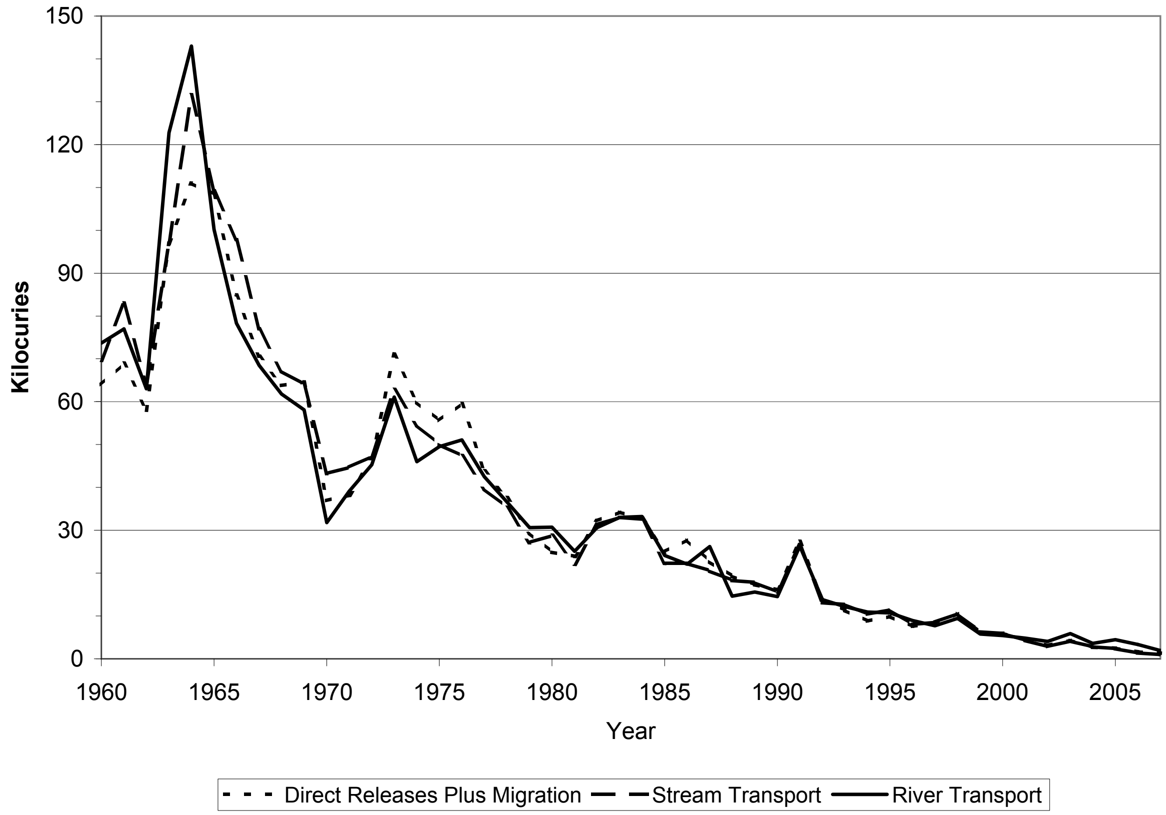

Figure 5–2 SRS Tritium Transport Summary, 1960–2009
SRS has maintained a tritium balance of direct releases plus migration, stream transport, and river transport since 1960 in an effort to account for and trend tritium releases in liquid effluents from the site. The general trend over time is attributable to (1) variations in tritium production at the site (production discontinued in the late 1980s); (2) the implementation of effluent controls, such as seepage basins, beginning in the early 1960s; and (3) the continuing depletion and decay of the site's tritium inventory.

The *direct releases* of tritium in 2009 totaled 1,559 Ci, compared to 1,535 Ci in 2008.

The *stream transport* of tritium increased to 1,271 Ci in 2009 (from 1,185 Ci in 2008).

The *river transport* of tritium measured in the Savannah River in 2009 was 2,350 Ci, compared with the previous year's 2,659 Ci. Both VEGP and SRS contributed to these values.

SRS tritium transport data for 1960–2009 are depicted in figure 5–2, which shows the history of direct releases, stream transport, and river transport, as determined by EM personnel.

EM continued to assess the tritium flux in the Lower Three Runs system in 2008. A more extensive tritium flux assessment initially was conducted in 2004—and described in the *SRS Environmental Report for 2004*. As it has during the past several years, a small but measurable amount of tritium from earlier Energy*Solutions* LLC (formerly Chem-Nuclear Systems) low-level radioactive waste disposal facility operations entered the stream system in 2009. The facility is privately owned and located adjacent to SRS. The amount of tritium entering the system is expected to continue a gradual decline over time. Energy*Solutions* LLC began a program of capping the tritium sources in 1991, thereby reducing the amount of tritium entering the groundwater. The tritium currently in groundwater will continue to decay and dilute as it moves from the source toward Lower Three Runs. EM and Energy*Solutions* will maintain a monitoring program for Lower Three Runs to evaluate this tritium migration.

Domestic Water

Description of Surveillance Program

EM collected domestic water samples in 2009 from locations at SRS and at water treatment facilities that use Savannah River water. Potable water was analyzed at offsite treatment facilities to ensure that SRS operations did not adversely affect the water supply and to provide voluntary assurance that drinking water did not exceed EPA drinking water standards for radionuclides.

Onsite domestic water sampling consisted 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. Composite samples were collected monthly off site from

- the Beaufort-Jasper Water and Sewer Authority's Chelsea and Purrysburg Water Treatment Plants
- the City of Savannah Industrial and Domestic Water Supply Plant
- the North Augusta (South Carolina) Water Treatment Plant

Surveillance Results Summary

All domestic water samples collected by EM in 2009 were screened for gross alpha and gross beta concentrations to determine if activity levels warrant further analysis. No domestic water exceeded EPA's 15-pCi/L alpha activity limit or 50-pCi/L beta activity limit. Also, no onsite or offsite domestic water samples exceeded the 20,000-pCi/L EPA tritium limit or the 8-pCi/L strontium-89,90 MDC.

No cesium-137, uranium-235, plutonium-239, or curium-244 was detected in any domestic water samples in 2009. On site, strontium-89,90, cobalt-60, curium-244, and plutonium-238 each was detected at one location. Uranium-234 was detected at six locations, uranium-235 at one location, and uranium-238 at seven locations.

Terrestrial Food Products

Description of Surveillance Program

The terrestrial food products surveillance program consists of radiological analyses of food product samples typically found in the Central Savannah River Area (CSRA). These foods include milk, meat (beef), fruit (melons or peaches), and green vegetables (collards). 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 validate dose models and determine environmental trends.

Samples of food—including meat, fruit, and a green vegetable—are collected from one location within each of four SRS quadrants and from a control location within an extended (to 25 miles beyond the perimeter) southeast quadrant. All food samples are collected annually except milk, which is collected quarterly from seven dairies within a 25-mile radius of the site. Two of the eight dairies were open during only two quarters in 2009; a third was open for three quarters. The food product surveillance program was expanded in 2005 to include secondary crops on a rotating schedule. Soybeans and wheat were sampled in 2009 as part of this program.

Food samples typically are analyzed for the presence of gamma-emitting radionuclides, tritium, strontium-89,90, uranium-234, uranium-235, uranium-238, plutonium-238, plutonium-239, americium-241, curium-244, gross alpha, and gross beta. Technetium-99 was added to analytical suite in 2009. A laboratory detection method for neptunium-237 in food products is being developed.

Surveillance Results Summary

The gamma-emitting radionuclides detected in food products in 2009 were cobalt-60 in milk at one location, and cesium-137 in collards at four locations and soybeans at one. Strontium-89,90 was detected in collards at all five locations and in soybeans at one location. Uranium-234 was detected in collards at all locations, and in fruit, beef, and soybeans at one location. Uranium-235 was detected in collards at one location, while uranium-238 was detected in collards at four locations and beef at one. Plutonium-238 was detected in collards at three locations and beef at two. Americium-241 was detected in collards at one location and in wheat at one. Technetium-99 was detected in collards at one location. Gross beta was detected in all food products. The 2009 results appeared to be randomly distributed among the monitoring locations, and no underlying spatial distribution was observed.

Tritium in food products is attributed primarily to releases from SRS. Tritium was detected only in collards at two locations in 2009. These results are similar to those of previous years.

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—from above SRS at Augusta, Georgia, to the coast at Savannah, Georgia. Composite samples—comprised of three to five fish of a given species—are prepared for each species from each location. Analyses for technetium-99, iodine-129, and the actinide series (uranium-234, uranium-235, and uranium-238, plutonium-238 and plutonium-239, americium-241, and curium-244) were added to all samples in 2006. Neptunium-237 was added in 2008.

Surveillance Results Summary

Cesium-137 was the only manmade gamma-emitting radionuclide found in Savannah River edible fish composites during 2009. Strontium-89,90, uranium-234, uranium-238, plutonium-238, and tritium were detected in freshwater fish at most of the river locations. Concentrations were similar to those of previous years. Technetium-99 was detected at four river locations. Curium-244 was detected at one location and neptunium-237 was detected at none of the locations. Uranium-234, uranium-235, uranium-238, plutonium-238 and strontium-89,90 were detected in saltwater fish; uranium-234 uranium-238, and plutonium-238 were detected in shellfish. Concentrations were similar to those of previous years. .

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, EM personnel use portable sodium iodide detectors to perform field analyses for cesium-137. 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. SRS established an administrative dose limit of 30 mrem per year for the consumption of game animals in 2006. This limit, which ensures that no single pathway contributes more than 30 percent to the all-pathway dose limit of 100 mrem, is consistent with DOE guidance. The doses from deer and hog consumption are quantified and reported in chapter 6.

Surveillance Results Summary

A total of 396 deer and 78 feral hogs were taken during the 2009 site hunts. 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 1 pCi/g to 9.17 pCi/g, while lab measurements ranged from 1 pCi/g to 8.24 pCi/g. The average field cesium-137 concentration was 1.38 pCi/g in deer (with a maximum of 9.17 pCi/g) and 1.06 pCi/g in hogs (with a maximum of 2.78 pCi/g). This range of concentrations is slightly below normal for the site's deer and hog populations.

The muscle and bone samples from a subset of the animals returned to the lab for cesium-137 analysis also are analyzed for strontium-89,90. Because of its chemistry, strontium is more readily measured in bone than in muscle tissue. In 2009, strontium was detected in seven of 68 deer muscle tissue samples and one of the five hog muscle tissue samples. These positive results were slightly above the minimum detection limit for strontium. Lab measurements of strontium-89,90 in bone ranged from 1.47 pCi/g to

8.38 pCi/g in deer, and from 1.67 pCi/g to 5.32 pCi/g in hogs. These results are similar to those of previous years.

Turkeys/Beavers

Description of Surveillance Programs

Prior to 2003, wild turkeys were trapped on site by the South Carolina Department of Natural Resources and used to repopulate game areas in South Carolina and other states. Since that time, the program has remained inactive because of reduced needs.

During April 2009, a special hunt for the mobility impaired was held that resulted in the harvest of 27 turkeys. The average cesium-137 concentration measured in the field was 1.30 pCi/g, which is comparable with the results from previous hunts.

The U.S. Department of Agriculture Forest Service–Savannah River harvests beavers in selected areas within the SRS perimeter to reduce the 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. This activity resumed during 2006. Although population control activities continued in 2009, no beavers were removed from their habitat for disposal.

Soil

Description of Surveillance Program

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

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. However, the data is available in previous environmental reports and can be evaluated over a period of years to determine and analyze long-term trends.

Surveillance Results Summary

In 2009, radionuclides were detected in soil samples from all 21 locations, as follows:

- cesium-137 at 11 locations (two onsite, eight perimeter, and two offsite)
- uranium-234 at all locations
- uranium-235 at all locations
- uranium-238 at all locations
- neptunium-237 at six locations (four perimeter and two offsite)
- plutonium-238 at 15 locations (four onsite, seven perimeter, and four offsite)
- plutonium-239 at 11 locations (four onsite, four perimeter, and three offsite)
- strontium-89,90 at four locations (one onsite and three perimeter)
- americium-241 at 15 locations (three onsite, eight perimeter, and four offsite)
- curium-244 at two locations (one onsite and one perimeter)

The concentrations at these locations are consistent with historical results. Uranium is naturally occurring in soil and therefore expected to be present in soil samples.

Settleable Solids

Description of Surveillance Program

Settleable-solids monitoring in effluent water is required to determine—in conjunction with routine sediment monitoring—whether a long-term buildup of radioactive materials occurs 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 SRS 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, EM uses TSS results—gathered as part of the routine National Pollutant Discharge Elimination System (NPDES) monitoring program—from outfalls co-located at or near radiological effluent points. If an outfall shows that TSS levels regularly are greater than 30 ppm, a radioactivity-levels-in-settleable-solids program and an increase in sediment monitoring will be implemented.

Surveillance Results Summary

In 2009, only two NPDES TSS samples exceeded 30 ppm. Both samples were collected from NPDES Outfall D–1D—one in April, the other in May—with results of 32 and 38 ppm, respectively. Second TSS samples were collected each of the two months, with results of 8 ppm and 10 ppm, respectively, to establish and verify compliance with permit average limits. The higher results (32 and 38 ppm) were attributed to infiltration of solids from nearby construction activities and did not lead to permit exceptions. The 2009 NPDES TSS results indicate that overall, SRS remains in compliance with the DOE radioactivity-levels-in-settleable-solids requirement.

Sediment

Description of Surveillance Program

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.

Sediment samples were collected at eight Savannah River and 19 onsite stream locations in 2009.

Surveillance Results Summary

Cesium-137 was the only manmade gamma-emitting radionuclide observed in river and stream sediments in 2009. The highest cesium-137 concentration in streams, 85.40 pCi/g, was detected in sediment from R-Canal; the lowest levels were below detection at six locations. The highest level from the river, 1.50 pCi/g, was at River Mile 150.2; the lowest levels were below detection at two 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 swamp areas along the river.

Strontium-89,90 was above the MDC in sediment at seven stream locations in 2009. The maximum detected value was 27.60 pCi/g at the FM3–A Below F-Area Effluent location.

Plutonium-238 was detected in sediment during 2009 at 14 stream locations and five river locations. The results ranged from a maximum of 0.30 pCi/g at FM–2A at Road 4 to below detection at several locations. Plutonium-239 was detected in sediment at 11 stream and no river locations. The maximum value was 0.08—at FM–A7A. Uranium-234, uranium-235, and uranium-238 were detected at most locations.

The distribution and concentration of radionuclides in river sediment during 2009 were similar to those of previous years.

Concentrations of all isotopes generally were higher in streams than in the river. As indicated in the earlier discussion of cesium-137, this is to be expected. 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.

Grassy Vegetation

Description of Surveillance Program

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 to help validate the dose models used by SRS. Bermuda grass is preferred because of its importance as a pasture grass for dairy herds.

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
- all air sampling locations

Surveillance Results Summary

Radionuclides in the grassy vegetation samples collected in 2009 were detected as follows:

- tritium at three locations (one onsite, two perimeter)
- cesium-137 at six locations (perimeter)
- strontium-89,90 at all but two locations (one onsite and the 100-mile-radius)
- uranium-234 at all 17 locations
- uranium-235 at three locations (one onsite, one perimeter, and one offsite)
- uranium-238 at all 17 locations
- plutonium-238 at three locations (one onsite and two perimeter)
- plutonium-239 at two locations (one onsite and one perimeter
- americium-241 at three locations (one onsite and two perimeter)
- curium-244 one location (offsite)
- gross beta at all 17 locations
- gross alpha at one location (perimeter)

Overall results show a slight increase in radionuclide concentrations from the past several years, but remain consistent with historical results.

Savannah River Swamp Surveys

Description of Surveillance Program

The Creek Plantation, a privately owned land area located along the Savannah River, borders part of the southern boundary of SRS. 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. During high river levels, water from Steel Creek flowed along the lowlands comprising the swamp, resulting in the deposition of radioactive material. SRS studies estimated that a total of approximately 25 Ci of cesium-137 and 1 Ci of cobalt-60 were deposited in the swamp.

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 series of 10 sampling trails—ranging from 240 to 3,200 feet in length—was established through the swamp. Fifty-four monitoring locations were designated on the trails to allow for continued monitoring at a consistent set of locations. [Fledderman, 2007]

The 2009 survey was designated as a cursory survey, requiring limited media sampling and analysis. Cursory surveys provide assurance that conditions observed during the more detailed comprehensive surveys have not changed significantly. A comprehensive survey requiring extensive media sampling and analyses was conducted in 2007 and is planned again for 2012.

Surveillance Results Summary

As anticipated, based on source term information and historical survey results, cesium-137 was the primary manmade radionuclide detected in the 2009 survey. Cesium-137 was detected in all 40 soil samples while no cobalt-60 was detected in any of these samples. Cesium-137 concentrations varied from a minimum of 0.22 pCi/g to a maximum of 49.90 pCi/g. These levels are comparable with those from previous surveys. Examination of the 10 shallow core samples showed that in general, higher concentrations of cesium-137 were observed in the shallow depths. Increased activity at shallower depths was observed as far away as trail 10, while higher concentrations were present on trails 1, 4, 5, 6, and 9 (see Environmental Data/Maps section on accompanying CD/website). Stronium-89,90 was detected in 10 of the 40 soil samples.

Cesium-137 was detected in eight of the 10 vegetation samples while no cobalt-60 was detected in any of these samples. Detectable concentrations varied from a minimum of 0.38 pCi/g to a maximum of 7.60 pCi/g. These levels are comparable with results of previous surveys. Higher concentrations generally were observed on trails 1, 4, 5, and 7, which correlates well with the Cs-137 concentrations in soil on these trails. Strontium-89,90 was detected in eight of the 10 vegetation samples.

TLD sets were placed at all 54 monitoring sites in 2009 to determine ambient gamma exposure rates, and all were retrieved from the swamp. The exposure time varied from 55 to 62 days. The gamma exposure rate ranged from 0.20 to 0.55 mrem/day, which is consistent with the range observed historically. The highest exposure rates were measured on trails 1, 4, 5, and 9. This follows the trends observed in previous surveys, and correlates well with the soil cesium-137 concentration results in this survey.

Nonradiological Surveillance

Air

SRS does not conduct onsite surveillance for nonradiological ambient air quality. However, to ensure compliance with SCDHEC air quality regulations and standards, SRNL most recently conducted air dispersion modeling for all site sources of criteria pollutants and toxic air pollutants in 2001. 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 current applicable 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.

SRNL sponsors a monitoring and collection station in support of the National Mercury Deposition Network of the National Atmospheric Deposition Program (NADP). This network provides data on the geographic distributions and trends of mercury in precipitation. It is the only network providing a long-term record of mercury concentrations in North American precipitation. All monitoring sites follow standard procedures and have uniform precipitation collectors and gauges. In 2008 (the last year for which data is available), the SRNL monitoring station (SC03) was one of 100 sites that satisfied NADP completeness criteria for national mapping of total mercury concentration and wet deposition. Data from this station indicated that the average (volume weighted) concentration of total mercury in precipitation in 2008 was 9.3 ng/L and the wet deposition rate was 9.5 µg/m^2. Data from 2009 will not be available until the fall of 2010. Additional information on this network is accessible via the following link: http://nadp.sws.uiuc.edu/mdn/.

Surface Water

SRS streams and the Savannah River are classified by SCDHEC as "Freshwaters," which 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") of this report provides some of the specific guidelines used in water quality surveillance, but because some of these guidelines are not quantifiable, they are not tracked at SRS.

Surveillance Results Summary

Water quality parameters were measured at all 16 locations, and metals were detected in at least one sample at each location. No samples had detectable pesticides/herbicides in 2009. These results continue to indicate that SRS discharges are not significantly affecting the water quality of onsite 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 14 small drinking water facilities, each of which serves populations of fewer than 25 persons.

Surveillance Results Summary

All samples collected from SRS drinking water systems during 2009 were in compliance with SCDHEC and EPA water quality standards. Additional information is provided in the Safe Drinking Water Act section of chapter 3, "Environmental Compliance."

Sediment

The nonradiological sediment surveillance program provides a method to determine the deposition and accumulation of nonradiological contaminants in stream systems. Sample preparation prior to analysis was changed in 2007 from an extraction (toxicity characteristic leaching procedure, or TCLP) to a total sample digestion.

Surveillance Results Summary

In 2009, as in the previous 5 years, no pesticides or herbicides were found to be above the quantitation limits in sediment samples. Metals analyses results for 2009 also were comparable to those of the previous 5 years.

Fish

EM personnel analyze the flesh of fish caught from the Savannah and Edisto Rivers to determine concentrations of mercury in the fish. In 2008, the addition of metals (arsenic, cadmium, manganese, and antimony) to the analytical suite was completed. The fish analyzed represent the most common edible species of fish in the CSRA (freshwater) and at the mouth of the Savannah River (saltwater).

Surveillance Results Summary

In 2009, mercury analyses were performed on 513 fish from the Savannah River and 21 from the Edisto River at West Bank Landing. Concentrations of mercury generally were slightly lower than those observed in 2008. The highest concentrations were found in the Savannah River—in bass at the Highway 301 bridge area (1.254 µg/g), in catfish at Upper Three Runs Creek Mouth (0.944 µg/g), and in bream at the Augusta Lock and Dam (0.722 µg/g). The highest concentrations found at West Bank Landing were 0.889 µg/g in bass, 0.929 µg/g in bream, and 0.897 µg/g in catfish.

Arsenic was detected in 16 samples, with the highest concentration in mullet (1.05 µg/g) at RM–08 of the Savannah River. Cadmium was below detection in all samples. Manganese was detected at all 10 locations, with the highest concentration in catfish (5.57 µg/g) at Upper Three Runs Creek Mouth. Antimony was detected in 100 samples, with the highest concentration in bass (0.760µg/g) at the mouth of Steel Creek.

River Water Quality Surveys

Description of Surveys

Academy of Natural Sciences (ANS) personnel conducted biological and water quality surveys of the Savannah River from 1951 through 2003, when EM assumed this responsibility. The surveys were 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 geographically associated with the site
- patterns of change over seasons or years that indicate improving or deteriorating conditions

EM conducted macroinvertebrate sampling during the spring and fall of 2009, and diatom sampling was conducted monthly. The diatom slides were sent to ANS for archiving. No adverse biological impacts have been identified in the Savannah River diatom communities.

Macroinvertebrates collected from river traps during 2008 were similar in species diversity to those documented in surveys during the 1990s. An overall decrease in total populations was observed that likely is associated with low flow in the river and incipient drought conditions. No evidence of adverse biological impacts was found in the observed macroinvertebrate communities. Collections from 2009 will be sorted and archived during 2010.

Potential Radiation Doses

CHAPTER 6

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This chapter presents the potential doses to offsite individuals and the surrounding population from the 2009 Savannah River Site (SRS) atmospheric and liquid radioactive releases. Also documented are potential doses from special-case exposure scenarios—such as the consumption of deer meat, fish, and goat milk. 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 basis.

Descriptions of the SRS effluent monitoring and environmental surveillance programs discussed in this chapter can be found in chapter 4, "Effluent Monitoring," and chapter 5, "Environmental Surveillance." A complete description of how potential doses are calculated can be found in section 1108 of the Savannah River Site Environmental Monitoring Program, WSRC–3Q1–2, Volume 1, Revision 4 [SRS EM Program, 2002a].

All dose calculation results are presented in data tables on the CD housed inside the back cover of this report.

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 living at the SRS boundary
- population living within an 80-km (50-mile) radius of SRS

Because the U.S. Department of Energy (DOE) has

Dose to the Hypothetical Maximally Exposed Individual

When calculating radiation doses to the public, SRS uses the concept of the hypothetical 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 as follows:

For airborne releases - Someone who lives at the SRS boundary 365 days per year and consumes 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 19 kg (42 pounds) per year 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.

adopted dose factors only for adults [DOE, 1988], SRS calculates maximally-exposed-individual and collective doses as if the entire 80-km population consists of adults. For the radioisotopes that contribute the most to SRS's estimated maximum individual doses (i.e., tritium and cesium-137), the dose to infants could be approximated as two to three times more than the adult dose. The dose to older children becomes progressively closer to the adult dose.

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 a regional survey [Hamby, 1991].

For dose calculations, the unspecified alpha releases were conservatively treated as plutonium-239, and the unspecified beta releases were treated as strontium-90. These radionuclides have the highest dose factors of the alpha- and beta-emitters, respectively, that are commonly measured in SRS waste streams.

Dose Calculation Methods

To calculate annual offsite doses, SRS uses transport and dose models developed for the commercial nuclear industry [NRC, 1977]. The models are described in SRS EM Program, 2002a.

Meteorological Database

To show compliance with DOE environmental orders, potential offsite doses from releases of radioactivity to the atmosphere were calculated with quality-assured meteorological data for A-Area, K-Area (for combined releases from C-Area, K-Area, and L-Area), and H-Area (for combined releases from all other areas). The meteorological databases were for the years 2002–2006, reflecting the most recent 5-year compilation period.

To show compliance with U.S. Environmental Protection Agency (EPA) regulations, only the H-Area database was used in the calculations because the EPA-required dosimetry code (CAP88, Mainframe version 1.0, henceforth referred to simply as CAP88) is limited to a single release location.

Population Database and Distribution

Collective (population) doses from atmospheric releases are calculated for the population within an 80-km radius of SRS. Within this radius, the total population is 713,500, based on 2000 census data.

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 (Savannah I&D), near Port Wentworth, Georgia, and by the Beaufort-Jasper Water and Sewer Authority's (BJWSA) Chelsea and Purrysburg Water Treatment Plants, near Beaufort, South Carolina. According to the treatment plant operators, the population served by the Savannah I&D facility during 2009 was 26,300 persons, while the population served by the BJWSA Chelsea facility was 77,000 persons and by the BJWSA Purrysburg facility, 58,000 persons.

River Flow Rate Data

Savannah River flow rates—recorded at a gauging station near River Mile 118.8 (U.S. Highway 301 bridge)—are based on the measured water elevation. However, these data are not used directly in SRS dose calculations. Used instead are "effective" flow rates, which are based on (1) the measured annual release of tritium and (2) the annual average tritium concentrations measured at River Mile 118.8 and at the three downriver water treatment plants. The use of effective river flow rates in the dose calculations generally is more conservative than the use of measured flow rates because it accounts for less dilution.

For 2009, the River Mile 118.8 calculated (effective) flow rate of 6,324 cubic feet per second (cfs) was used in the dose calculations. This flow rate was nearly 46 percent more than the 2008 effective flow rate of 4,340 cfs, which was the lowest annual average river flow rate since the startup of SRS operations in 1954. For comparison, the 2009 annual average flow rate (as measured by the U.S. Geological Survey) was 7,666 cfs. This flow rate is still well below the 1954–2009 mean annual flow rate of 10,228 cfs—likely because of persistent drought conditions in the Central Savannah River Area.

The 2009 calculated effective flow rates were 8,807 cfs for the Savannah I&D facility, 8,226 cfs for the BJWSA Chelsea facility, and 7,873 cfs for the BJWSA Purrysburg facility.

Dose Calculation Results

Liquid Pathway

Liquid Release Source Terms

The 2009 radioactive liquid release quantities used as the source term in SRS dose calculations are discussed in chapter 4 and shown by radionuclide in table 6–1. Tritium accounts for more than 99 percent of the total amount of radioactivity released from the site to the Savannah River. In 2009, a total of 1,559 curies of tritium were released from SRS to the river. In the recent past, the total amount of tritium used in SRS dose calculations was based on the measured tritium concentration at River Mile 118.8. However, the total from this location includes the tritium releases from Georgia Power Company's Vogtle Electric Generating Plant (VEGP). Since 2006, maximally-exposed-individual doses have been calculated and documented in this report using SRS-only releases.

Data from continuously monitored liquid effluent discharge points are used in conjunction with site seepage basin and Solid Waste Disposal Facility migration release measurements to quantify the total tritium released from SRS. A separate dose calculation is performed (for information only) that includes the total amount of tritium (SRS plus VEGP) measured at River Mile 118.8, which in 2009 was 2,784 curies.

Radionuclide Concentrations in Savannah River Water, Drinking Water, and Fish

The concentrations of tritium in Savannah River water and cesium-137 in Savannah River fish are measured at several locations along the river for use in dose determinations and model comparisons. The amounts of all other radionuclides released from SRS are so small that they usually cannot be detected in the Savannah River using conventional analytical techniques. Therefore, their concentrations in the river are calculated using the LADTAP XL code, based on the annual release amounts and on the applicable effective flow rate.

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 Savannah I&D and BJWSA water treatment facilities are shown in table 6–1, as are the calculated concentrations for the other released radionuclides. These downriver tritium concentrations include the tritium releases from SRS and the neighboring VEGP.

In 2009, the 12-month average tritium concentration measured in Savannah River water near River Mile 118.8 (493 pCi/L) was 28 percent less the 2008 concentration of 686 pCi/L. This decrease is attributed to the 46 percent increase in river flow from 2008 to 2009. The 2009 concentrations at the BJSWA Chelsea (379 pCi/L) and Purrysburg (396 pCi/L) facilities, and at the Savannah I&D (354 pCi/L) water treatment plant, were proportionately lower than in 2008, and remained below the EPA drinking water maximum contaminant level (MCL) of 20,000 pCi/L.

The drinking water MCL for each radionuclide released from SRS during 2009 is provided in table 6–1. The table indicates that all individual radionuclide concentrations at the three 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 fractions of the reported concentration of each radionuclide to its corresponding MCL must not exceed 1.0. The sums of the fractions were 0.0257 at the BJSWA Chelsea facility, 0.0268 at the BJSWA Purrysburg facility, and 0.0240 at the Savannah I&D facility. These are below the 1.0 sum-of-the-fractions requirement.

For 2009, the sum of the fractions at the River Mile 118.8 location was 0.0334. This is provided 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 the concentration of cesium found in the water in which the fish live [Carlton et al., 1994].

Table 6–1
2009 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]	BJWSA Chelsea[b]	BJWSA Purrysburg[b]	Savannah I&D[c]	EPA MCL
H-3[d]	2.78E+03	4.93E+02	3.79E+02	3.96E+02	3.54E+02	2.00E+04
Zn-65	5.51E-04	9.76E-05	7.50E-05	7.84E-05	7.01E-05	3.00E+02
Sr-90	4.02E-02	7.12E-03	5.47E-03	5.72E-03	5.11E-03	8.00E+00
Tc-99	1.96E-02	3.47E-03	2.67E-03	2.79E-03	2.49E-03	9.00E+02
I-129	3.55E-02	6.29E-03	4.83E-03	5.05E-03	4.51E-03	1.00E+00
Cs-137	9.15E-02	1.62E-02	1.25E-02	1.30E-02	1.16E-02	2.00E+02
U-234[e]	1.62E-04	2.87E-05	2.21E-05	2.30E-05	2.06E-05	1.03E+01
U-235[e]	2.17E-06	3.84E-07	2.95E-07	3.09E-07	2.76E-07	4.67E-01
U-238[e]	1.16E-04	2.05E-05	1.58E-05	1.65E-05	1.47E-05	1.00E+01
Np-237	9.07E-06	1.61E-06	1.23E-06	1.29E-06	1.15E-06	1.50E+01
Pu-238	2.28E-03	4.04E-04	3.10E-04	3.24E-04	2.90E-04	1.50E+01
Pu-239	1.55E-04	2.74E-05	2.11E-05	2.20E-05	1.97E-05	1.50E+01
Am-241	1.05E-04	1.86E-05	1.43E-05	1.49E-05	1.33E-05	1.50E+01
Cm-244	2.92E-05	5.17E-06	3.97E-06	4.15E-06	3.71E-06	1.50E+01
Alpha	1.77E-02	3.13E-03	2.41E-03	2.52E-03	2.25E-03	1.50E+01
Beta	5.48E-02	9.70E-03	7.46E-03	7.79E-03	6.97E-03	8.00E+00

[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] The tritium concentrations and source term are based on actual measurements of the Savannah River water at the various locations. They include contributions from the VEGP. All other radionuclide concentrations are calculated based on the effective river flow rate.
[e] MCL for uranium in natural water, based on radioisotope-specific activity X 30 μg/L X isotopic abundance

Because of this high bioaccumulation factor, cesium-137 is detected more easily in fish flesh than in river water. Therefore, the fish pathway dose from cesium-137 normally 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. However, in 2009, the LADTAP XL dose model calculated concentration of cesium-137 in fish, which is based on measured effluent releases, was determined to be more than the actual measured concentration in fish. To be conservative, this higher calculated cesium-137 concentration in fish was used in the 2009 dose determinations.

Dose to the Maximally Exposed Individual

As shown in table 6–2, the highest potential dose to the maximally exposed individual from liquid releases in 2009 was estimated at 0.08 mrem (0.0008 mSv). This dose is 0.08 percent of the DOE Order 5400.5 ("Radiation Protection of the Public and the Environment") 100-mrem all-pathway dose standard for annual exposure. The 2009 dose is the same as the 2008 dose.

Approximately 61 percent of the 2009 dose to the maximally exposed individual resulted from the ingestion of cesium-137, mainly from the consumption of fish. About 17 percent of the dose resulted from the ingestion of tritium (mainly via drinking water), an additional 14 percent from the ingestion of unspecified alpha emitters. Every other radionuclide contributed less than 3 percent to the dose.

Using the 2009 total Savannah River tritium source term (which includes SRS and VEGP releases) of 2,784 curies, the maximally-exposed-individual dose was calculated to be 0.09 mrem (0.0009 mSv). This dose, which is provided here for information only, is the same as the equivalent 2008 dose.

Drinking Water Pathway Dose

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 2009, tritium in downriver drinking water represented the majority of the dose (about 46 percent) received by persons at the three downriver water treatment plants. Unspecified alpha-emitters accounted for about 36 percent, and iodine-129 releases, about 5 percent. All other individual radionuclides contributed 3 percent or less to the dose.

Based on SRS-only releases, the maximum potential drinking water dose during 2009 was determined to be 0.02 mrem (0.0002 mSv)—about 50 percent less than the 2008 dose of 0.04 mrem (0.0004 mSv). This decrease is attributed primarily to the 46 percent increase in Savannah River flow rate from 2008 to 2009. As shown in table 6–2, the maximum dose of 0.02 mrem is 0.5 percent of the DOE standard of 4 mrem per year for public water supplies.

Using the SRS-plus-VEGP total tritium source term of 2,784 curies, the maximum drinking water dose

Table 6–2
Potential Dose to the Maximally Exposed Individual from SRS Liquid Releases in 2009

	Committed Dose (mrem)	Applicable Standard (mrem)	Percent of Standard
Maximally Exposed Individual			
Near Site Boundary (all liquid pathways)	0.08	100[a]	0.08
At BJSWA Chelsea (public water supply only)	0.02	4[b]	0.50
At BJSWA Purrysburg (public water supply only)	0.02	4[b]	0.50
At Savannah I&D (public water supply only)	0.02	4[b]	0.50

[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)

was calculated to be 0.03 mrem (0.0003 mSv) in 2009.

Collective (Population) Dose

The collective drinking water consumption dose is calculated for the discrete population groups served by the BJWSA and Savannah I&D water treatment plants. 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.

In 2009, the collective dose from SRS liquid releases was estimated at 2.2 person-rem (0.022 person-Sv). This is about 42 percent less than the 2008 collective dose of 3.8 person-rem (0.038 person-Sv). Again, this decrease is attributed mainly to the higher Savannah River flow rate during 2009.

Using the SRS-plus-VEGP total tritium source term of 2,784 curies, the collective dose was calculated to be 2.9 person-rem (0.029 person-Sv) in 2009.

Potential Dose from Agricultural Irrigation

Based on discussions with personnel in the Georgia Department of Natural Resources (GDNR) and the South Carolina Department of Health and Environmental Control (SCDHEC), there are no known large-scale uses of Savannah River water downstream of SRS for agricultural irrigation purposes. However, the potential for agricultural irrigation does exist, so potential doses from this pathway are calculated for informational purposes only, but are not included in calculations of the official maximally-exposed-individual or collective doses.

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 population (713,500) within 80 km of SRS.

For 2009, a potential offsite dose of 0.06 mrem (0.0006 mSv) to the maximally exposed individual and a potential collective dose of 3.9 person-rem (0.039 person-Sv) were estimated for this exposure pathway.

Air Pathway

Atmospheric Source Terms

The 2009 radioactive atmospheric release quantities used as the source term in SRS dose calculations are discussed in chapter 4. Estimates of unmonitored diffuse and fugitive sources were included in the atmospheric source term, as required, for demonstrating compliance with National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations.

Atmospheric Concentrations

Calculated radionuclide concentrations instead of measured concentrations are used for dose determinations. This is because most radionuclides released from SRS cannot be measured (using conventional analytical 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.

Dose to the Maximally Exposed Individual

In 2009, the estimated dose from atmospheric releases to the maximally exposed individual (calculated with MAXDOSE–SR) was 0.04 mrem (0.0004 mSv), which is 0.4 percent of the DOE Order 5400.5 air pathway standard of 10 mrem per year. Table 6–3 compares the maximally-exposed-individual dose with the DOE standard. The 2009 dose was the same as the dose for 2008.

Tritium oxide releases accounted for about 80 percent of the dose to the maximally exposed individual, and iodine-129 releases accounted for about 10 percent of the dose. No other individual radionuclide accounted for more than 5 percent of the maximally-exposed-individual dose.

The major pathways contributing to the maximally-exposed-individual dose from atmospheric releases were inhalation (41 percent), vegetation consumption (39 percent), and meat and milk consumption (17 percent). For 2009, the due north sector of the site was the location of the highest dose to the maximally exposed individual.

Table 6–3
Potential Dose to the Maximally Exposed Individual from SRS Atmospheric Releases in 2009

	MAXDOSE–SR	CAP88 (NESHAP)
Calculated dose (mrem)	0.04	0.04
Applicable Standard	10[a]	10[b]
Percent of Standard	0.40	0.40

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

Additional calculations of the dose to the maximally exposed individual again were performed substituting goat milk for the customary cow milk pathway. The potential dose to the maximally exposed individual using the goat milk pathway instead of the cow milk pathway was estimated at 0.05 mrem (0.0005 mSv).

Collective (Population) Dose

In 2009, the airborne-pathway collective dose (calculated with POPDOSE–SR) was estimated at 2.0 person-rem (0.020 person-Sv)—less than 0.01 percent of the annual collective dose received from natural sources of radiation (about 214,000 person-rem). Tritium oxide releases accounted for about 82 percent of the collective dose. The 2009 collective dose was about 11 percent more than the 2008 collective dose of 1.8 person-rem (0.018 person-Sv).

NESHAP Compliance

To demonstrate compliance with NESHAP regulations [EPA, 2002a], maximally-exposed-individual and collective doses were calculated using (1) the CAP88 computer code, (2) the 2009 airborne-release source term, and 3) site-specific input parameters [SRS EM Program, 2002a]. The CAP88 code estimates a higher dose for tritium oxide than do the MAXDOSE–SR and POPDOSE–SR codes, which are used for demonstrating compliance with DOE environmental orders. 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, other radionuclides (such as iodine-129) are less important—on a percentage-of-dose basis—for the CAP88 doses than for the MAXDOSE–SR and POPDOSE–SR doses.

For 2009, the maximally-exposed-individual dose was estimated at 0.04 mrem (0.0004 mSv), which is 0.4 percent of the 10-mrem-per-year EPA standard, as shown in table 6–3. Tritium oxide releases accounted for about 96 percent of this dose. The 2009 NESHAP compliance dose of 0.04 mrem (0.0004 mSv) was the same as the dose for 2008.

For NESHAP, the dose from diffuse and fugitive releases is required to be reported separately. For 2009, the maximally-exposed-individual dose from diffuse and fugitive releases was estimated to be 0.01 mrem (0.0001 mSv), which accounts for slightly less than half the total maximally-exposed-individual dose.

The CAP88-determined collective dose was estimated at 5.0 person-rem (0.05 person-Sv). Tritium oxide releases accounted for about 96 percent of this dose.

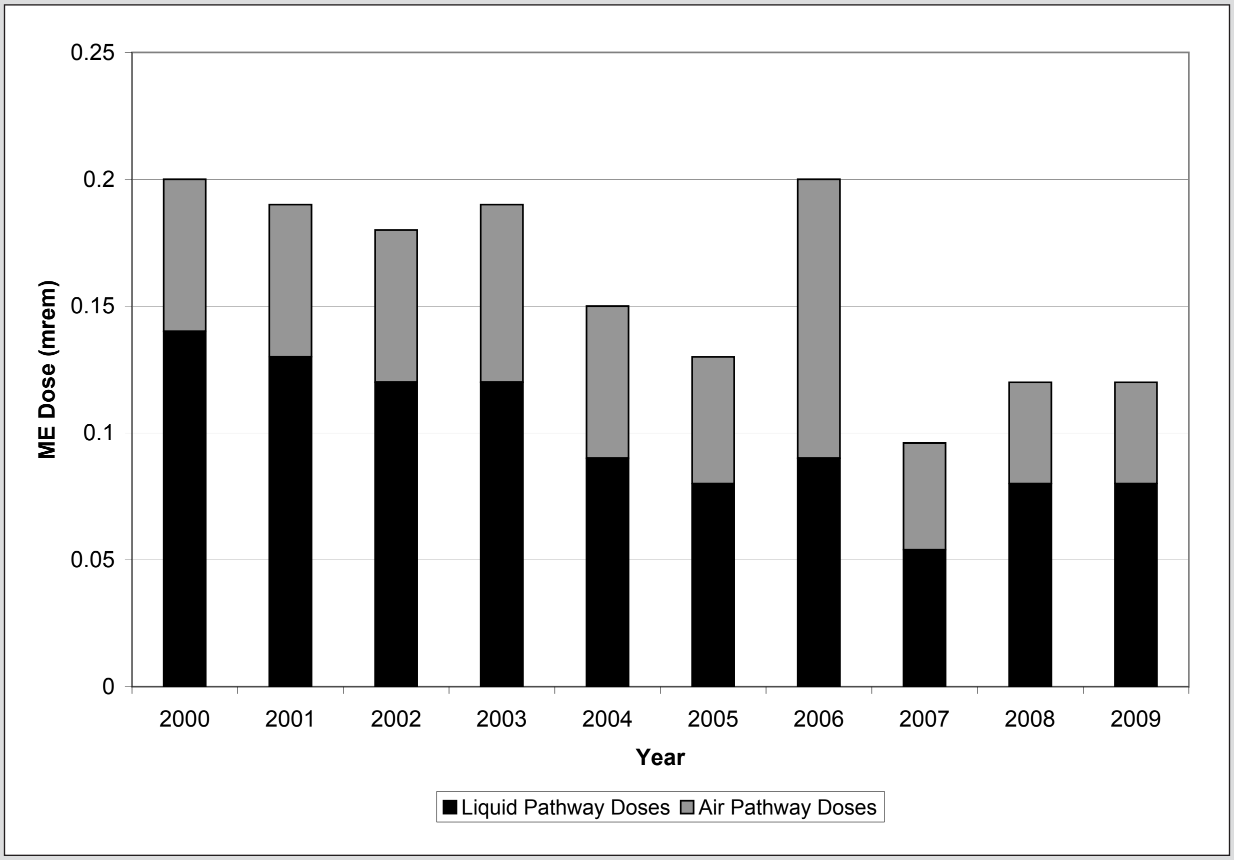


Figure 6–1 Ten-Year History of SRS Maximum Potential All-Pathway Doses

All-Pathway Dose

To demonstrate compliance with the DOE Order 5400.5 all-pathway dose standard of 100 mrem (1.0 mSv) per year, SRS conservatively combines the maximally-exposed-individual airborne pathway and liquid pathway dose estimates, even though the two doses are calculated for hypothetical individuals residing at different geographic locations.

For 2009, the potential maximally-exposed-individual all-pathway dose was 0.12 mrem (0.0012 mSv)—0.04 mrem from air pathways plus 0.08 mrem from liquid pathways. The all-pathway dose is 0.12 percent of the 100-mrem-per-year DOE dose standard. The 2009 all-pathway dose is the same as the 2008 dose.

Figure 6–1 shows a 10-year history of SRS's all-pathway (airborne pathway plus liquid pathway) doses to the maximally exposed individual.

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.

In addition to deer, hog, and fish consumption, the following exposure pathways were considered for an offsite hunter and an offsite fisherman—both on Creek Plantation, a privately owned portion of the Savannah River Swamp, which was contaminated by SRS operations in the 1960s (chapter 5):

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

Onsite Hunter Dose

Deer and Hog Consumption Pathway 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. The estimated dose from the consumption of harvested deer or hog meat is determined for every onsite hunter. During 2009, the maximum dose that could have been received by an actual onsite hunter was estimated at 8.4 mrem (0.084 mSv), or 8.4 percent of DOE's 100-mrem all-pathway dose standard (table 6–4). This dose was determined for

Table 6–4
2009 Maximum Potential All-Pathway and Sportsman Doses Compared to the DOE All-Pathway Dose Standard

	Committed Dose (mrem)	Applicable Standard (mrem)[a]	Percent of Standard
Maximally-Exposed-Individual Dose			
All-Pathway (Liquid Plus Airborne Pathway)	0.12	100	0.12
Sportsman Dose			
Onsite Hunter	8.40	100	8.40
Creek-Mouth Fisherman[b]	0.35	100	0.35
Savannah River Swamp Hunter			
Offsite Hog Consumption	0.24		
Offsite Deer Consumption	1.54		
Soil Exposure[c]	2.90		
Total Offsite Deer Hunter Dose	4.44	100	4.44
Savannah River Swamp Fisherman			
Steel Creek Fish Consumption	0.10		
Soil Exposure[d]	0.28		
Total Offsite Fisherman Dose	0.38	100	0.38

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

[b] In 2009, the maximum dose to a hypothetical fisherman was caused by the consumption of bass from the mouth of Lower 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

an actual hunter who in fact harvested seven animals (4 deer and 3 hogs) during the 2009 hunts. The hunter-dose calculation is based on the conservative assumption that this prolific hunter individually consumed the entire edible portion—approximately 168 kg (370 pounds)—of the animals he harvested from SRS.

Offsite Hunter Dose

Deer and Hog Consumption Pathway The deer and hog consumption pathway considered was for hypothetical offsite individuals whose entire intake of meat during the year was either deer or hog meat. It was assumed that these individuals harvested deer or hogs that had resided on SRS but then moved off site.

Based on these low-probability assumptions and on the measured average concentration of cesium-137 in all deer (1.38 pCi/g) and hogs (1.06 pCi/g) harvested from SRS during 2009, the potential maximum doses from this pathway were estimated at 1.54 mrem (0.0154 mSv) for the offsite deer hunter and 0.24 mrem (0.0024 mSv) for the offsite hog hunter.

A background cesium-137 concentration of 1 pCi/g is subtracted from the onsite average concentrations before calculating the doses. The background concentration is based on previous analyses of deer harvested at least 80 km from SRS (table 33, SRS Environmental Data for 1994) [SRS Data, 1995].

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 2009 was estimated using the RESRAD code [Yu et al., 2001]. 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.

Using the worst-case radionuclide concentrations from the most recent comprehensive survey—conducted in 2007—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 2.9 mrem (0.029 mSv).

As shown in table 6–4, 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 4.44 mrem (0.0444 mSv). This potential dose is 4.44 percent of the DOE 100-mrem all-pathway dose standard.

Offsite Fisherman Dose

Creek-Mouth Fish Consumption Pathway For 2009, radioanalyses were conducted of three species of fish (panfish, catfish, and bass) taken from the mouths of the five SRS streams, and the resulting estimated doses were calculated. SRS reports the maximum dose from this combination of fish and creek mouths. As shown in table 6–4, the maximum potential dose from this pathway was estimated at 0.35 mrem (0.0035 mSv)—from the consumption of bass collected at the mouth of Lower Three Runs. This hypothetical dose is based on the low-probability scenario that, during 2009, a fisherman consumed 19 kg of bass caught exclusively from the mouth of Lower Three Runs. About 91 percent of this potential dose was from cesium-137.

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 2007 (year of last comprehensive swamp survey; refer to chapter 5) was estimated using the RESRAD code [Yu et al., 2001]. 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.

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 0.28 mrem (0.0028 mSv) in 2009.

As shown in table 6–4, the maximum Steel Creek-mouth fish consumption dose (0.10 mrem) and the Savannah River Swamp fisherman soil exposure pathway were conservatively added together to obtain a total offsite creek-mouth fisherman dose of 0.38 mrem (0.0038 mSv). This potential dose is 0.38 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

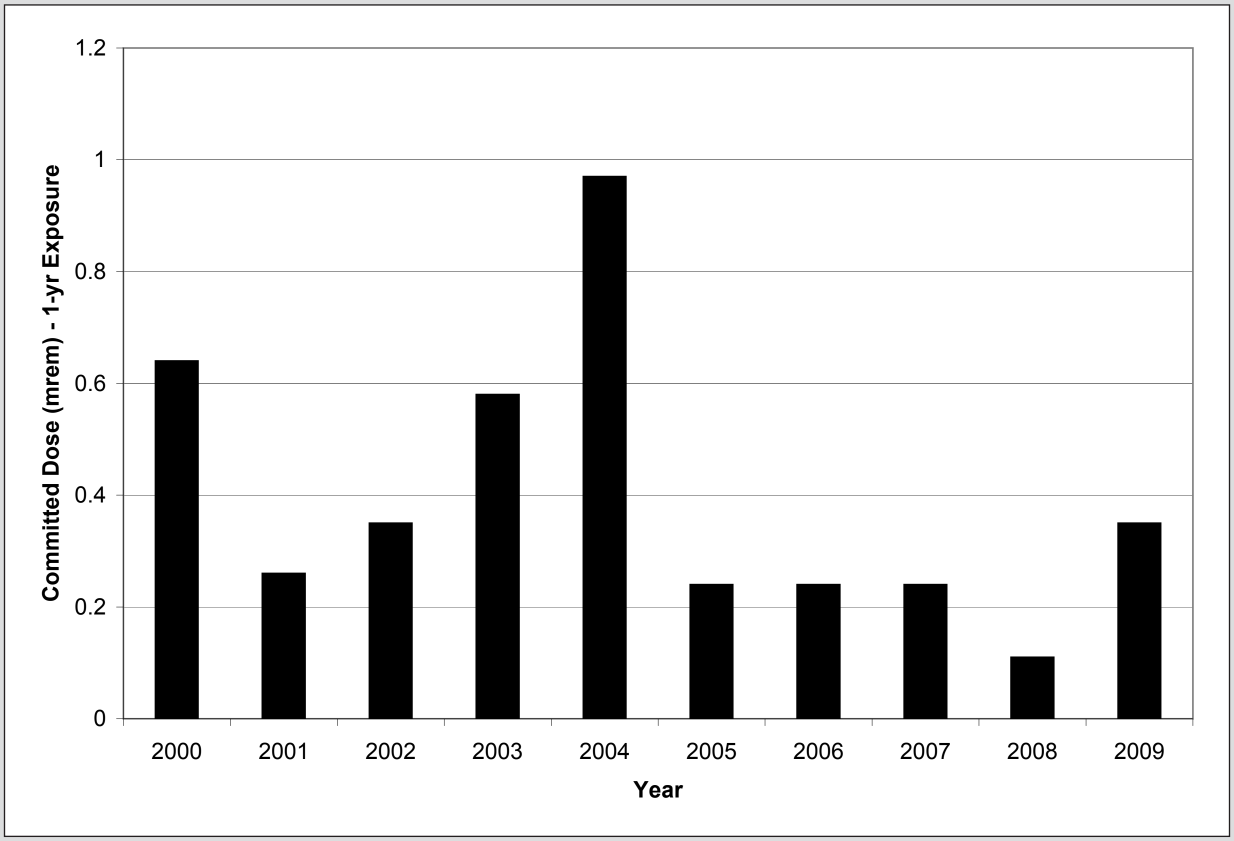


Figure 6–2 Ten-Year History of SRS Creek-Mouth Fisherman's Doses

of Representatives 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, and the South Carolina Department of Health and Environmental Control—the *Westinghouse Savannah River Company/Environmental Monitoring Section Fish Monitoring Plan*, which is summarized in SRS EM Program, 2002. Among the reporting requirements of this plan are (1) assessing radiological risk from the consumption of Savannah River fish and (2) presenting a summary of the results in the annual *SRS Environmental Report*.

Risk Comparisons For 2009, 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 6–5, 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 potential risks were estimated using the cancer morbidity risk coefficients from Federal Guidance Report No. 13 [EPA, 1999a].

For 2009, the maximum recreational fisherman dose was caused by the consumption of bass collected at the mouth of Lower Three Runs. Figure 6–2 shows a 10-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 of large variability in the 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
- the amount of cesium-137 (and other radionuclides) available in the water and sediments at the SRS stream mouths—caused by annual

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

	Committed Dose (mrem)	Potential Risk[a] (unitless)
2009 Savannah River Fish		
1-Year Exposure	0.35	2.8E-07
30-Year Exposure	10.50	7.8E-06
50-Year Exposure	17.50	1.3E-05
Dose Standard		
100-Mrem/Year All Pathway		
1-Year Exposure	100	7.3E-05
30-Year Exposure	3,000	2.2E-03
50-Year Exposure	5,000	3.7E-03

[a] 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.

changes in stream flow rates (turbulence) and water chemistry

As indicated in table 6–5, the 50-year maximum potential lifetime risk from consumption of SRS creekmouth fish was 4.1E-06, which is below the 50-year risk (3.7E-03) associated with the 100-mrem-per-year dose standard.

If a potential lifetime 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 risk may be deemed acceptable if it is kept as low as reasonably achievable (ALARA), although actions to further reduce this risk can be considered. At SRS, the environmental ALARA program [SRS EM Program, 2002a] is in place to ensure that the potential risk from site radioactive liquid effluents (and, therefore, from consumption of Savannah River fish) is kept ALARA.

Release of Material Containing Residual Radioactivity

No materials containing residual radioactivity were released from SRS during 2009. DOE issued a moratorium in January 2000 prohibiting the release of volume-contaminated metals, and suspended the release of metals from DOE radiological areas in July 2000 for recycling purposes. No volume-contaminated metals or metals for recycling purposes were released from SRS in 2009.

DOE approved an SRS request in 2003 to use supplemental limits for releasing material from the site with no further DOE controls. These supplemental release limits are dose-based, and are such that if any member of the public received any exposure, it would be less than 1 mrem/year. The supplemental limits include both surface and volume concentration criteria. The surface criteria are very similar to those used in previous years. The volume criteria allow the disposal of potentially volume-contaminated material in SRS's Three Rivers Landfill, an onsite sanitary facility. In 2009, no material was released from the site using the SRS Supplemental Release Limits volume concentration criteria.

These measures ensure that radiological releases of material from SRS are consistent with the requirements of DOE Order 5400.5.

Radiation Dose to Aquatic and Terrestrial Biota

DOE Order 5400.5 establishes an interim dose standard for protection of native aquatic animals. The absorbed dose limit to these organisms is 1.0 rad per day (0.01 Gy per day) from exposure to radioactive material in liquid effluents released to natural waterways.

DOE Biota Concentration Guides

At SRS, the evaluations of biota doses for aquatic and terrestrial systems are performed using the RESRAD-Biota model (version 1.21), which is based on the DOE standard entitled *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* [DOE, 2002].

The aquatic-systems evaluation includes exposures to primary (herbivores) and secondary (predators) aquatic animals, and the biota concentration guides (BCGs) are based on the 1.0-rad-per-day dose limit. Aquatic plants are not considered. The terrestrial-systems evaluation includes exposures to terrestrial plants and animals, and is based on a 10-rad-per-day dose limit for plants and a 0.1-rad-per-day dose limit for animals.

For the aquatic-systems evaluation, initial screenings were performed in 2009 using maximum radionuclide concentration data from the 10 SRS Environmental Monitoring (EM) stream sampling locations from which co-located water and sediment samples are collected. An exception to this was made for sample location FM–2B (located on Four Mile Creek between F-Area and H-Area) 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 is collected there. The combined water-plus-sediment BCG sum of the fractions was used for the aquatic systems evaluation. A sum of the fractions less than 1.0 indicates the sampling site has passed its initial pathway screening.

For the terrestrial-systems evaluation, initial screenings were performed using concentration data from the five EM onsite radiological soil sampling locations. Only one soil sample per year is collected and analyzed for radioactivity from each location.

For 2009, all terrestrial locations and all but one aquatic location passed their initial pathway screenings. Location FM–2B failed the initial screening but passed the secondary screening using average concentrations in lieu of the maximum concentrations.

Groundwater

CHAPTER 7

Dan Wells
Regulatory Integration & Environmental Services

Groundwater protection at the Savannah River Site (SRS) has evolved into a program with the following primary components:

- *Protect groundwater by good practices in managing chemicals and work.*
- *Monitor groundwater to identify areas of contamination.*
- *Remediate contamination as needed.*
- *Conserve groundwater.*

SRS operations have contaminated groundwater around certain waste disposal facilities. Extensive monitoring and remediation programs are tracking and cleaning up the contamination. Remediation includes (1) closing waste sites to reduce the migration of contaminants into groundwater and (2) actively treating contaminated water.

No offsite wells have been contaminated by the migration of SRS groundwater.

This chapter describes SRS's groundwater environment and the programs in place for investigating, monitoring, remediating, and using the groundwater.

Groundwater at SRS

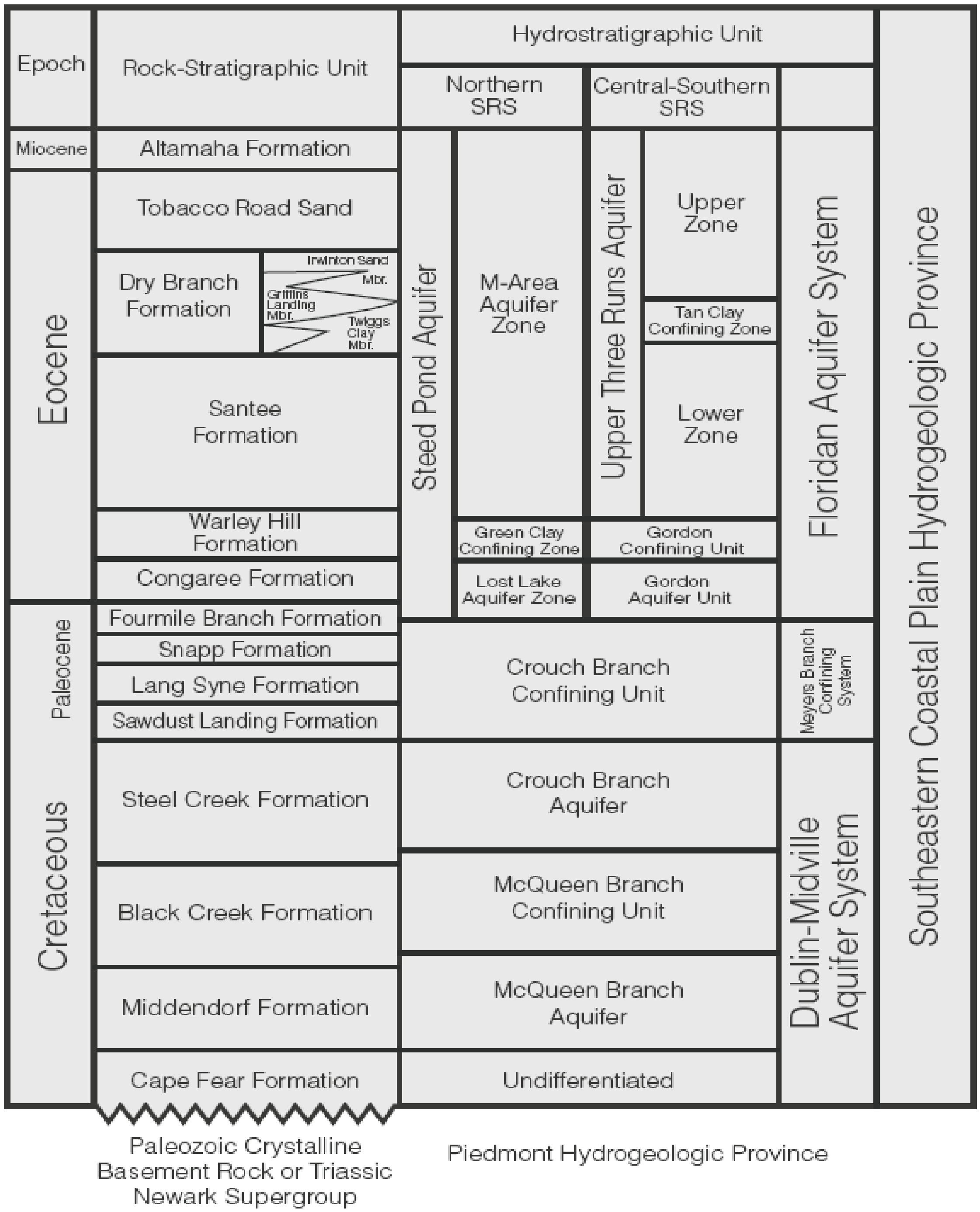
SRS is underlain by sediment of the Atlantic Coastal Plain. The Atlantic Coastal Plain consists of a southeast-dipping wedge of unconsolidated sediment that extends from its contact with the Piedmont Province at the Fall Line to the edge of the continental shelf. The sediment ranges from Late Cretaceous 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.

Water flows easily through the sandy layers (aquifers) but is retarded by less permeable clayey beds (confining units). Operations during the life of SRS have resulted in contamination migrating into groundwater at various site locations, 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.

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 used widely at SRS and is regarded as the current site 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, 1998]. Figure 7–1 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

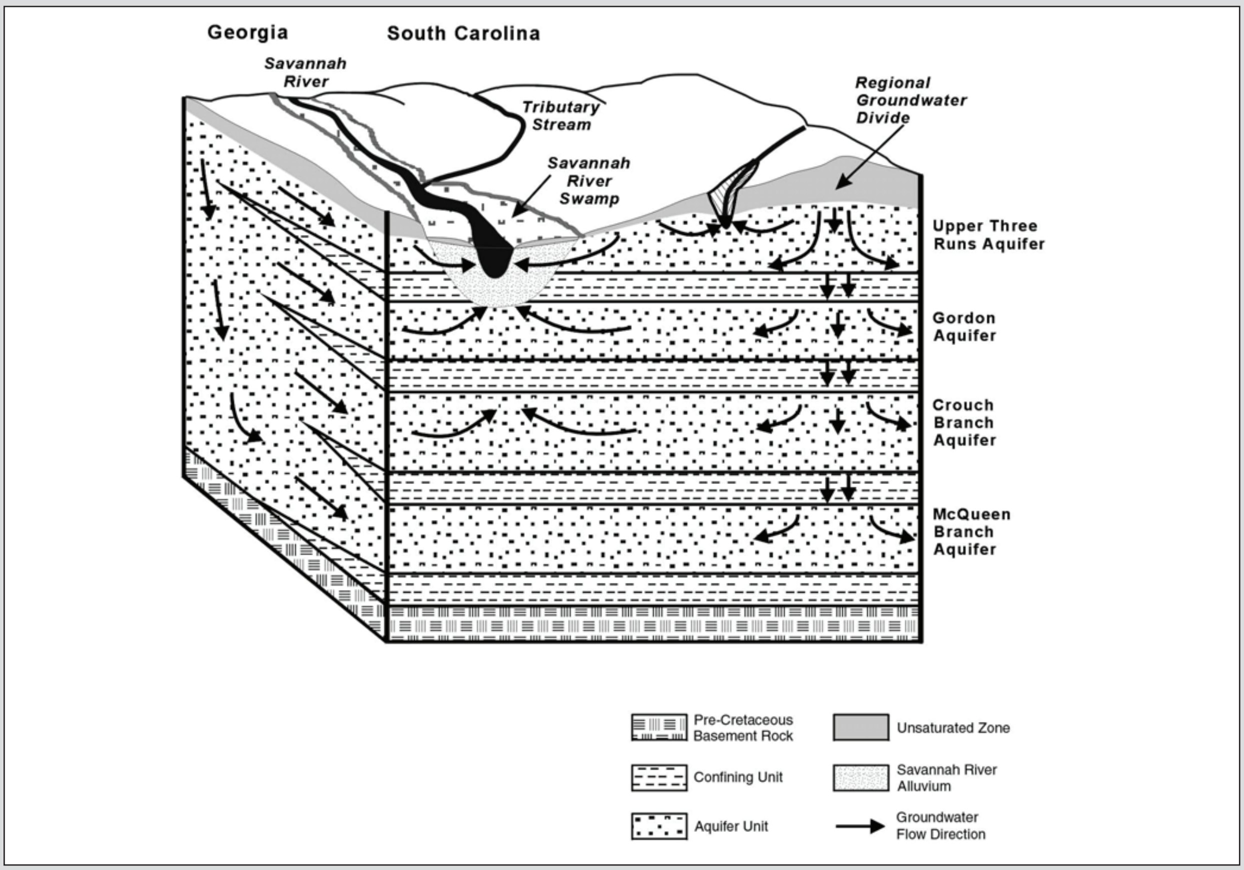


Modified from Aadland et al., 1995, and Fallaw and Price, 1995

Figure 7–1 Hydrostratigraphic Units at SRS

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 unit within which the water table usually occurs at SRS; hence, it is referred to informally as the "water table" aquifer. The water table surface can be as deep as 160 feet below ground surface (bgs), but intersects the ground surface in seeps along site streams. The top of the Gordon Aquifer typically is encountered at depths of 150–250 feet bgs. 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, 1998]. The top of the Crouch Branch Aquifer typically is encountered at depths of 350–500 feet bgs. The top of the McQueen's Branch Aquifer typically is encountered at depths of 650–750 feet bgs.

Figure 7–2 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. Maps of the potentiometric surfaces of these units are presented in figures 19–22 of the "Environmental Data/Maps - 2009" appendix on the CD accompanying this report.



Modified from Clarke and West, 1998

Figure 7–2 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. Additional information concerning hydraulic heads and flow directions may be found in figures 19–22 of the "Environmental Data/Maps - 2009" appendix on the CD accompanying this report.

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 major streams, such as Upper Three Runs or Fourmile Branch, or along the Savannah River itself. 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.

Monitoring wells are used extensively at SRS to assess the effects of site activities on groundwater quality. Most of the wells monitor the upper groundwater zone (see figure 7–1), although wells in lower zones are present at the sites with the larger groundwater contamination plumes. Groundwater in some areas contains one or more constituents at or above the levels of the drinking water standards of the U.S. Environmental Protection Agency (EPA). These areas can be seen in figure 18 of the "Environmental Data/Maps - 2009" appendix on the CD accompanying this report.

Groundwater Protection Program at SRS

The SRS groundwater protection program is designed to meet federal and state laws/regulations, DOE orders, and site policies/procedures. It contains the following elements:

- investigating site groundwater
- using site groundwater
- protecting site groundwater
- remediating contaminated site groundwater
- monitoring site groundwater

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 multifaceted program 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:

- collection of geologic core material and performance of seismic profiles to better delineate subsurface structural features
- installation of wells to allow periodic collection of both water levels and groundwater samples at strategic locations
- development of water table and potentiometric maps to delineate the direction of groundwater movement in the subsurface
- 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 SRS 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 are 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. Geophysical data 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 cores and install wells
- borehole flow-meters to measure ambient flow and hydraulic conductivity distributions along wells.

Models have been used extensively as analytical tools at SRS for both regional and local 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 process water supply from groundwater. SRS domestic and process water systems are supplied from a network of approximately 40 wells in widely scattered locations across the site, of which eight supply the primary drinking water system for the site (figure 14 in the “Environmental Data/Maps - 2009” appendix on the CD accompanying this report). In 1983, SRS began reporting its water usage annually to the South Carolina Water Resources Commission—and later to the South Carolina Department of Health and Environmental Control (SCDHEC). Since that time, the amount of groundwater pumped on site has dropped by more than two thirds—from 10.8 million gallons per day during 1983–1986 to 2.7 million gallons per day in 2009. 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 high-capacity supply wells, were consolidated into three systems located in A-Area, D-Area, and K-Area. This greatly reduced the amount of excess water being pumped to waste. Site facility shutdowns and reductions in population also were contributing factors.

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. The A-Area, D-Area, and K-Area systems supply an average of 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. SCDHEC periodically samples the large- and small-system wells for Safe Drinking Water Act contaminants. An unscheduled biannual SCDHEC sanitary survey also is performed.

The process water systems in A-Area, F-Area, H-Area, K-Area, L-Area, and S-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.

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 site's Area Completion Projects (ACP) organization

Monitoring around known waste disposal sites and operating facilities provides the best means to detect and track groundwater contamination. To detect contamination from as-yet undiscovered sites, SRS depends on a sitewide groundwater monitoring and protection effort—the site Groundwater Surveillance Monitoring Program (GSMP). This program is an upgraded replacement of the site screening program.

Monitoring wells and production wells are properly abandoned when no longer needed. A typical abandonment involves placing a smaller diameter pipe ("tremie pipe") near the bottom of the well and pumping cement grout through it until the well is full. This ensures that grout reaches the bottom of the well. SRS abandoned 160 wells in 2009; additional abandonments are planned for 2010.

One goal of the GSMP is to protect potential offsite receptors from contamination by detecting the contamination in time to apply appropriate corrective actions. SRS is a large site, and most groundwater contamination is located in its central areas. 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 flow in each aquifer and determined where there is potential for flow across the site boundary. This gives a conservative indication of where offsite contamination might be possible, and allows for a focused monitoring effort in those few areas. Another pathway for existing groundwater contamination to flow off site is by discharge into surface streams and subsequent transport into the Savannah River. SRS monitors site streams for contamination, and has installed wells along several site streams to (1) detect contamination before it enters the streams and (2) assess the contamination's concentration in groundwater.

The SRS groundwater monitoring program gathers information to determine the effects of site operations on groundwater quality. The program is designed to

- assist the site in complying with environmental regulations and DOE directives
- provide data to identify and monitor constituents in the groundwater
- provide data for evaluating new facility locations to ensure suitablity for the intended facilities
- support basic and applied research projects

The groundwater monitoring program at SRS includes two primary components: (1) waste site monitoring associated with remediation, overseen by the Geochemical Monitoring group of ACP, and (2) groundwater surveillance monitoring, conducted by the Environmental Protection Section. To assist other departments in meeting their responsibilities, personnel of both organizations provide the services for installing monitoring wells, collecting and analyzing samples, and reporting results.

Monitoring data are evaluated each year to identify unexpected results in any SRS wells that might indicate new or changing groundwater contamination.

Remediating Contaminated SRS Groundwater

SRS has maintained an environmental remediation effort for many years. ACP personnel manage the cleanup of contaminated groundwater associated with Resource Conservation and Recovery Act (RCRA) hazardous waste management facilities and other non-RCRA contamination sites specified in SRS's Federal Facility Agreement. Their mission is to aggressively manage the inactive waste site and groundwater cleanup program so that

- schedules for environmental agreements are consistently met

Sample Scheduling and Collection

The Geochemical Monitoring group and the Environmental Monitoring Services section schedule groundwater sampling either in response to specific requests from SRS personnel or as part of their ongoing groundwater monitoring program. Approximately 1,100 wells and numerous direct-push holes are sampled each year. Most of the wells are sampled semiannually, but many are sampled only annually. These groundwater samples provide data for reports required by federal and state regulations and for internal reports and research projects. The data are presented in spreadsheets on the attached CD, and fill approximately 200,000 lines.

Constituents that may be analyzed are commonly imposed by permit or work plan approval. These include metals, field parameters, and 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 each 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 prior to shipment to determine appropriate packaging and labeling requirements.

Deviations from scheduled sampling and analysis for 2009 (caused by dry wells, inoperative pumps, etc.) were entered into the site's groundwater database and issued in appropriate reports.

- the utilization of financial and technological resources is continually improved
- the overall risk posed by existing contaminated sites is continually reduced

The ACP strategy 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. Remedial technologies being used include pump and treat, in situ pH adjustment, steam injection, phytoremediation, and barrier wall construction. In cases where remediation to background quality is impractical, the intent is to prevent plume migration and exposure and to evaluate alternate methods of risk reduction.

Monitoring SRS Groundwater

The first priority of the groundwater monitoring program at SRS is to ensure that contamination is not being transported from the site by groundwater flow. Contaminated groundwater at SRS discharges into site streams or the Savannah River. Nowhere have offsite wells been contaminated by groundwater from SRS, and only a few site locations have groundwater with even a remote chance of contaminating such wells.

One of these locations is near A-Area/M-Area, the site of a large chlorinated solvent plume. This area's groundwater monitoring program uses more than 200 wells, and some of the contaminated wells lie within a half-mile of the site's northeastern boundary. While it is believed that the major component of groundwater flow is not directly toward the site boundary, flow in the area is complex and difficult to predict. For this reason, particular attention is paid to data from wells along the site boundary and from those between A-Area/M-Area and the nearest population center, Jackson, South Carolina (figure 23 in the "Environmental Data/Maps - 2009" appendix on the CD accompanying this report). Two of the JAX series wells showed trace amounts of acetone, and JAX–2LCB contained trace amounts of toluene. Well MSB 84A contained trace amounts of methyl chloride and 1,1,2-trichloro-1,2,2-trifluoroethane. Toluene and trichloroethylene (TCE) were detected at a depth of approximately 350 feet in well MSB 91TB. The concentration of TCE detected was 1.6 parts per billion.

Since the early 1990s, considerable effort has been directed at assessing the likelihood of transriver flow from South Carolina to Georgia, and 44 wells have been drilled by the USGS and the Georgia Department of Natural Resources (figure 24 in the "Environmental Data/Maps - 2009" appendix on the CD accompanying this report). Despite the fact that the USGS groundwater model indicates there is no mechanism by which transriver flow could contaminate Georgia wells [Cherry, 2006], SRS continues to maintain and sample the Georgia monitoring wells annually. In 2009, none of the tritium results exceeded 1,000 pCi/L. Levels this low are consistent with aquifer recharge from rainfall. EPA's maximum contaminant level for tritium is 20,000 pCi/L.

Although contaminated groundwater in most SRS areas does not approach the site boundary, it does have the potential to impact site streams. For this reason—and because of the need to meet the requirements of various environmental regulations—extensive monitoring is conducted around SRS waste sites and operating facilities, regardless of their proximity to the boundary.

All groundwater monitoring data for 2009 are included in the "2009 Groundwater Data" table on the CD accompanying this report. It would be impractical to provide maps of all wells; however, Universal Transverse Mercator (UTM) coordinates are provided. These coordinates can be used in conjunction with figure 25 in the "Environmental Data/Maps - 2009" appendix on the CD to find the approximate locations of the wells. Time-versus-concentrations plots for selected wells and analytes also can be viewed on the CD. The wells selected are from the large plumes at M Area, the F and H Area Seepage Basins and the Mixed Waste Management Facility. As the plots show, no generalizations can be made about concentration trends sitewide.

Contaminant plumes of particular interest are depicted in a series of maps in the "Environmental Data/Maps - 2009" appendix on the CD. Figures 26–31 depict the trichloroethylene plumes in aquifers beneath A and M Areas. Figures 32–34 depict the tritium plumes in aquifers beneath E, F, and H Areas. For details about monitoring and conditions at individual sites, one should refer to site-specific documents, such as RCRA corrective action reports or RCRA/Comprehensive Environmental Response, Compensation, and Liability Act and RCRA facility investigation/remedial investigation reports.

Quality Assurance

CHAPTER 8

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[During 2009, responsibility for the environmental Quality Assurance (QA) program continued to be divided among three groups—Environmental Monitoring Laboratory (EML), Environmental Monitoring (EM), and Data Management and Waste Engineering (DMWE).]

SRS's environmental QA program is conducted to verify the integrity of analyses determined by onsite and subcontracted offsite environmental laboratories, and to ensure that quality control program requirements are met. The program's objectives are to ensure that samples are representative of the surrounding environment, and that analytical results are accurate.

SRS and Environmental QA Programs Integration

The SRS comprehensive environmental QA program follows the QA requirements defined in the SRS Quality Assurance Manual (1Q) [SRS, 2008]. Each environmental organization has developed and implemented QA procedures that address these requirements. In addition, a Cognizant Quality Function (CQF) from the site's independent QA organization is assigned responsibility for environmental program oversight for each organization. The CQF periodically performs QA reviews and assessments on environmental programs to ensure compliance with site requirements. In addition, each organization assigns QA responsibilities to individuals to oversee daily QA activities for the organization. Results, improvement opportunities, and corrective actions that come from assessments and reviews are documented in the Site Tracking, Analysis and Reporting (STAR) system. Site environmental professionals periodically conduct QA self-assessments on specific environmental program activities. The results of these assessments are documented in STAR. Site management participates in the Management Field Observation process; the results from these reviews also are documented in STAR.

QA for EM Program Samples

Internal Quality Assurance Program

EM has a documented QA program that meets SRS and U.S. Department of Energy (DOE) requirements (3Q1–2 Volume III, "Quality Assurance Plan") [SRS EM Program, 2002b]. Based on data reviews, no QA issues or corrective actions were identified during 2009.

Laboratory Certification

EM is certified by the South Carolina Department of Health and Environmental Control (SCDHEC) Office of Laboratory Certification for field pH, temperature, total residual chlorine measurements, and low-level mercury sampling. Certification is renewed every three years; the current certification expires in June 2012.

Blind pH Samples

EM personnel routinely conduct blind sample analyses for field measurements of pH to assess the quality and reliability of field data measurements.

During 2009, two blind pH field measurements were taken monthly, for a total of 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. Blind pH sample results can be found in the data tables section of the CD accompanying this report ("Blind Sample Results for pH Field Measurements").

QA for EML Sample Analyses

Internal QA Program

EML has a documented QA program that meets SRS and DOE requirements [SRNS, 2009]. Analytical instrumentation includes liquid scintillation and gas flow proportional counters, alpha and gamma spectrometry, inductively coupled plasma atomic emission spectrometry (ICP–AES), inductively coupled plasma mass spectrometry (ICP–MS), flow injection mercury system (FIMS) and gas chromatography mass spectrometry (GC–MS). Analyses include tritium, carbon-14, nickel-63, gamma-emitting isotopes (cesium-137, cobalt-60, potassium-40, plus any other detected isotopes), iodine-129, strontium 89/90, strontium-90, americium-241, curium-244, neptunium-237, plutonium-238, plutonium-239, thorium-229, thorium-230, thorium-232, uranium-234, uranium-235, uranium-238, inorganic metals, mercury, and volatile organic compounds. Total suspended solids are determined gravimetrically. Instruments are calibrated with known reference standards. Instrument performance is monitored through the use of check standards and control charts. Analytical batch performance is measured through the use of quality control (QC) samples (blanks, spikes, carriers, tracers, laboratory control samples, and laboratory duplicates). QC results that fall outside of specified limits may result in analytical batch or sample reruns. For those batches or samples that fall outside of limits but for which the results are determined to be satisfactory, the reason is documented in the data package, which includes the QA cover sheet, instrument data printouts, and associated QC data.

Based on inspections of instrument records and analytical data packages, no corrective actions were identified during 2009.

Laboratory Certification

EML is certified by the SCDHEC Office of Laboratory Certification for analytical measurements using the following methods:

- total suspended solids (Standard Methods, 2540D), 27 metals by ICP–AES (EPA, 200.7), mercury by FIMS (EPA, 245.2),, and 18 metals by ICP–MS (EPA, 200.8)

- 42 volatile organic compounds by GC–MS (EPA, 8260B), 28 metals by ICP–AES (EPA, 6010C), mercury by FIMS (EPA, 7470A and 7471B), and 18 metals by ICP–MS (EPA, 6020A)

Certification is renewed every three years; the current certification expires in June 2012.

External QA Program

In 2009, EML participated in the DOE Mixed Analyte Performance Evaluation Program (MAPEP), an interlaboratory comparison program that tracks performance accuracy and tests the quality of environmental data reported to DOE. The Radiological and Environmental Sciences Laboratory (RESL), under the direction of DOE–Headquarters Environmental Safety and Health (ES&H), administers the MAPEP.

MAPEP samples include water, soil, air filter, and vegetation matrices with environmentally important stable inorganic, organic, and radioactive constituents.

In 2009, EML completed the analysis of 54 radioisotopes and 15 metals for MAPEP–20 (designation of a specific study set) and the analysis of 55 radioisotopes and 15 metals for MAPEP–21. Results show that the laboratory passed the 80-percent-acceptable-results level for the study set (table 8–1). The percentage was calculated by dividing the acceptable and the acceptable-with-warning results by the total number of results.

MAPEP intercomparison study results for EML can be found in the data tables section of the CD accompanying this report ("MAPEP Performance Study 20" and "MAPEP Performance Study 21"). The MAPEP information has been copied from the actual MAPEP final report; "NR" in the report stands for "not reported," which indicates that the laboratory did not submit data for that particular analysis. The Flag column is used to denote if a result is Acceptable (A), Not Acceptable (N),

Table 8–1
EML Performance on Mixed-Analyte Performance Evaluation Program (MAPEP)

Study Set	Matrix	EML
MAPEP–09–GrF20	Air Filter	100%
MAPEP–09–GrW20	Water	100%
MAPEP–09–MaS20	Solid	100%
MAPEP–09–MaW20	Water	100%
MAPEP–09–RdF20	Air Filter	100%
MAPEP–09–MaV20	Vegetation	100%
MAPEP–09–GrF21	Air Filter	100%
MAPEP–09–GrW21	Water	100%
MAPEP–09–MaS21	Solid	100%
MAPEP–09–MaW21	Water	100%
MAPEP–09–RdF21	Air Filter	100%
MAPEP–09–MaV21	Vegetation	100%

Warning (W), etc., and the Uncertainty (Unc) Flag column is used to note uncertainty values that may be High (H) or (L), etc..

QA for EM Sample Analyses

Onsite and subcontract environmental laboratories providing analytical services must have documented QA programs and meet the quality requirements defined in the SRS Quality Assurance Manual (1Q).

An annual DOE Consolidated Audit Program (DOECAP) evaluation of each subcontract laboratory is performed to ensure that all the laboratories maintain technical competence and follow the required QA programs. The 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. In 2009, evaluations were conducted at three laboratories, resulting in a total of 27 Priority II findings. A Priority II finding documents a deficiency that in and of itself does not represent a concern of sufficient magnitude to render the audited facility unacceptable to provide services to DOE. A report on the 2009 findings and recommendations was provided to each laboratory. For findings, each affected laboratory submitted corrective action responses, and the responses subsequently were reviewed. The findings typically are closed during the next laboratory audit (scheduled for 2010).

Evaluations were conducted at four laboratories in 2008, resulting in a total of 22 Priority II findings. Each laboratory submitted a corrective action response that addressed each finding. All 22 of the 2008 findings were reviewed and closed during 2009.

Nonradiological Liquid Effluents

National Pollutant Discharge Elimination System (NPDES) samples are analyzed by four onsite laboratory groups—EML, EM, D-Area Powerhouse, and the Waste Treatment Plant—and one offsite subcontract laboratory, Shealy Environmental Services, Inc. (SES). All these laboratories are certified by SCDHEC for NPDES analyses.

Interlaboratory Program

During 2009, all laboratories performing NPDES analyses for SRS participated in the SCDHEC-required proficiency testing studies, per State Regulation 61–81 ("State Environmental Laboratory Certification Program"). The former EPA-required annual NPDES Discharge Monitoring Report–Quality Assurance (DMR–QA) studies program was eliminated. EPA notified SCDHEC May 14 that it had granted SCDHEC's request for an exemption from the NPDES DMR–QA studies. It was determined that SCDHEC's proficiency testing program requirements provide adequate QA to replace EPA's DMR–QA study program. All laboratories utilized Environmental Resource Associates (ERA) as the accredited proficiency testing provider. ERA, as required by EPA, is accredited by the American Association of Laboratory Accreditation.

EPA and SCDHEC use the study results to certify laboratories for specific analyses. As part of the recertification process, these agencies require that laboratories investigate the unacceptable results and implement corrective actions as appropriate.

The onsite laboratories reported 30 proficiency testing results in 2009. One pH analysis was not acceptable on the initial study, but results were acceptable for the follow-up study. Therefore, state certification was maintained for all analyses during 2009.

The offsite laboratory reported 121 proficiency testing results in 2009. Two lead analyses and one copper analysis were not acceptable on the initial study, but results were acceptable for the follow-up study. Therefore, state certification was maintained for all analyses during 2009.

Interlaboratory program results can be found in the data tables section of the CD accompanying this report ("Discharge Monitoring Proficiency Testing Studies").

Intralaboratory Program

The environmental monitoring intralaboratory program reviews laboratory performance by analyzing field duplicate and blind samples throughout the year.

The onsite and offsite laboratories processed 64 field duplicate analyses during 2009. The relative-percent difference was equal to zero for 55 of these analyses. Only four of the 64 field duplicate analyses exceeded the relative-percent (20-percent) difference. The five remaining analysis results were between zero and 20 percent.

The onsite and offsite laboratories processed 73 blind analyses during 2009. The relative-percent difference was equal to zero for 54 of these analyses. Only four of the 73 blind analyses exceeded the relative percent (20-percent) difference. The 15 remaining results were between zero and 20 percent."

Results for the field duplicate and blind sampling programs indicated no consistent problems with the laboratories. Field duplicate and blind sample program results can be found in the data tables section of the CD accompanying this report ("NPDES Duplicate Sample Results" and "NPDES Blind Sample Results").

Stream and River Water Quality

SRS's water quality program requires checks of 10 percent of the samples to verify analytical results. Duplicate grab samples from SRS streams and the Savannah River were analyzed by SES and EML in 2009. SES and EML reported approximately 3,000 analyses for this program. Greater than 95 percent of the approximately 1,100 field duplicate results were within acceptable limits (< 20-percent difference). Results for the field duplicate sampling program indicated no consistent problems with the laboratories. Detailed stream and Savannah River field duplicate sample results can be found in the data tables section of the CD accompanying this report ("SRS Stream and Savannah River Water Quality Duplicate Sample Results").

QA for DMWE Sample Analyses

Groundwater analyses at SRS are performed by offsite (subcontract) and onsite laboratories. During 2009, General Engineering Laboratories (GEL) and TestAmerica, Inc., were the primary full-service subcontract laboratories used by Area Completion Projects (ACP). EML performed groundwater analyses for ACP during 2009. Eberline Services Oak Ridge Lab (radiological only) and Lionville Laboratory (nonradiological only) were subcontracted laboratories; however, no samples were sent to these laboratories for analysis in 2009 because their services were not required to support the site's sample analysis needs.

GEL and TestAmerica participated in various water pollution (WP) and water supply (WS) studies in 2009. The WP study results (table 8–2) show that the laboratories met or exceeded the 80-percent-acceptable-results level. The table reflects only the studies

Table 8–2
Subcontract-Laboratory Percent Acceptable Performance for Environmental Resource Associates (ERA) Water Pollution Studies

Study	General Engineering	TestAmerica
WS–149	100%	
WS–153		95.2% [j,k,v]
WS–155	100%	
WP–159		88.7% [l,m,n,p,r,s,w,y]
WP–168	98.5% [t]	98.4% [a,b,c,d,e,f,g,i,q]
WP–173		98.4% [g,h,o,u,y]
WP–174		98.7% [x]
WP-177	100%	

Results Not Acceptable

[a] Volatile Solids
[b] Nitrite as N
[c] COD
[d] trans-1,2-Dichloroethylene
[e] 2,4-DB
[f] Hexachlorocyclopentadiene
[g] Ethylbenzene
[h] Ortho-phosphate as P
[i] Xylenes, total
[j] tert-Butylbenzene
[k] trans-1,3-Dichloropropene
[l] cis-1,2-Dichloroethylene
[m] sec-Butylbenzene
[n] 2-Chlorotoluene
[o] Boron
[p] 1,1,1,2-Tetrachloroethane
[q] Toluene
[r] 1,2,3-Trichloropropane (TCP)
[s] 1,3,5-Trimethylbenzene
[t] 2,4 Dinitrotoluene
[u] Dichlorprop
[v] Bromoform
[w] 4-Isopropyltoluene
[x] Naphthalene
[y] 2,4-D

associated with contracted analyses performed for SRS.

Results from the subcontract-laboratory performance on MAPEP are summarized in table 8–3. The results show that all laboratories exceeded the 80-percent-acceptable-results level for all studies for the air filter, water, soil, and vegetation matrices.

To help participants identify, investigate, and resolve potential quality concerns, the MAPEP issues a letter of concern to a participating laboratory upon identification of a potential analytical data quality problem in the MAPEP results. Letters of concern have been issued since 1996, shortly after the beginning of the MAPEP program. A copy of the letter is sent to DOE/contractor oversight points of contact (POCs), including DOE Field Office and Headquarters POCs and contractor sample management POCs. Intended to be informative and not punitive, each letter states, "This letter is solely intended to alert your laboratory to a potential quality concern that you may wish to investigate for corrective action." Table 8–4 summarizes MAPEP concerns from 2009 for the primary full-service subcontracted laboratories. Eberline Services Oak Ridge Lab and Lionville Laboratory were under subcontracts for a portion of 2009; however, as indicated earlier, no samples were sent to these laboratories for analyses in 2009, and no letters of concern were issued to them for MAPEP–20 or MAPEP–21.

Soil/Sediment

Environmental investigations of soils and sediments, primarily for RCRA/Comprehensive Environmental Response, Compensation, and Liability Act units,

Table 8–3
Subcontract-Laboratory Performance on Mixed-Analyte Performance Evaluation Program (MAPEP)

Study	Matrix	General Engineering	TestAmerica
MAPEP–09–GrF20	Air Filter	100%	100%
MAPEP–09–GrF21	Air Filter	100%	100%
MAPEP–09–GrW20	Water	100%	100%
MAPEP–09–GrW21	Water	100%	100%
MAPEP–09–MaS20	Soil	98.4% [b,c]	99.2% [a]
MAPEP–09–MaS21	Soil	98.4% [d,e]	97.6% [f,g,h]
MAPEP–09–MaW20	Water	100%	100%
MAPEP–09–MaW21	Water	100%	100%
MAPEP–09–OrW20	Water	100%	95.9% [i,j,l]
MAPEP–09–OrW21	Water	100%	97.3% [n,o]
MAPEP–09–RdF20	Air Filter	100%	94.4%
MAPEP–09–RdF21	Air Filter	100%	100%
MAPEP–09–RdV20	Vegetation	100%	88.9% [k,m]
MAPEP–09–RdV21	Vegetation	100%	100%

Results Not Acceptable

[a] Selenium
[b] Technetium-99
[c] 2,4-Dimethylphenol
[d] Benzo(k)fluoranthene
[e] Endrin Aldehyde
[f] Uranium-235
[g] Uranium-238
[h] Total Uranium
[i] Chrysene
[j] Benzo(a)anthracene
[k] Zinc-65
[l] Hexachlorobenzene
[m] Cesium-137
[n] 4,4'-DDE
[o] 4,4'-DDT

are performed by subcontract laboratories. Data are validated by ACP according to EPA standards for analytical data quality, or as specified by SRS onsite customers.

The environmental validation program is based in part on two EPA guidance documents, "Guidance for the Data Quality Objectives Process for Superfund" [EPA, 1993] and "Systematic Planning: A Case Study for Hazardous Waste Site Investigations" (QA/CS–1) [EPA, 2006]. These documents identify QA issues to be addressed, but they do not formulate a procedure for data evaluation or provide pass/fail criteria to apply to data and document acceptance. Hence, the SRS validation program contains elements from—and is influenced by—several other references, including

- "Guidance on Environmental Data Verification and Data Validation" (QA/G–8) [EPA, 2002b]
- "USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review," [EPA, 1999b]

- "USEPA Contract Laboratory Program National Functional Guidelines for Chlorinated Dioxin/Furan Data Review," [EPA, 2005]
- "USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review," [EPA, 2004]
- "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," EPA, November 1986, SW–846, Third Edition; Latest Update, February 2008 [EPA, 2008f]
- "DOE Quality Systems for Analytical Services," Revision 2.4, October 2008 [DOE, 2008]
- "Analytical Data Qualification," ER–SOP–033, Revision 3 [SRNS, 2007]

Many QA parameters are evaluated by automated processing of electronically reported data. Others are selectively evaluated by manual inspection of associated analytical records. A summary of findings is presented in each project narrative or validation report prepared by DMWE personnel.

Data Review

The QA program's detailed data review for groundwater and soil/sediment analyses is described in WSRC–3Q1–2, Section 1100.

The following issues from 2009 were resolved and closed:

- incomplete record packages for validation are no longer a significant issue
- issues involving logic failures and omissions in electronically reported data have been satisfactorily resolved

The identification and resolution of quality and technical issues illustrates that, although laboratory procedures are well defined, analytical data quality does benefit from technical scrutiny.

Table 8–4
Subcontract-Laboratory Performance MAPEP Letters of Concern

General Engineering	TestAmerica
None	Cobalt-57 (MAPEP–20)
	Plutonium-239/240 (MAPEP–20)
	Zinc-65 (MAPEP–20)

APPENDIX A

Applicable Guidelines, Standards, and Regulations

Jack Mayer
Savannah River National Laboratory

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 5400.5, "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, and the National Emission Standards for Hazardous Air Pollutants (NESHAP)]; in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA—also known as 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).

SRS compliance with environmental requirements is assessed by the DOE–Savannah River Operations Office (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 (ICRP) in *Principles of Monitoring for the Radiation Protection of the Public*, ICRP Publication 43
- DOE Order 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 1100 (SRS Environmental Monitoring Program) of the SRS Environmental Monitoring Plans and Procedures, WSRC–3Q1–2, Volume 1. This document is reviewed annually and updated every 3 years.

SRS has implemented and adheres to the SRS Environmental Management System (EMS) Policy. Implementation of a formal EMS, such as that described in the International Organization for Standardization (ISO) 14001 standard, is an Executive Order 13148 ("Greening the Government Through Leadership in Environmental Management") and DOE Order 450.1A ("Environmental Protection Program") requirement. SRS maintains an EMS that fully meets the requirements of ISO 14001. The full text of the SRS EMS Policy appears on the CD accompanying this report.

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 ICRP publications 26 (Recommendations of the International Commission on Radiological Protection) and 30 (Limits for Intakes 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 beginning on page A-7.

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. Therefore, SCDHEC 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 also are cited in the permits issued by SCDHEC. The applicable SCDHEC regulations are too numerous to discuss here, so only the most significant are listed.

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 provided in table A–1.

A total of 258 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.

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 limit is 40 percent. For new sources constructed after this date, the opacity limit 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 depend 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 began after December 31, 1985, the opacity limit is 20 percent.

As previously noted, 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 apply. 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.

Because these units were constructed after applicability dates found in both regulations, the opacity limit for the units is the same in both regulations. The emissions standards for these boilers are presented in table A–3.

In September 2008, a new steam facility that uses a smaller, less polluting, biomass boiler and a backup oil-fired boiler replaced the old coal-fired boilers that had operated previously in A-Area. This new facility (i.e., Building 784–7A) complies with 40 CFR 63, Subpart DDDDD standards. Both particulate and sulfur dioxide emissions at the new facility are projected to be considerably lower than at the existing coal-fired facility. The emission standards for these two new boilers are presented in tables A–4 and A–5.

(Process) Liquid Effluent Discharges

DOE Order 5400.5 establishes DCGs for radionuclides in process effluents. (DCGs for radionuclides in liquid are discussed in more detail on page A-8.) 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

Table A–1
National Ambient Air Quality Standards for Criteria Air Pollutants - 2009

	Primary Standards		Secondary Standards	
Pollutant	**Level**	**Averaging Time**	**Level**	**Averaging Time**
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour[a]		None
	35 ppm (40 mg/m^3)	1-hour[a]		
Lead	0.15 µg/m^3 [b]	Rolling 3-Month Average	Same as Primary	
1.5 µg/m^3	Quarterly Average		Same as Primary	
Nitrogen Dioxide	53 ppb[c]	Annual (Arithmetic Average)	Same as Primary	
	100 ppb	1-hour [d]		None
Particulate Matter (PM_{10})	150 µg/m^3	24-hour[e]	Same as Primary	
Particulate Matter ($PM_{2,5}$)	15.0 µg/m^3	Annual [f] (Arithmetic Average)	Same as Primary	
	35 µg/m^3	24-hour[g]	Same as Primary	
Ozone	0.075 ppm (2008 std)	8-hour[h]	Same as Primary	
	0.08 ppm (1997 std)	8-hour[i]	Same as Primary	
	0.12 ppm	1-hour[j]	Same as Primary	
Sulfur Dioxide	0.03 ppm	Annual (Arithmetic Average)	0.5 ppm	3-hour[a]
	0.14 ppm	24-hour[a]		

[a] Not to be exceeded more than once per year

[b] Final rule signed October 15, 2008

[c] The official level of the annual NO_2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard.

[d] To attain this standard, the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 100 ppb (effective January 22, 2010).

[e] Not to be exceeded more than once per year on average over 3 years

[f] To attain this standard, the 3-year average of the weighted annual mean PM2.5 concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m3.

[g] To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m3 (effective December 17, 2006).

[h] To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm (effective May 27, 2008).

[i] [1] To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.
[2] The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as EPA undertakes rulemaking to address transition from the 1997 ozone standard to the 2008 ozone standard.
[3] EPA is in the process of reconsidering these standards (set in March 2008).

[j] [1] EPA revoked the 1-hour ozone standard in all areas, although some areas have continuing obligations under that standard (“anti-backsliding”).
[2] The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is < 1.

Table A–2
Airborne Emission Limits for SRS Coal-Fired Boilers

Sulfur Dioxide	3.5 lb/10^6 Btu[a,b]
Total Suspended Particulates	0.6 lb/10^6 Btu[a,b]
Opacity	40%

[a] British thermal unit
[b] Heat input per hour

- 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.

Four NPDES permits are in place that allow SRS to discharge water into site streams and the Savannah River: two industrial wastewater permits (SC0047431 and SC0000175) 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 803–898–3882.

Site Streams

SRS streams are classified as "Freshwaters" by South Carolina Regulation 61–69, "Classified Waters." Freshwaters are defined in Regulation 61–68, "Water Classifications and Standards," 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 the survival and propagation of a balanced indigenous aquatic community of fauna and flora
- industrial and agricultural uses

Table A–6 provides some of the specific South Carolina freshwater standards used in water quality surveillance, but because some of these standards 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 South Carolina Regulation 61–69 as a freshwater system, the river is regulated in the same manner as site streams (table A–6).

Drinking Water

The federal Safe Drinking Water Act—enacted in 1974 to protect public drinking water supplies—was amended in 1977, 1979, 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).

Table A–3
Airborne Emission Limits for SRS Fuel Oil-Fired Package Boilers

Sulfur Dioxide	0.5 lb/10^6 Btu[a,b]
Total Suspended Particulates	0.6 lb/10^6 Btu[a,b]
Opacity	20%

[a] British thermal unit
[b] Heat input per hour

Table A–4
Airborne Emission Limits for SRS 784–7A Biomass Boiler

Sulfur Dioxide	0.5 lb/10^6 Btu[a,b]
Total Suspended Particulates	0.6 lb/10^6 Btu[a,b]
Nitrogen Oxides	0.33 lb/10^6 Btu[a,b]
Opacity	20%

[a] British thermal unit
[b] Heat input per hour

SRS drinking water is supplied to most site areas by the A-Area, D-Area, and K-Area systems, which are actively regulated by SCDHEC. Remote facilities—such as field laboratories, barricades, and pumphouses—utilize bottled water for drinking, and receive a lesser degree of regulatory oversite.

Bacteriological samples are collected and analyzed monthly or quarterly at an onsite laboratory. SCDHEC personnel periodically collect and analyze chemical and organics samples from the A-Area, D-Area, and K-Area systems. Lead and copper compliance samples are collected every 3 years from these systems. All sample results in 2009 met SCDHEC water quality standards

Groundwater

Groundwater is a valuable resource and is the subject of both protection and cleanup programs at SRS. More than 1,000 wells are monitored each year at the site for a wide range of constituents. Monitoring in the groundwater protection program is performed to detect new or unknown contamination across the site, and monitoring in the groundwater cleanup program is performed to meet the requirements of state and federal laws and regulations. Most of the monitoring in the cleanup program is governed by SCDHEC's administration of RCRA regulations.

The analytical results of samples taken from SRS monitoring wells are compared to various standards. The most common are final federal primary drinking water standards (DWS)—or other standards if DWS do not exist. The DWS are considered first because groundwater aquifers are defined as potential drinking water sources by the South Carolina Pollution Control Act. DWS can be found at http://www.epa.gov/safewater/standards.html on the Internet. Other standards sometimes are applied by regulatory agencies to the SRS waste units under their jurisdiction. For example, standards under RCRA can include DWS, groundwater protection standards, background levels, or alternate concentration limits.

SRS responses to groundwater analytical results require careful evaluation of the data and relevant standards. Results from two constituents having DWS—dichloromethane and bis (2–ethylhexyl) phthalate—are evaluated more closely than other constituents and are commonly dismissed. 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 detailed groundwater monitoring results that can be obtained by contacting the Savannah River Nuclear Solutions (SRNS) Environmental Monitoring group's manager at 803–952–8247. Also, the SCDHEC standard used for lead is 50 µg/L. The federal standard of 15 µg/L is a treatment standard for drinking water at the consumer's tap.

The regulatory standards for radionuclide discharges

Table A–5
Airborne Emission Limits for SRS 784–7A Oil-Fired Package Boiler

Sulfur Dioxide	3.5 lb/10^6 Btu[a,b]
Sulfur Dioxide	0.5% Sulfur
Total Suspended Particulates	0.6 lb/10^6 Btu[a,b]
Total Suspended Particulates	0.03 lb/10^6 Btu[a,b]
Nitrogen Dioxide	0.15 lb/10^6 Btu[a,b]
Opacity	20%

[a] British thermal unit
[b] Heat input per hour

Table A–6
South Carolina Water Quality Standards for Freshwaters[a]

Parameters	Standards
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
pH	Range between 6.0 and 8.5
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 more details, see E.12, Regulation 61–68, "Water Classifi cations and Standards" (April 25, 2008)
Dissolved oxygen	Daily average not less than 5.0 mg/L, with a low of 4.0 mg/L
Garbage, cinders, ashes, sludge, or other refuse	None allowed
Treated wastes, toxic wastes, deleterious substances, colored or other wastes, except in the parameter immediately above	None alone or in combination with other substances of 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
Toxic pollutants listed in South Carolina Regulation 61–68, "Water Classifications and Standards"	See Appendix: Water Quality Numeric Criteria for the Protection of Aquatic Life and Human Health, Regulation 61–68, "Water Classifications and Standards" (April 25, 2008)

SOURCE: SCDHEC, 2008

[a] This is a partial list of water quality standards for freshwaters.

from industrial and governmental facilities are set under the Clean Water Act and under Nuclear Regulatory Commission and DOE regulations. In addition, radionuclide cleanup levels, which fall under the authority of DOE, are included in the site RCRA permit. The proposed drinking water maximum contaminant levels (MCLs) discussed in this report are only an adjunct to these release restrictions and are not used to regulate SRS groundwater.

Many potential radionuclide contaminants are beta emitters. 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 considered is the activity per liter that would, if only that isotope were present, exceed the dose equivalent. Similarly, the standards for alpha emitters are calculated to present the same risk at the same rate of ingestion.

The element radium has several isotopes of concern in groundwater monitoring. Although radium has a DWS of 5 pCi/L for the sum of radium-226 and radium-228, the isotopes have to be measured separately, and the combined numbers may not be representative of the total. 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 commonly used as indicators of potential contamination in wells.

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 120 mg/L
- total dissolved solids (TDS) at values equal to or greater than 500 mg/L
- pH at values equal to or less than 6.5 or equal to or greater than 8.5

The selection of these values as standards for comparison is somewhat arbitrary; however, the 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 also may indicate leaching of the grouting material used in well construction, rather than degradation of the groundwater.

Potential Doses

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 Pathway ....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.

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 total body or organ 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 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 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. Because of security controls and the considerable distances between most SRS operating facilities and the site boundary, this scenario is highly improbable, if not impossible.

For each SRS facility that releases radioactivity, the site's Environmental Monitoring group 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 established a National Priority List of sites targeted for assessment and, if necessary, corrective/remedial action. SRS was placed on this list December 21, 1989 [EPA, 1989]. In August 1993, SRS entered into the Federal Facility Agreement (FFA) [FFA, 1993] 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 Site Area Completion Projects. The disposition process is conducted in accordance with DOE Order 430.1B, "Real Property Asset Management," and its associated guidance documents. The major emphases are reducing risks to workers and the public and minimizing real property asset lifecycle costs..

Quality Assurance/Quality Control

DOE Order 414.1C, "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, the previous site management and operations contractor, Washington Savannah River Company (WSRC), developed its Quality Assurance Management Plan, Rev. 21 (WSRC–RP–92–225). The plan's requirements are implemented by the WSRC Quality Assurance Manual (WSRC 1Q).

The SRS Environmental Monitoring Section Quality Assurance Program (WSRC–3Q1–2, Volume 3, Section 8200), was written to apply the QA requirements of WSRC 1Q to the environmental monitoring and surveillance program. The WSRC–3Q1 series includes procedures on sampling, radiochemistry, and water quality that emphasize the quality control requirements for the Environmental Monitoring group.

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 for Radionuclides (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 Retention Schedule Matrix (WSRC–EM–96–00023).

Environmental Monitoring group assessments are implemented according to the following documents:

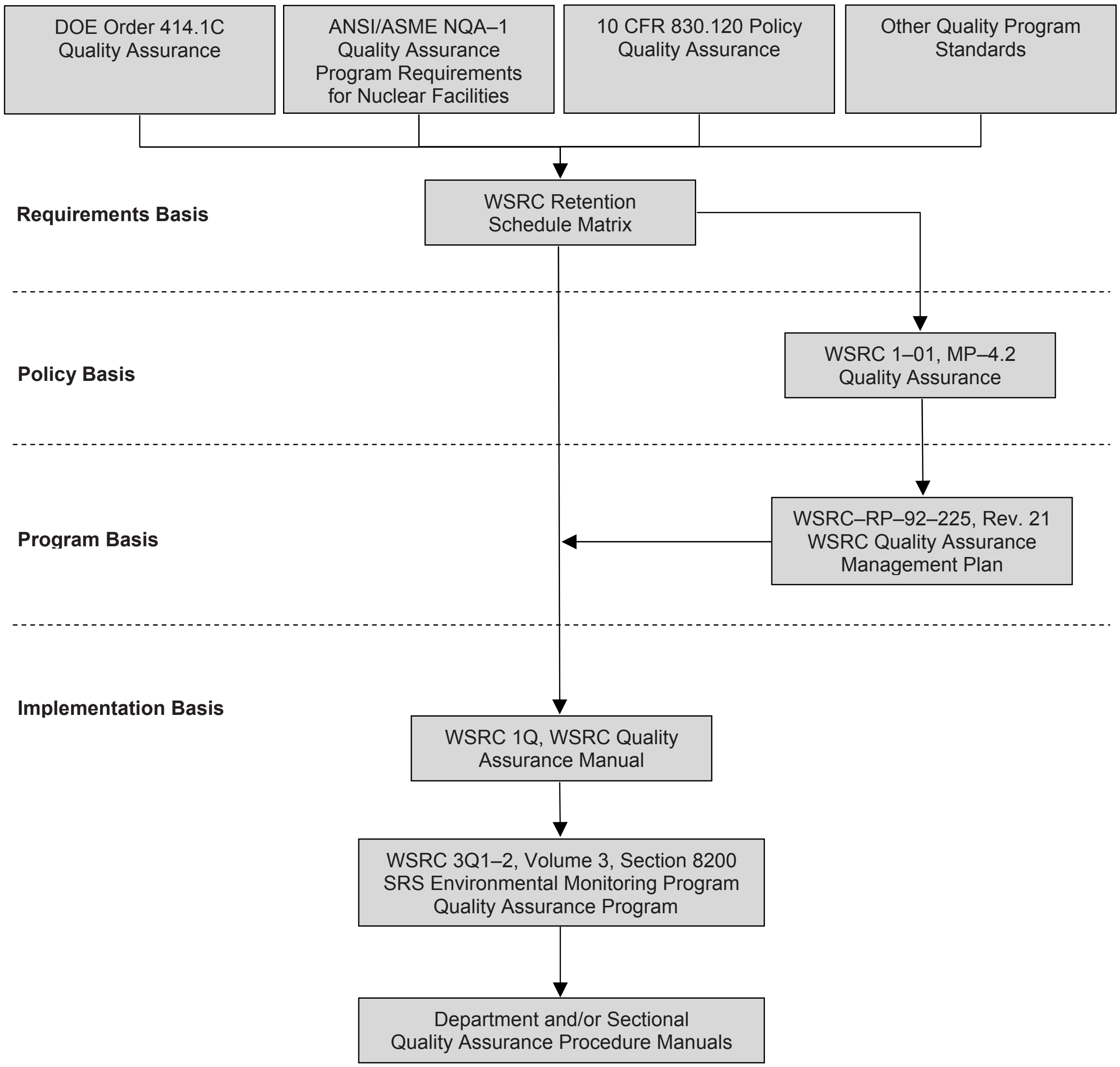
- DOE Order 414.1C
- DOE/EH–0173T
- DOE Environmental Management Consolidated Audit Program (EMCAP)
- WSRC 1Q, Quality Assurance Manual
- WSRC 12Q, Assessment Manual

Figure A–1 illustrates the hierarchy of relevant guidance documents that support the SRS QA program.

Reporting

DOE Orders 231.1A, "Environment, Safety and Health Reporting," and 5400.5, "Radiation Protection of the Public and Environment," require that SRS submit an annual environmental report.

This report, the *SRS Environmental Report for 2009*, is an overview of effluent monitoring and environmental surveillance activities conducted on and in the vicinity of SRS from January 1 through December 31, 2009.



References to the standards, guidance, and documents cited in this figure can be found in WSRC, 2008 (see References, page R-3).

Figure A–1 SRS EM Program QA Document Hierarchy
This diagram depicts the hierarchy of relevant guidance and supporting documents for the SRS QA program.

Radionuclide and Chemical Nomenclature

APPENDIX B

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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	Iodine-129	I-129	1.57E7 y
Americium-241	Am-241	432.7 y	Iodine-131	I-131	8.020 d
Americium-243	Am-243	7.37E3 y	Iodine-133	I-133	20.8 h
Antimony-124	Sb-124	60.20 d	Krypton-85	Kr-85	10.76 y
Antimony-125	Sb-125	2.758 y	Lead-212	Pb-212	10.64 h
Argon-39	Ar-39	269 y	Lead-214	Pb-214	27 m
Barium-133	Ba-133	10.53 y	Manganese-54	Mn-54	312.1 d
Beryllium-7	Be-7	53.3 d	Mercury-203	Hg-203	46.61 d
Bismuth-212	Bi-212	1.009 h	Neptunium-237	Np-237	2.14E6 y
Bismuth-214	Bi-214	19.9 m	Neptunium-239	Np-239	2.355 d
Carbon-14	C-14	5715 y	Nickel-59	Ni-59	7.6E4 y
Cerium-141	Ce-141	32.50 d	Nickel-63	Ni-63	101 y
Cerium-144	Ce-144	284.6 d	Niobium-94	Nb-94	2.0E4 y
Cesium-134	Cs-134	2.065 y	Niobium-95	Nb-95	34.99 d
Cesium-137	Cs-137	30.07 y	Plutonium-238	Pu-238	87.7 y
Chromium-51	Cr-51	27.702 d	Plutonium-239	Pu-239	2.41E4 y
Cobalt-57	Co-57	271.8 d	Plutonium-240	Pu-240	6.56E3 y
Cobalt-58	Co-58	70.88 d	Plutonium-241	Pu-241	14.4 y
Cobalt-60	Co-60	5.271 y	Plutonium-242	Pu-242	3.75E5 y
Curium-242	Cm-242	162.8 d	Potassium-40	K-40	1.27E9 y
Curium-244	Cm-244	18.1 y	Praseodymium-144	Pr-144	17.28 m
Curium-245	Cm-245	8.5E3 y	Praseodymium-144m	Pr-144m	7.2 m
Curium-246	Cm-246	4.76E3 y	Promethium-147	Pm-147	2.6234 y
Europium-152	Eu-152	13.54 y	Protactinium-231	Pa-231	3.28E4 y
Europium-154	Eu-154	8.593 y	Protactinium-233	Pa-233	26.967 d
Europium-155	Eu-155	4.75 y	Protactinium-234	Pa-234	6.69 h

[a] m = minute; h = hour; d = day; y = year

[b] Reference: Chart of the Nuclides, 16th edition, revised 2002, Lockheed Martin Company

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Nomenclature and Half-Life for Radionuclides (cont.)

Radionuclide	Symbol	Half-life[a,b]	Radionuclide	Symbol	Half-life[a,b]
Radium-226	Ra-226	1599 y	Thorium-234	Th-234	24.10 d
Radium-228	Ra-228	5.76 y	Tin-113	Sn-113	115.1 d
Ruthenium-103	Ru-103	39.27 d	Tin-126	Sn-126	2.3E5 y
Ruthenium-106	Ru-106	1.020 y	Tritium (Hydrogen-3)	H-3	12.32 y
Selenium-75	Se-75	119.78 d	Uranium-232	U-232	69.8 y
Selenium-79	Se-79	2.9E5 y	Uranium-233	U-233	1.592E5 y
Sodium-22	Na-22	2.604 y	Uranium-234	U-234	2.46E5 y
Strontium-89	Sr-89	50.52 d	Uranium-235	U-235	7.04E8 y
Strontium-90	Sr-90	28.78 y	Uranium-236	U-236	2.342E7 y
Technetium-99	Tc-99	2.13E5 y	Uranium-238	U-238	4.47E9 y
Thallium-208	Tl-208	3.053 m	Xenon-135	Xe-135	9.10 h
Thorium-228	Th-228	1.912 y	Zinc-65	Zn-65	243.8 d
Thorium-230	Th-230	7.54E4 y	Zirconium-85	Zr-85	7.9 m
Thorium-232	Th-232	1.40E10 y	Zirconium-95	Zr-95	64.02 d

[a] m = minute; h = hour; d = day; y = year
[b] Reference: Chart of the Nuclides, 16th edition, revised 2002, Lockheed Martin Company

APPENDIX C

Errata

The following entry corrects information that was reported inaccurately in the *Savannah River Site Environmental Report for 2008* (WSRC–STI–2009–00190):

- **A reference in the Errata section** correcting two inaccurate values from the 2007 environmental report indicated that "the Cm-224 release value was entered as 1.49E-60 curies; the correct value is 1.49E-06 curies." The reference should have been to Cm-242.

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 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 - A sample that has not been exposed to the sample stream in order to monitor contamination during sampling, transport, storage, or analysis. The blank is subjected to the usual analytical and measurement process to establish a zero-baseline or

-background value, and sometimes is used to adjust or correct routine analytical results.

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 Services 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 - A subsample for analysis with a composition known to the submitter. The analyst/ laboratory may know the identity of the sample, but not its composition. It is used to test the analyst's or laboratory's proficiency in the execution of the measurement process.

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 water.

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.

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 - Six common air pollutants found all over the United States. They are particle pollution (often referred to as particulate matter), ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, and lead. EPA is required by the Clean Air Act to set National Ambient Air Quality Standards for these six pollutants.

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 x 10^{4} disintegrations per second.

picocurie (pCi) - 10^{-12} Ci, one-trillionth of a curie; 0.037 disintegrations per second.

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 - A blend of more than one portion to be used as a sample for analysis.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) - This act addresses the cleanup of hazardous substances and establishes a National Priority List of sites targeted for assessment and, if necessary, restoration (commonly known as "Superfund").

cross talk - The fraction of all recorded pulses from alpha particles that are recorded in the beta channel due to degradation in their pulse height or the fraction of all recorded pulses from beta particles that are recorded in the alpha channel due to pulse pileup or other phenomenon.

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.

decommissioning and demolition - 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 U.S. 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 U.S. 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 = 0.01 Gy).

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 U.S. 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 the U.S. Environmental Protection Agency.

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 purpose of characterizing and quantifying the release of contaminants, assessing radiation exposures of members to 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 - U.S. 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 U.S. Department of Energy sites and their environs and the measurement of external radiation for purpose of demonstrating compliance with applicable standards, assessing radiation exposures to members of the public, and assessing effects, if any, on the local environment.

exception (formerly "exceedence") - Term used by the U.S. 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 the exposure to ionizing radiation that 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 U.S. Department of Energy, the U.S. 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 site waste units identified for evaluation and, if necessary, cleanup.

feral hog - Hog that has reverted to the wild state from domestication.

field duplicates - Independent samples collected as closely as possible to the same point in space and time. They are two separate samples taken from the same source, stored in separate containers, and analyzed independently.

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 column's surface. Process is reversible so that trapped ions are removed (eluted) from column and 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 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.

laboratory control sample - A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It generally is used to establish intralaboratory or analyst-specific precision and bias, or to assess the performance of all or a portion of the measurement system.

laboratory duplicate - Aliquot of a sample taken from the same container under laboratory conditions and processed and analyzed independently.

legacy - Anything handed down from the past; inheritance, as of nuclear waste.

lower limit of detection - Smallest concentration/amount of an 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 U.S. 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.

maximum contaminant level - The maximum allowable concentration of a drinking water contaminant as legislated through the Safe Drinking Water Act

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 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, pH < 7; basic solutions, pH > 7; and neutral solutions, 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 at 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 essentially are simultaneous to 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 Savannah River 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 x the radiation quality factor). Dose equivalent frequently is reported in units of millirem (mrem), which is one-thousandth of a rem.

remediation - Assessment and cleanup of U.S. 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 Services 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 that subsequently is discharged.

sievert - The International System of Units (SI)-derived unit of dose equivalent. It attempts to reflect the biological effects of radiation as opposed to the physical aspects, which are characterized by the absorbed dose, measured in gray. One sievert is equal to 100 rem.

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, to a blank sample, of a known amount of reference material containing the analyte of interest.

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; they consist of inorganic salts, small amounts of organic matter, and dissolved materials.

total phosphorus - May occasionally stimulate excessive or nuisance growths of algae and other aquatic plants when concentrations exceed 25 mg/L at the time of the spring turnover on a volume-weighted basis in lakes or reservoirs.

total suspended particulates - Refers to the concentration of particulates in suspension in the air, regardless of the nature, source, or size of the particulates.

transport pathway - Pathway by which a released contaminant is transported physically 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, methyl alcohol).

W

waste management - The U.S. Department of Energy uses this term to refer to the safe, effective management of various kinds of nonhazardous, hazardous, and radioactive waste generated at Savannah River Site.

waste unit - An inactive area known to have received contamination or to have had a release to the environment.

water table - Planar, underground surface beneath which earth materials, such 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).

wetland - 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 wind direction and speed 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		*Rate*	
d	day	cfs	cubic feet per second
h	hour	gpm	gallons per minute
y	year		
Length		*Conductivity*	
cm	centimeter	µmho	micromho
ft	foot		
in	inch		
km	kilometer	*Radioactivity*	
m	meter	Ci	curie
mm	millimeter	cpm	counts per minute
µm	micrometer	mCi	millicurie
Mass		µCi	microcurie
g	gram	pCi	picocurie
kg	kilogram	Bq	becquerel
mg	milligram		
µg	microgram	*Radiation Dose*	
Area		mrad	millirad
mi^2	square mile	mrem	millirem
ft^2	square foot	Sv	sievert
Volume		mSv	millisievert
gal	gallon	µSv	microsievert
L	liter	R	roentgen
mL	milliliter	mR	milliroentgen
		µR	microroentgen
		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)