

 Savannah River Site

Environmental Report for 2016

Front Cover—Rainbow Bay at the Savannah River Site. Inset photographs are marbled salamanders (top) and a green tree frog (bottom). *Photographs are courtesy of David Scott of the University of Georgia's Savannah River Ecology Laboratory.*

Back Cover—The Savannah River, which divides South Carolina and Georgia. *Photograph courtesy of SRNS Corporate Communications.*

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or go to the SRS Environmental Report webpage at
<http://www.srs.gov/general/pubs/ERsum/index.html>
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Environmental Report for 2016

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The magnolia tree behind the team was planted in observance of Earth Day.

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To Our Readers

Highlights

The U.S. Department of Energy (DOE) Order 231.1B (Environment, Safety, and Health Reporting) requires Annual Site Environmental Reports to assess field environmental program performance, site-wide environmental monitoring and surveillance effectiveness, and to confirm sites are complying with environmental standards and requirements.

Annual Site Environmental Reports are prepared in a manner that addresses likely public concerns and to solicit feedback from the public and other stakeholders. Savannah River Site (SRS) began publishing Annual Site Environmental Reports in 1959.

Readers can find the SRS Annual Environmental Report on the World Wide Web at the following address:

<http://www.srs.gov/general/pubs/ERsum/index.html>

The Savannah River Site Environmental Report for calendar year 2016 is an overview of environmental management activities conducted on and in the vicinity of the SRS from January 1 through December 31, 2016. This report includes the following:

- A summary of implemented environmental management systems that facilitate sound stewardship practices, as well as the compliance with applicable environmental regulations and laws intended to protect air, water, land, and other natural and cultural resources that SRS operations have impacted.
- A summary of the results of nonradiological parameters. These results are compared to permit limits and applicable standards.
- A summary of the results of effluent monitoring and environmental surveillance of air, water, soil, vegetation, biota, and agricultural products to determine radioactivity in these media. SRS compares the results with historical data and background measurements, and to applicable standards and requirements in order to verify that SRS does not adversely impact the environment or the health of humans or biota.
- A discussion of the potential doses to members of the public from radioactive releases from SRS operations compared to applicable standards and regulations, and from special-case exposure scenarios.
- An explanation of the quality assurance and quality control program, which ensures that samples and data SRS collects and analyzes are reported with utmost confidence.

The report addresses three general levels of reader interest:

- 1) The first is a brief summary with a “take-home” conclusion. This is presented in the “Highlights” text box at the beginning of each chapter. There are no technical tables, figures, or graphs in the “Highlights.”
- 2) The second level is a more in-depth discussion with figures, summary tables, and summary graphs accompanying the text. The chapters of the annual report represent this level, which requires some familiarity with scientific data and graphs.
- 3) The third level includes links to supplemental and technical reports and websites that support the annual report. The links to these reports may be found in the chapters or on the SRS Annual Environmental Report webpage. Many of the reports mentioned in Chapter 3, *Compliance Summary*, are submitted to meet compliance requirements and are not available on the SRS Annual Environmental Report webpage or through direct links. These reports may be obtained through a Freedom of Information Act request.

The SRS Environmental Report webpage contains reports from multiple years with the 2016 report being the latest. The report folders feature:

- The full report with hyperlinks to all supplemental information or reports.
- Maps with environmental sampling locations for the various media samples. These figures are identified as “Maps Figure” within the text of the report.
- Annual reports from other SRS organizations.

Savannah River Nuclear Solutions (SRNS), LLC develops this report as the Management & Operations contractor to the Department of Energy for SRS. In addition to SRNS, the contributors to the annual report include Savannah River Remediation (SRR), LLC; Parsons Government Services; U.S. Department of Energy, Savannah River Operations Office (DOE-SR); Chicago Bridge & Iron Areva MOX Services, LLC; Centerra-SRS; Ameresco Federal Solutions, Inc.; Savannah River Ecology Laboratory (SREL); and U.S. Forest Service-Savannah River (USFS-SR). Links to their websites may be found on pages 1–4 through 1–6 of this report.

The SRS Annual Environmental Report is available on the World Wide Web at the following address:

<http://www.srs.gov/general/pubs/ERsum/index.html>

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Acronyms and Abbreviations

A

ARP	Actinide
ASME	American Society of Mechanical Engineers

B

BCF	Biomass Cogeneration Facility
BJWSA	Beaufort-Jasper Water & Sewer Authority
BLLDF	Barnwell Low-Level Disposal Facility

C

C&D	Construction and Demolition
CA	Composite Analysis
CAA	Clean Air Act
CB&I	Chicago Bridge & Iron Company N.V.
CEI	Compliance Evaluation Inspection
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMIP	Coupled Model Intercomparison Project
CMP	Chemicals, Metals, and Pesticides
COC	Contaminant of Concern
CX	Categorical Exclusion
CWA	Clean Water Act
CY	Calendar Year

D

DCS	Derived Concentration Standard
DOE	United States Department of Energy
DOE-SR	United States Department of Energy-Savannah River Operations Office
DOECAP	DOE Consolidated Audit Program
DWPF	Defense Waste Processing Facility

E

EA	Environmental Assessment
ECHO	Enforcement and Compliance History Online
EDAM	Environmental Dose Assessment Manual
EEC	Environmental Evaluation Checklist
EIS	Environmental Impact Statement
EM	Environmental Management
EMS	Environmental Management System
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPEAT	Electronic Product Environmental Assessment Tool
EPP	Environmentally Preferable Purchasing
ERPP	Environmental Radiological Protection Program
ESA	Endangered Species Act
ESPC	Energy Saving Performance Contracts
ETP	Effluent Treatment Project

F

FERC	Federal Energy Regulatory Commission
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FFA	Federal Facility Agreement
FFCA	Federal Facility Compliance Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FONSI	Finding of No Significant Impact
FTF	F-Tank Farm
FY	Fiscal Year

G

GA	Georgia
GHG	Greenhouse Gas
GTCC	Greater-Than-Class C
GWPS	Groundwater Protection Standard

H

HLW	High-Level Waste
HVAC	Heating, Ventilation, and Air Conditioning
HWMF	Hazardous Waste Management Facility

I

I&D	Industrial and Domestic
ICRP	International Commission on Radiological Protection
IMNM	Interim Management of Nuclear Materials
ISO	International Organization for Standardization
ISMS	Integrated Safety Management System

L

LED	Light-Emitting Diode
LEU	Low-Enriched Uranium
LLRW	Low-Level Radioactive Waste

M

MACT	Maximum Achievable Control Technology
MAPEP	Mixed Analyte Performance Evaluation Program
MBTA	Migratory Bird Treaty Act
MCL	Maximum Contaminant Level
MCU	Modular Caustic Side Solvent Extraction Unit
MDC	Minimum Detectable Concentration
MDN	Mercury Deposition Network
MEI	Maximally Exposed Individual
MFFF	Mixed Oxide Fuel Fabrication Facility
MOX	Mixed Oxide
MWMF	Mixed Waste Management Facility
Mrem	Millirem

N

NADP	National Atmospheric Deposition Program
NA-MRF	North Augusta, SC Material Recovery Facility
NDAA	National Defense Authorization Act
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act

NNSA	National Nuclear Security Administration
NOAV	Notices of Alleged Violation
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NQA	Nuclear Quality Assurance
NRC	Nuclear Regulatory Commission
NTN	National Trends Network
NWP	Nationwide Permit

O

ODS	Ozone-Depleting Substances
ORPS	Occurrence Reporting and Processing System

P

PA	Performance Assessment
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethylene
pH	Potential of Hydrogen

Q

QA	Quality Assurance
QC	Quality Control

R

RCRA	Resource Conservation and Recovery Act
REMP	Radiological Environmental Monitoring Program

RESRAD	RESidual RADioactivity
RICE	Reciprocating Internal Combustion Engine
RM	River Mile
ROD	Record of Decision
RPD	Relative Percent Difference
RQ	Reportable Quantity
RSL	Regional Screening Levels

S

SA	Supplement Analysis
SARA	Superfund Amendment and Reauthorization Act of 1986
SC	South Carolina
SCDHEC	South Carolina Department of Health and Environmental Control
SDF	Saltstone Disposal Facility
SDU	Saltstone Disposal Unit
SDWA	Safe Drinking Water Act
SEER	Seasonal Energy Efficiency Ratio
SNF	Spent Nuclear Fuel
SPCC	Spill Prevention, Control, and Countermeasure
SRARP	Savannah River Archaeological Research Program
SREL	Savannah River Ecology Laboratory
SRNL	Savannah River National Laboratory
SRNS	Savannah River Nuclear Solutions, LLC
SRR	Savannah River Remediation LLC
SRS	Savannah River Site
SRSCRO	Savannah River Site Community Reuse Organization
SSP	Site Sustainability Plan

Std dev	Standard Deviation
STP	Site Treatment Plan
SWDA	Solid Waste Disposal Act
SWDF	Solid Waste Disposal Facility
SWPF	Salt Waste Processing Facility
SWPPP	Stormwater Pollution Prevention Plan

T

TCE	Trichloroethylene
TLD	Thermoluminescent Dosimeter
TRI	Toxic Release Inventory
TRU	Transuranic
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facilities
TSS	Total Suspended Solids

U

ULTB	Uranium Lease and Take-Back
U.S.	United States
USACE	United States Army Corps of Engineers
USC	University of South Carolina
USDA	United States Department of Agriculture
U.S. EPA	United States Environmental Protection Agency
USFS-SR	United States Forest Service-Savannah River
USGS	United States Geological Survey
USFWS	United States Fish and Wildlife Service

UST	Underground Storage Tank
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V

VEGP	Vogtle Electric Generating Plant
------	----------------------------------

VOC	Volatile Organic Compound
-----	---------------------------

VSDS	Visual Survey Data System
------	---------------------------

W

WIPP	Waste Isolation Pilot Plant
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WTP	Water Treatment Plant
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Sampling Location Information

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

Location Abbreviations	Location Name/Other Applicable Information
4M	Fourmile
4MB	Fourmile Branch (Fourmile Creek)
4MC	Fourmile Creek
BDC	Beaver Dam Creek
BG	Burial Ground
BLTW	Burke and Screven Counties Wells (Georgia)
EAV	E-Area Vaults
FM	Four Mile
FMB	Fourmile Branch (Fourmile Creek)
GSTW	Burke and Screven Counties Wells (Georgia)
HP	HP (sampling location designation only; not an actual abbreviation)
HWY	Highway
JAX	SRS Boundary Wells
KP	Kennedy Pond
L3R	Lower Three Runs
MCQBR	McQueens Branch
MHTW	Burke and Screven Counties Wells (Georgia)
MPTW	Burke and Screven Counties Wells (Georgia)
MSB	SRS Boundary Wells
NSB L&D	New Savannah Bluff Lock & Dam (Augusta Lock and Dam)
PAR	"P" and "R" Pond
PB	Pen Branch
RM	River Mile
SC	Steel Creek
SWDF	Solid Waste Disposal Facility
TB	Tims Branch
TC	Tinker Creek
TNX	Multipurpose Pilot Plant Campus
TR	Burke and Screven Counties Wells (Georgia)
U3R	Upper Three Runs
VEGP	Vogtle Electric Generating Plan (Plant Vogtle)

Sampling Locations Known by More Than One Name
Augusta Lock and Dam; New Savannah River Lock & Dam
Beaver Dam Creek; 400-D
Fourmile Creek-2B; Fourmile Creek at Road C
Fourmile Creek-3A; Fourmile 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, Georgia Welcome Center at Highway 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 160.5; Demier 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 Hwy 125
Upper Three Runs-1A; Upper Three Runs-1A at Road 8-1
Upper Three Runs-3; Upper Three Runs-3 at Road C
Highway 17 Bridge; Houlihan Bridge

The Savannah River Site (SRS) Annual Site Environmental Report is the primary document that the U.S. Department of Energy (DOE) uses to inform the public of environmental performance and conditions at SRS. This report meets the requirements of U.S. Department of Energy (DOE) Order 231.1B, *Environment, Safety, and Health Reporting*. It also is the principal document that demonstrates how the Site complies with the requirements of DOE Order 458.1, *Radiation Protection of the Public and the Environment*.

This document summarizes SRS's environmental information and data to achieve the following:

- Highlight significant Site programs
- Report environmental occurrences and responses
- Describe SRS's compliance with environmental standards and requirements
- Describe SRS's Environmental Management System and sustainability performance
- Provide results of radiological and nonradiological environmental monitoring and the results from monitoring property for release from SRS

Chapter Background

This chapter presents the following:

- A brief history of SRS along with a summary of its current missions
- Highlights of various onsite organizations and their primary responsibilities
- Description of the physical characteristics and attributes of the environment in and around SRS
- SRS's primary mission and annual programmatic updates

1.1 HISTORY

SRS is a DOE site in the western region of South Carolina, along the Savannah River. The Atomic Energy Commission constructed SRS in the early 1950s to produce materials used to create nuclear weapons during the Cold War. Over the next decades, five nuclear reactors produced these materials. The reactors operated until 1988. Several of the support facilities continue to operate. The main activities onsite today involve treating and processing waste, environmental cleanup and remediation, tritium processing, and protecting nuclear material.

1.2 MISSIONS

The SRS mission is to operate safely and efficiently and to protect public health and the environment, while supporting the nation's nuclear deterrent programs. SRS has three main mission areas:

Environmental Stewardship—SRS is focused on reducing the environmental legacy of nuclear materials and radioactive waste through initiatives such as groundwater restoration, deactivation and decommissioning of excess contaminated facilities, and disposing of radioactive waste.

National Security—SRS is focused on enhancing national security by creating safe, innovative solutions to manage nuclear materials. Activities include surplus nuclear materials disposition, tritium supply management, and maintaining and evaluating the nuclear stockpile.

Clean Energy—SRS is focused on accelerating developing technology to provide sustainable energy through public and private research and development partnerships.

You will find more information on [SRS's website](#).

1.3 ORGANIZATION

The DOE Environmental Management (DOE-EM) program and the National Nuclear Security Administration (NNSA) oversee the Site missions. These two DOE Program Offices provide direction to the Savannah River Operations Office (DOE-SR). To execute SRS's missions, two federal agencies, two state universities, and several contractors participate in various supporting roles. Figure 1-1 shows the relationship of these contractors with DOE. You will find a description of each entity on the following pages.

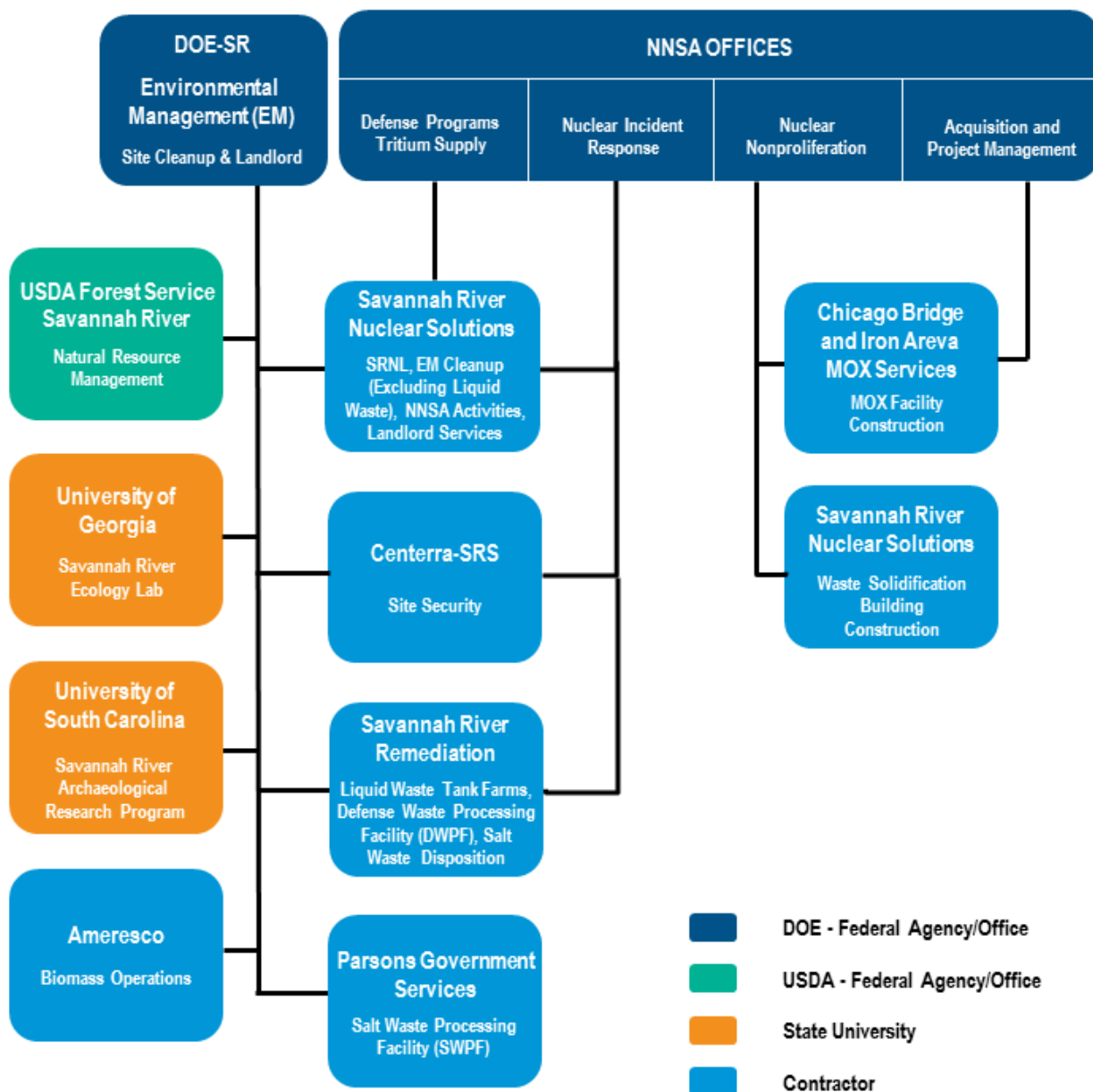


Figure 1-1 SRS Organization



The mission of DOE-EM is to safely clean up the environmental legacy remaining from five decades of developing nuclear weapons and government-sponsored research. DOE-SR is responsible for overseeing EM operations and landlord services supporting all mission areas at SRS. You will find more information on the [DOE-SR website](#).



NNSA is responsible for the defense programs and nuclear nonproliferation elements of the national security mission. NNSA is also responsible for emergency operations related to SRS tritium facility functions and the national Radiological Assistance Program. You will find more information on the [NNSA website](#).



Savannah River Nuclear Solutions, LLC (SRNS), a joint venture of Fluor Corporation, Newport News Nuclear, and Honeywell International, Inc., is the SRS management and operations contractor. SRNS is responsible for nuclear materials facilities, solid waste management facilities, tritium programs, Site infrastructure, and waste site remediation and closure projects. You will find more information on the [SRNS website](#).



Savannah River National Laboratory (SRNL), which SRNS operates, is the only EM-applied research and development laboratory. SRNL creates practical, high-value, cost-effective technological solutions in all three SRS mission areas as well as throughout the DOE complex, with other Federal agencies, and within the private sector. You will find more information on the [SRNL website](#).



Savannah River Remediation LLC (SRR) is responsible for treating and disposing of radioactive liquid waste and operationally closing waste tanks. SRR is composed of a team of companies led by AECOM with partners Bechtel National, CH2M, and BWX Technologies. Critical subcontractors for the contract are AREVA, Atkins, and AECOM Technical Services. You will find more information on the [SRR website](#).



Parsons Government Services, Inc. is responsible for designing, constructing, starting up, and operating the Salt Waste Processing Facility (SWPF). When completed, SWPF will separate radioactive salt solutions currently stored in below-ground tanks at SRS. SWPF will transfer separated solutions to the Defense Waste Processing Facility (DWPF) or the Saltstone Facility for more processing. You will find more information on the [Parsons website](#).



Chicago Bridge & Iron Areva MOX Services, LLC is responsible for the designing, constructing, starting up, and operating the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF). The MFFF will convert plutonium that could be used to make weapons to a form that can be used in a commercial nuclear power plant. You will find more information on the [Chicago Bridge & Iron Areva MOX Services website](#).



Centerra-SRS is responsible for the protective force that focuses on safely ensuring that criminal or terrorist acts do not disrupt the Site and its employees or compromise sensitive information or nuclear materials. You will find more information on the [Centerra website](#).



Ameresco Federal Solutions, Inc. constructed and now operates biomass steam-generating plants in K and L Areas and the steam and electricity cogeneration plant located near F Area. Ameresco currently supplies steam to SRS. You will find more information on the [Ameresco website](#).



The Savannah River Archaeological Research Program (SRARP) is a research unit of the University of South Carolina that provides the technical expertise to manage SRS cultural resources. SRARP responsibilities include identifying, evaluating, and protecting SRS archaeological sites and artifacts, conducting compliance-based research, offering public outreach programs, and preparing documents and reports for state and federal regulators. You will find more information on the [SRARP website](#).



The Savannah River Ecology Laboratory (SREL) is a research unit of the University of Georgia. For more than 65 years, the lab has independently evaluated the environmental risk associated with DOE activities. This mission includes educating graduate and undergraduate students through advanced hands-on research and providing outreach to public schools and communities surrounding the Site. You will find more information on the [SREL website](#).



The U.S. Department of Agriculture (USDA) Forest Service-Savannah River (USFS-SR), under an interagency agreement with DOE-SR, manages SRS's natural resources. These include managing timber; maintaining and improving habitat for threatened, endangered, and sensitive species; maintaining secondary roads and Site boundaries; performing prescribed burns and protecting the Site from wildland fires; and evaluating the effects of its management practices on the environment. You will find more information on the [USFS-SR website](#).

1.4 SITE LOCATION, DEMOGRAPHICS, AND ENVIRONMENT

SRS borders the Savannah River and encompasses about 310 square miles in the South Carolina counties of Aiken, Allendale, and Barnwell. SRS is about 12 miles south of Aiken, South Carolina, and 15 miles southeast of Augusta, Georgia (Figure 1-2). The Savannah River flows along the Site's southwestern border. On Figure 1-2, the capital letters within SRS borders identify operational areas referenced in this report.

Based on the U.S. Census Bureau's 2010 data, the population within a 50-mile radius of the center of SRS is about 781,060 people. This translates to an average population density of about 104 people per square mile outside the SRS boundary, with the largest concentration in the Augusta metropolitan area.

1.4.1 Water Resources

The Savannah River bounds SRS on the southwest for 35 river miles. The upriver boundary of SRS is about 160 river miles from the Atlantic Ocean. The nearest downriver municipal facility that uses the river as a drinking water source (Beaufort-Jasper Water and Sewer Authority's Purrysburg Water Treatment Plant) is about 90 river miles from the Site. Commercial fishermen, sport fishermen, and boaters also use the river. The river is not currently used for any large-scale irrigation projects downriver of the Site.

The groundwater flow system at SRS consists of four major aquifers. Groundwater migrates through the subsurface, eventually either discharging into the Savannah River and its tributaries or migrating vertically downward into the deeper regional flow systems. SRS uses groundwater for both industrial processes and drinking water.

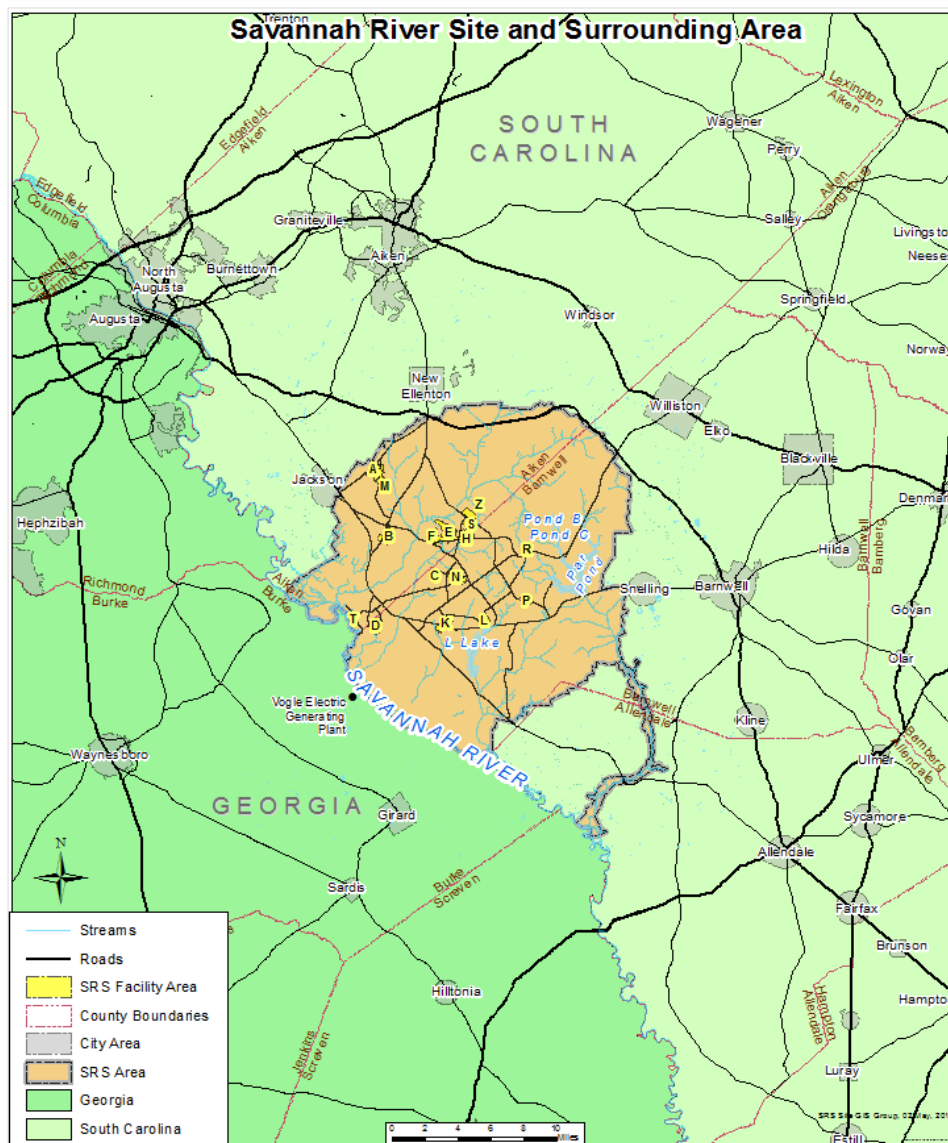


Figure 1-2 The Savannah River Site and Surrounding Area

1.4.2 Geology

SRS is 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 about 25 miles southeast of the geological fall line that separates the Coastal Plain from the Piedmont.

With nearly three centuries of available historic and contemporary seismic data, the Charleston/Summerville area remains the most seismically active region affecting SRS. However, levels of earthquake activity within this region are usually low, with magnitudes generally less than or equal to 3.0 on the Richter Scale.

1.4.3 Land and Forest Resources

About 10% of SRS's land is industrial; the remaining 90% consists of natural and managed forests that the USFS-SR plants, maintains, and harvests. SRS consists of four major forests: 1) mixed pine-hardwoods, 2) sandhills pine savanna, 3) bottomland hardwoods, and 4) swamp floodplain forests. These forests, as well as Carolina Bays, are accessible to the public when visiting the Crackerneck Wildlife Management Area and Ecological Reserve near Jackson, South Carolina. More than 345 Carolina Bays exist on SRS. Carolina Bays are relatively shallow depressions that provide important wetland habitat and refuge for many plants and animals. The photograph on the cover of this report is of Rainbow Bay, one of the many Carolina Bays onsite.

1.4.4 Animal and Plant Life

SRS is home to many species of plants and animals, including:

- Approximately 1,500 species of plants
- More than 100 species of reptiles and amphibians
- Approximately 50 species of mammals
- Nearly 100 species of fish
- Nearly 600 species of aquatic insects

SRS also provides habitat for more than 250 species of birds. Additionally, the Site provides habitat for protected species including the wood stork, the red-cockaded woodpecker, the pondberry, the gopher tortoise, and the smooth purple coneflower (all federally listed as threatened or endangered species). There are at least 40 plant species onsite that are of state or regional concern.

1.5 DOE-EM PRIMARY SITE ACTIVITIES

1.5.1 Nuclear Materials Stabilization

In the past, the mission of the F- and H-Areas separations facilities was to process special nuclear materials and spent fuel from Site reactors to produce materials for nuclear weapons and isotopes for both medical and National Aeronautics and Space Administration applications. Central to these separations facilities were the canyons, where the radionuclides were chemically separated from nuclear fuels. The end of the Cold War in 1991 shifted that mission to stabilizing nuclear materials and providing safe interim storage or disposal. F Canyon completed its production mission in 2002 and was deactivated in 2006.

Since 2003, H Canyon has recovered and disposed of highly enriched uranium from various spent and unirradiated nuclear fuels as well as from uranium-bearing materials from sites across the DOE complex. In H Canyon, a separations process purifies the highly enriched uranium and then dilutes it into a low-enriched uranium product using natural uranium. The low-enriched product is shipped offsite and used to



SRS Employee Monitoring Operations at H Canyon

manufacture commercial reactor fuel. H Canyon also dissolves plutonium materials into a solution that is converted into a purified oxide product. You will find more information on [H-Area Nuclear Materials Disposition](#) on SRS's website.

1.5.2 Nuclear Materials Consolidation and Storage

The K-Area Complex is DOE's only special interim nuclear materials storage facility designated to safely store plutonium. The principal operations building formerly housed K Reactor, which produced nuclear materials to support the United States for nearly four decades during the Cold War. DOE has revitalized this safe and robust structure to store nuclear materials. The stored materials have various proposed disposition paths including the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico; DWPF; H-Area facilities; and the Mixed Oxide (MOX) Fuel Fabrication Facility.

SRS handles and provides interim storage of our nation's surplus plutonium and other special nuclear materials, fulfilling the United States' commitment to international nonproliferation in a safe and environmentally sound manner.

You will find more information on [Nuclear Materials Management](#) on SRS's website.

1.5.3 Spent Nuclear Fuel Storage

SRS supports the DOE National Security mission by safely receiving and storing spent fuel elements from foreign and domestic research reactors, pending disposition. Currently, SRS stores spent nuclear fuel at the L-Area Complex. You will find more information in the [L-Area Complex](#) fact sheet on SRS's website.

1.5.4 Waste Management

SRS manages radiological and nonradiological waste created by previous operations, as well as newly generated waste created by ongoing Site operations.

1.5.4.1 Radioactive Liquid Waste Management

Processing nuclear materials for national defense, research, and medical programs generates radioactive liquid waste. SRS safely stores approximately 35 million gallons of radioactive liquid waste underground in waste tanks located in the F- and H-Area Tank Farms. SRS waste tanks safely stored radioactive liquid waste for decades. Closing the liquid waste storage tanks is a high priority for DOE-EM. In order to do this, SRS must first remove the waste from the tanks and then process and treat the waste before disposing of it. In 2016, SRS closed Tank 12H, the eighth of 51 storage tanks.



L-Area Complex



Saltstone Disposal Units—with Newly Constructed SDU-6 in Center of Photo (Large Disc-Shaped Object)

SRS uses cylindrical tanks, known as Saltstone Disposal Units (SDUs) to dispose of the low-activity liquid waste. In 2016, SRS constructed SDU-6, a new design for the cylindrical SDUs, and processed and disposed of more than 1.5 million gallons of waste through the Saltstone facilities.

SRS uses DWPF to process high-activity waste from the Tank Farms. Since DWPF began operating in March 1996, it has produced more than 15.8 million pounds of glass, immobilizing 59.9 million curies of radioactivity and pouring more than 4,000 canisters. In FY 2016, DWPF produced 136 canisters with approximately 490,000 pounds of glass, immobilizing approximately 2.6 million curies of radioactivity.

You will find more information in the [Radioactive Liquid Waste: Operational Tank Closure](#) and [Liquid Waste Facilities](#) fact sheets on SRS's website.

1.5.4.2 Solid Waste Management

Solid wastes managed at SRS include the following types:

- Low-level radioactive solid waste, including ordinary items contaminated with small amounts of radioactive material
- Transuranic (TRU) waste, which contains alpha-emitting isotopes with an atomic number greater than that of uranium (92)
- Hazardous waste (nonradiological), which is any toxic, corrosive, reactive, or ignitable material that could affect human health or the environment
- Mixed waste, which contains both hazardous and radioactive components
- Sanitary waste, which like ordinary municipal waste, is neither radioactive nor hazardous

All low-level radioactive and hazardous wastes that SRS generates are treated, stored, and disposed of to meet environmental and regulatory requirements. The Site also emphasizes minimizing waste and recycling as a way to reduce the volume of waste that SRS must manage.

SRS packages TRU waste and transports it in Department of Transportation (DOT)-approved containers to WIPP for disposal. WIPP is the underground repository for DOE's TRU waste. SRS began shipping TRU waste to WIPP in May 2001. SRS has made more than 1,650 shipments to WIPP through 2014. In 2016, the Site began removing waste from TRU Pad 2. All remaining legacy TRU waste is packaged and ready for SRS to ship to WIPP. SRS did not make any TRU shipments in 2016 because WIPP was not accepting any shipments.

DOE conducts annual reviews to ensure that Site operations are within DOE's performance standards. The annual reviews for the E-Area Low-Level Waste Facility Performance Assessment (PA) and the Saltstone Disposal Facility PA, showed that operations in FY 2016 were within the performance standards DOE Orders establish and that the public and the environment were protected.

You will find more information on the [Solid Waste Management](#) page on SRS's website.

1.5.5 Waste Site Remediation and Closure

Past operations at SRS have released hazardous and radioactive substances to soil, which subsequently have ended up in the groundwater. Area Completion Projects is responsible for and focuses on reducing the footprint of legacy waste at SRS's contaminated waste sites and obsolete facilities. Area Completion Projects cleans up contamination in the environment by treating or immobilizing the source of the contamination, mitigating transport through soil and groundwater, and slowing the movement of contamination that has already migrated from the source. Cleanup includes capping inactive waste sites, installing and operating efficient groundwater treatment units, and using natural remedies, such as bioremediation (using naturally occurring microbes).



Construction of the Multi-Layer Protective Landfill Cover at the D-Area Ash Basin

In 2016, SRS continued a five-year project to restore 90 acres located near the former coal-fired power plant in D Area. SRS constructed the multilayer protective landfill cover for the second of the three basins. You will find additional information on the activities in Chapter 3, *Compliance Summary*. The restoration included removing ash that had been deposited over decades and constructing an engineered cover system. The result was two highly engineered grassy hills. You will find more information on the [Area Completion Projects](#) page on SRS's website.

1.5.6 Environmental Monitoring

SRS has an extensive environmental monitoring program that has been in place since 1951, prior to the start of Site operations. In the 1950s, onsite environmental monitoring program data were reported in Site documents. Beginning in 1959, SRS made offsite environmental surveillance data available to the public. SRS reported onsite and offsite environmental monitoring separately until 1985, when it merged data from both programs into one publicly available document, the *U.S. Department of Energy Savannah River Plant Environmental Report for 1985*.

SRS continues to conduct an extensive environmental monitoring program to determine impacts, if any, from SRS to the surrounding communities and the environment, both on and offsite. In addition to the onsite environmental monitoring the Site conducts, SRS also monitors a 2,000-square-mile area beyond the Site boundary. This area includes neighboring cities, towns, and counties in South Carolina and Georgia. SRS collects thousands of samples of air, rainwater, surface water, drinking water, groundwater, food products, wildlife, soil, sediment, and vegetation. These samples are checked for radionuclides, metals, and other chemicals that could be in the environment because of activities at SRS.

The Site's radioactive discharges to air and water were well below regulatory standards. However, SCDHEC gave SRS one Notice of Violation under the National Pollutant Discharge Elimination System (NPDES) program associated with nonradiological surface water discharges for total suspended solids, which had minimal impact on the environment. You will find additional detail on the Notice of Violation in Chapter 3, *Compliance Summary*. Chapter 4, *Nonradiological Environmental Monitoring Program*, contains more information on the surface-water sampling to support the NPDES program.

The potential radiation doses to the public from SRS operations were well below the DOE public dose limit. Chapter 6, *Radiological Dose Assessment*, contains more information on the public dose limit. You will find overview information on monitoring and radiation dose in the [Environmental Monitoring](#) fact sheet on SRS's website.

1.6 NNSA PRIMARY SITE ACTIVITIES

NNSA operates tritium facilities at SRS to supply and process tritium, a radioactive form of hydrogen gas that is a vital component of nuclear weapons. SRS also plays a critical role in NNSA's nonproliferation missions, helping the United States meet its commitments to security and disposing of plutonium and uranium.

1.6.1 Tritium Processing

SRS has the nation's only facility for extracting, recycling, purifying, and reloading tritium. SRS replenishes tritium by recycling tritium from existing warheads and by extracting tritium from target rods irradiated in nuclear reactors that the Tennessee Valley Authority operates. SRS purifies recycled and extracted gases to produce tritium suitable for use. SRS tritium facilities are part of the NNSA's Defense Program at SRS. You will find more information on [Defense Programs](#) on SRS's website.

1.6.2 Nuclear Nonproliferation

When construction is complete, the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) will convert surplus weapons-grade plutonium to a form compatible with generating electricity in commercial nuclear power reactors. The plutonium in the MOX fuel cannot be used for nuclear weapons. You will find more information on the [Chicago Bridge & Iron Areva MOX Services](#) website.



Tritium Facility



MFFF Facility under Construction

1.7 SPECIAL ENVIRONMENTAL STUDIES

SRS provides a unique setting for environmental research with 90% of SRS being in a natural state. Several organizations at SRS—the University of Georgia Savannah River Ecology Laboratory (SREL), U.S. Forest Service-Savannah River (USFS-SR), Savannah River Archeological Research Program (SRARP), and Savannah River National Laboratory (SRNL)—conduct research to support a better understanding of human impact on both plants and animals.

More than 30 species of frogs, toads, and salamanders use the more than 400 isolated wetlands on SRS as breeding areas. SRS wetlands come in many shapes, sizes, and most importantly for amphibians, the normal length of time they hold water. Researchers at SREL have studied isolated wetland ecosystems for almost five decades, including amphibian studies beginning in 1978 at Rainbow Bay, which is featured on the cover of this year's Annual Site Environmental Report. The Guinness World Records recognizes the SREL amphibian study at Rainbow Bay as the longest-running amphibian study in the world. SREL has recorded 9 species of salamanders, 3 toad species, and 14 frog species at Rainbow Bay during the 39-year study. Dramatic changes have occurred over time in which species produce offspring successfully because the wetland in recent years generally fills with rain later and holds water for less time than it did in the early years of the study.

[SREL](#), [USFS-SR](#), and [SRARP](#) summarized the environmental studies and research they have conducted on SRS in 2016. These summary reports are on the SRS 2016 Annual Environmental Report webpage. These reports present and discuss environmental studies and research that occurred during the reporting year and directly affected environmental sampling or dose calculations. Special environmental studies and research directly impacting the environmental monitoring program and dose calculations are presented and discussed in their respective chapters.

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The Savannah River Site (SRS) Environmental Management System (EMS) supports the U.S. Department of Energy (DOE) commitment to implement sound stewardship policy and practices to protect the air, water, land, and other natural, archaeological, and cultural resources that SRS construction, operations, maintenance, and decommissioning potentially affect.

The EMS plans, integrates, and evaluates SRS activities protecting public health and the environment, preventing pollution and minimizing waste, and complying with applicable environmental and cultural resource protection requirements. SRS activities demonstrate the Site's commitment to minimize waste, manage water, foster renewable energy, reduce greenhouse gases, acquire sustainable services, remediate with a focus on sustainability, and observe best management practices, all vital components of environmental management. The SRS Site Sustainability Plan contains more information on DOE and SRS goals and the progress toward achieving those goals.

2016 Highlights

The Department of Energy sets goals for carrying out its mission in an environmentally sustainable manner that supports a policy of national energy security and addresses global environmental challenges. SRS continues to make substantial progress in meeting the goals for the Site. Below are the highlights of the progress cumulative through 2016:

- **Pollution Prevention and Waste Minimization**—SRS diverted 50% (695 metric tons) of nonhazardous solid waste for recycling.
 - **Water Management**—SRS continued to reduce drinkable water use. The Site has reduced use by 32% since 2000.
 - **Renewable Energy Intensity**—SRS derived 100% of thermal energy and 48% of electricity from renewable energy sources.
 - **Greenhouse Gas Reduction**—SRS continued to reduce greenhouse gas emissions. The Site has reduced emissions by 74% since 2008.
 - **Transportation and Fleet Management**—More than 96% of SRS light-duty vehicles were hybrid, electric, or use E85 (ethanol) fuel.
- EMS Best Practices**—SRS led the DOE complex in identifying climate change and vulnerabilities of workers and buildings.

Chapter 2—Key Terms

Environmental impacts are any positive or negative change to the environment caused by an organization's activities, products, or services.

Environmental objectives define the organization's environmental goals.

Environmental sustainability is interacting responsibly with the environment to conserve natural resources and promote long-term environmental quality. It includes reducing the amount of waste produced, using less energy, and developing processes that maintain the long-term quality of the environment.

2.1 SRS EMS IMPLEMENTATION

2.1.1 Introduction

DOE has chosen the [International Organization for Standardization](#) (ISO) Standard 14001 as the framework to employ its Environmental Management Systems (EMS) and its sustainable practices of preventing pollution, reducing waste, and conserving energy. The ISO 14001 standard specifies the EMS requirements that an organization can use to enhance its performance in mitigating environmental impacts and complying with regulations.

ISO Standard 14001 establishes a continuous cycle of developing, planning, implementing, operating, evaluating, and correcting a management system, and then conducting a management review. The SRS EMS also meets the criteria of Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*, and DOE Order 436.1, *Departmental Sustainability*, which require federal facilities to use environmental management systems.

The EMS integrates protecting the environment into SRS's daily operations. For example, identifying safety and health hazards and managing with quality processes support and enhance protecting the environment. This linked approach to planning, executing, evaluating, and modifying ensures that SRS operates with minimal adverse impact on the environment.

SRS also uses the EMS as a platform to implement the [Site Sustainability Plan \(SSP\)](#), as well as carry out programs with goals and measurable targets that contribute to SRS meeting its sustainability goals. SRS EMS and SSP targets and goals, along with the status of the Site's progress toward meeting these goals, are available on the [SRS website](#). These documents, combined with Site policies and procedures, ensure SRS remains a leader in protecting the environment and is a steward of conserving energy and water.

Savannah River Nuclear Solutions (SRNS), Savannah River Remediation (SRR), Centerra, and Chicago Bridge & Iron (CB&I) Areva MOX Services maintain ISO 14001 credentials, which are valid for three years. Internal and external auditors routinely assess programs to ensure that they conform to the standard's requirements.

SRS contractors had the following audits for ISO 14001 compliance:

- SRNS and SRR had an external conformance audit in March 2015
- Centerra conducted ISO 14001 reregistration in January 2015 and had a review audit in January 2016
- Chicago Bridge & Iron Areva MOX Services had an external conformance audit in April 2016

SRS trains all employees annually on the EMS policies and requirements. Additionally, the Site generates regular and routine employee communications as a reminder of the SRS commitment to sustainability and the environment. The SRS Integrated Safety Management System (ISMS) is a process that integrates safety into management and work practices at all levels so that the Site accomplishes its missions, while protecting the public, the worker, and the environment. The ISMS execution comprises five functions: 1) defining scope of work, 2) analyzing hazards, 3) developing and implementing controls, 4) performing work, and 5) providing feedback and improvement. SRS implements ISO 14001 and accomplishes the EMS goals using the ISMS approach in programs and procedures.



**Integrated Safety Management
System Continual Improvement
Framework**

2.1.2 Targets and Goals

Through the EMS, SRS sets targets and goals annually to meet and to support DOE environmental objectives, which include:

- Reducing total energy use
- Increasing renewable energy use
- Reducing water use
- Purchasing environment-friendly, or “green,” products and services
- Reducing solid waste generation
- Reducing chemical use
- Increasing the number of sustainable buildings
- Reducing fleet and petroleum use
- Using energy-compliant electronic devices
- Maintaining compliance with requirements

Appendix A presents the goals, identifies the strategies for implementation, and provides the status of SRS’s progress toward achieving them. This chapter contains additional information on how SRS is moving forward in supporting DOE environmental objectives.

2.2 SUSTAINABILITY ACCOMPLISHMENTS

The following topics summarize the major accomplishments the SSP discusses. [Executive Order No. 13693, Planning for Federal Sustainability in the Next Decade](#), outlines each of these topics.

2.2.1 Greenhouse Gas Reduction

By reducing greenhouse gas (GHG) by 74%, SRS has surpassed the 50% goal to reduce Scope 1 and 2 from a FY 2008 baseline. Scope 1 consists of direct emissions such as onsite fossil-fuel combustion or fugitive GHG emissions; whereas, Scope 2 consists of indirect emissions associated with using electricity, heat, or steam.

The following inventoried sources at SRS currently generate Scope 1 and 2 emissions:

- Purchased electricity
- Wood (biomass)
- Fuel oil
- Propane
- Gasoline
- Diesel
- E85 (ethanol)
- Jet fuel
- Fugitive emissions



Biomass Cogeneration Facility

SRS continued to substantially reduce Scope 1 and 2 greenhouse gas emission during FY 2016 due to the Biomass Cogeneration Facility and operating three additional biomass facilities, one each in A Area, L Area, and K Area. DOE tracks the Site's combining of GHG data from various impact sources (such as Site energy use, alternative workplace arrangements and space optimization, and vehicle and equipment use).

2.2.2 Sustainable Buildings

By 2025, DOE must reduce by 25% the energy per square foot (energy intensity) used in an identified class of buildings using FY 2015 as a baseline. The annual goal is to reduce intensity by 2.5%. DOE expects sites to aggressively strive toward the overall DOE 25% reduction goal, particularly when cost-effective and prudent to do so. SRS has been well ahead of the goal in reducing energy and is continuing to look for ways to reduce energy intensity in its facilities.

Improving energy efficiency has been ongoing at the Site for many years, and additional benefits have come from a wide variety of strategies used to reduce energy and manage utilities, including the following:

- Upgrading utility systems
- Minimizing boiler use for winter heating
- Operating the Biomass Cogeneration Facility
- Operating biomass steam plants in A Area, K Area, and L Area
- Deactivating and decommissioning many facilities, including entire areas, which often comprise multiple buildings, land, and associated waste disposal and decontamination challenges
- Consolidating building space and roles of employees
- Using more setback equipment in facilities (such as lighting timers, lighting sensors, and thermostats)
- Upgrading various small-scale light fixtures

SRS conducted many activities in FY 2016 that reduced energy intensity. Operating the Biomass Cogeneration Facility had the most impact. The following are some additional notable accomplishments supporting this program:

- Conducted a required energy and water audit for 45 facilities, identifying more than 100 measures to conserve energy
- Removed 19 unoccupied and aging trailers, reducing energy consumption and representing 16,000 square feet of footprint reduction
- Installed energy-efficient light-emitting diode (LED) lighting in the 784-7A Biomass Facility
- Replaced remaining fluorescent lighting with LED lighting in 235-H, 248-H, and 264-H
- Installed 27 heating and cooling units with new, higher SEER (Seasonal Energy Efficiency Ratio) units in the Site's administrative areas
- Used cool-roof technology on four roof replacements

SRNS also manages energy efficiency at a facility level with the Peak Alert process, which reduces purchased power. Actions that will reduce the demand for energy include raising the thermostat (summer), lowering the thermostat (winter), and turning off lights when it is safe to do so. SRS used Peak Alerts to manage 11 peak events during FY 2016: three during warm months and eight during cool months.

2.2.3 Renewable Energy

DOE's Clean Energy goal requires the percentage of an agency's total electric and thermal energy coming from renewable and alternative energy in FY 2016–17 to be at least 10%, increasing to 25% by FY 2025. Additionally, DOE's Renewable Electric Goal requires that renewable electric energy account for at least 10% of a total agency electric consumption in FY 2016–17, working toward 30% of total agency electric consumption by FY 2025. SRS has exceeded these goals with current performance rates of 100% of thermal energy and 48% of electricity being produced from renewable energy sources. SRS no longer uses coal to generate energy. Using clean and renewable energy at the Site is a high-level priority.

The Biomass Cogeneration Facility is in its fourth year of fully operating and has played a significant role in supporting these renewable and alternative energy goals. In 2016, an additional biomass heating plant came online to back up the existing boilers in the case of an outage. The new biomass plant represents a subsequent modification to DOE's original Energy Savings Performance Contract executed in 2009 for constructing the 20-megawatt biomass cogeneration facility, which Ameresco currently operates and maintains at SRS.

The [Savannah River National Laboratory \(SRNL\)](#) supports DOE's clean energy goal by developing cutting-edge technologies in the following areas:

- hydrogen
- solar
- wind
- environmental
- natural gas
- bioenergy

2.2.4 Water Use Efficiency and Management

[Executive Order No. 13693, *Planning for Federal Sustainability in the Next Decade*](#), stipulates that by FY 2025, DOE as an agency will reduce the gallons of drinkable water used per square foot of building area by 36%, relative to a FY 2007 baseline. SRS has an FY 2016 target goal to reduce this ratio by 18%. The ratio is known as water intensity.

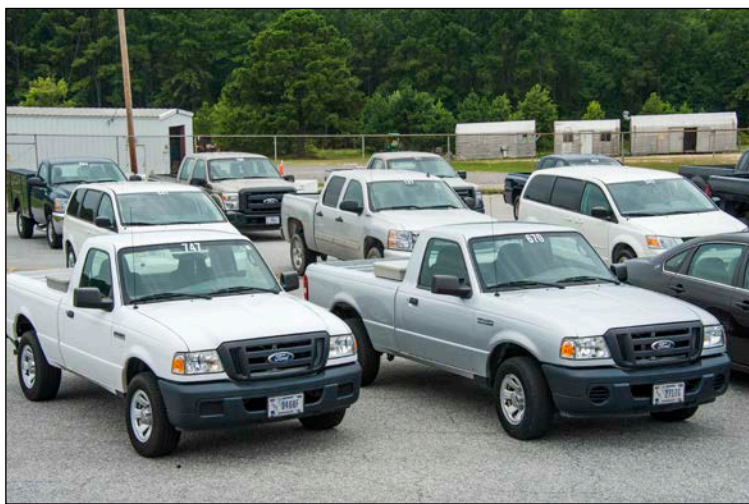
The Site has been significantly decreasing its water use over many years. In 1996, for example, the Site installed a new SRS primary domestic water system. The new system, along with replacing old and leaky piping, saved the Site several hundred million gallons of water annually. SRS also installed water meters on the main supply lines and periodically conducts a water balance to monitor use and help detect leaks.

Compared to the current baseline (FY 2007), SRS has reduced drinkable water intensity through FY 2016 by 20.3%. Over a longer timeframe, since FY 2000, the Site has reduced drinking water use by 31.9%. It will be harder for the Site to reduce water use more because it has already achieved the large decreases. Drinking water use fluctuates from year-to-year based on various factors such as the number of employees and the amount of drinkable water used for nondrinkable uses.

During FY 2016, SRS continued to benefit from the use of [WaterSense](#)® products and other water-conserving products, including low-flow toilet flush valves, low-flow urinal flush valves, and low-flow faucets. In recent years, the Site has replaced several hundred faucets and flush valves with reducers or low-flow units.

2.2.5 Fleet Management

The primary goal for DOE transportation and fleet management is to use less petroleum and more alternative fuel. SRS has met and exceeded these goals since FY 2000. SRS installed two E85 fueling stations in October 1999 and added a third in FY 2015. In FY 1999, the year prior to installing the fueling stations, the Site consumed more than 700,000 gallons of unleaded fuel and no E85 alternative fuel. In FY 2016, the Site consumed approximately 91,000 gallons of unleaded fuel, 39,000 gallons of diesel fuel, and more than 400,000 gallons of E85 alternative fuel. In addition, the Site completed its Vehicle Allocation Methodology Plan in July 2016. The Vehicle Allocation Methodology is a protocol that helps organizations eliminate from their fleets unnecessary, oversized, or fuel-inefficient vehicles. SRS updates its plan at least every 5 years. SRS has reduced its fleet-wide per mile greenhouse gas emissions goal by 17% toward a 30% goal.



SRS Vehicle Fleet

2.2.6 Sustainable Acquisition

SRS Procurement has established sustainable practices related to purchasing environmentally preferable products (EPP). For FY 2016, SRS reviewed applicable purchase-order line descriptions to determine if the product meets the definition of U.S. Department of Agriculture (USDA) BioPreferred®. The EPP procurements have led to several practices, as outlined below:



- The SRS Chemical Management Center reviews and approves chemical acquisitions. This review monitors using hazardous chemicals and, where appropriate, recommends EPPs.
- Electronic stewardship has led to procuring and leasing desktops, laptops, and monitors that meet [Electronic Product Environmental Assessment Tool \(EPEAT\)](#) standards and copiers that are [ENERGY STAR®](#)-compliant.
- EPP substitutions have been procured under various new and existing contracts, including bulk janitorial supplies (for example, cleaners, paper products) and safety items (for example, earplugs, filters).

SRS implemented a system to monitor and track EPP procurements. This new business system will enable SRS to develop an EPP baseline and track spending on EPP items and materials.

2.2.7 Pollution Prevention and Waste Reduction

In accordance with the Pollution Prevention Act of 1990, SRS's primary objective is to prevent or reduce pollution at the source whenever practical. Pollutants and wastes that cannot be prevented through source reduction will be diverted from entering the waste stream through environmentally safe and cost-effective reuse or recycling. Pollution prevention is the SRS preferred approach to reducing waste, mitigating health risks, and protecting the environment. The Pollution Prevention Program provides SRS a safe, effective, and environmentally responsible strategy to implement specific waste-reduction techniques based on current and projected information on waste generation, waste characteristics, and costs associated with managing waste. Pollution prevention is a key component of the SRS EMS.



The goal for FY 2016 was to divert at least 50% of nonhazardous solid waste, excluding construction and demolition debris, for recycling or reuse. SRS uses the North Augusta Material Recovery Facility (NA-MRF) for typical office and municipal-type waste recycling. In FY 2016, SRS recycled about 50% of this stream, 695 metric tons of the 1,380 metric tons of waste that it shipped. SRS worked with the subcontractor, NA-MRF, to improve the process to attain a 50% recovery rate. Other efforts include initiating a vendor contract to purchase plastic waste bags and revising operating procedures to improve recovery rates. In addition, SRS uses NA-MRF to recycle most of the waste from its area cafeterias and building kitchenettes. The Site segregates the main cafeteria's waste due to there being very little material suitable for recycling or composting. SRS continues to monitor this waste stream for opportunities to recycle materials.

2.2.8 Energy Saving Performance Contracts

SRS has Energy Saving Performance Contracts (ESPC) through two separate contractors—Honeywell Building Solutions and Ameresco Federal Solutions—for several projects to conserve energy and water.

Ameresco Federal Solutions, tasked with the DOE’s largest-ever ESPC, operates the Biomass Cogeneration Facility located on SRS. This facility produces steam and electricity on a 24-hour, full-time basis.

The contracts included the following work in 2016:

- Ameresco continued operating the Biomass Cogeneration Facility, which includes three biomass boilers for steam and electricity
- Ameresco also operated steam-only biomass plants for heating buildings in two other areas at SRS
- Honeywell Building Solutions installed more-efficient lighting in several Site buildings
- Honeywell continued monitoring the efficiency of operating a biomass boiler that provides steam to the SRNL complex

2.2.9 Electronics Stewardship

SRS is implementing many electronics stewardship strategies to reduce energy use and waste, and their associated costs. In FY 2016, SRS continued exemplary performance and met sustainable electronics purchasing and disposal goals. SRS purchased Electronic Products Environmental Assessment Tool (EPEAT) and registered ENERGY STAR®-qualified products for all eligible laptops, desktops, and monitors. SRS has 431 leased copiers, which all are ENERGY STAR®-certified. More than 99% of the eligible electronics SRS acquires meet EPEAT standards.



2.2.10 Climate Change Resilience

SRS ensures that federal operations and facilities can continue to protect and serve citizens in a changing climate. SRS uses global climate model projections and data as the starting point to assess the impact of climate change to Site buildings and outdoor workers. SRS sent the assessment results to a climate scientist at the University of South Carolina for external review in June 2016. SRS continues to assess the effects of climate change on preserving forests, maintaining water levels in Site ponds and lakes, and the ability of a Site energy plant to “dump” heat to the environment.

2.3 EMS BEST PRACTICES

2.3.1 Sustainability Campaign

SRS continued to implement its “One Simple Act of Green” environmental awareness campaign. The program empowers SRS employees with the information, tools, and programs needed to reduce our footprint on the environment. Employees practice simple acts, such as turning off lights when leaving a room or workspace, which promote positive actions toward environmental stewardship.



2.3.2 Earth Day

SRS participated in Earth Day celebrations held in Aiken, South Carolina on April 18. The theme was “Preserving for Tomorrow What We All Enjoy Today.” The SRNS booth and display theme was “Reduce, Reuse, and Recycle.” The display highlighted the SRS Sustainability Program and included E85 fuel use, biomass power generation, and ideas for home recycling and solar power.

2.3.3 Excess Equipment and Materials

SRS is partnering with the Savannah River Site Community Reuse Organization (SRSCRO) to turn excess equipment and material into money to benefit the counties of Aiken, Allendale, and Barnwell in South Carolina and Richmond and Columbia counties in Georgia. Surplus material includes the following:

- Small items such as office equipment, valves, and glassware for laboratory experiments
- Large items of potentially much greater value such as electrical turbines, diesel powered pumps, and fire engines
- Tons of metal

SRSCRO is the interface organization that takes in items that the Site no longer needs. The SRSCRO sells these items and uses the proceeds for the economic good of numerous businesses throughout the large region surrounding SRS.

In FY 2016, the SRSCRO removed one trailer from D Area and four from C Area. The SRSCRO removed one of the five trailers as an asset for resale and economic development. It disposed of the remaining four trailers. The SRSCRO also removed eight transformers, miscellaneous equipment, and materials from multiple facilities at SRS.

The DOE Sustainability Performance Office recognized SRS for having outstanding sustainability projects and practices and awarded the Site with the 2016 Innovative & Holistic Approach Award for this significant continuous teamwork with the SRSCRO.

2.3.4 Challenges and Barriers to Implementation

SRS has made significant accomplishments in conserving and managing resources over many years. However, the cost effectiveness of achieving new goals is becoming significantly more difficult. Economic paybacks are typically long, due to low energy costs and the high cost of implementing sustainability upgrades in SRS’s many aging nuclear production and support (for example, administrative, shops, laboratories, warehouses) facilities. Additionally, the Site will have increases to energy and greenhouse gas emissions as additional processing facilities, such as the MOX Fuel Fabrication Facility and the Salt Waste Processing Facility, begin operating. This is a major challenge for meeting the future goals.



SRNS personnel explained the SRS Sustainability Program at Earth Day

The Savannah River Site (SRS) implements programs to meet the requirements of applicable federal and state environmental laws and regulations, and U.S. Department of Energy (DOE) Orders, notices, directives, policies, and guidance. Our goal is to comply with regulatory requirements and eliminate or minimize any environmental impacts. SRS's exceptional compliance record demonstrates our commitment to protect human health and the environment.

2016 Highlights

SRS managed more than 400 operating and construction permits. SRS received one Notice of Violation (NOV) from South Carolina Department of Health and Environmental Control (SCDHEC) for exceeding the National Pollutant Discharge Elimination System (NPDES) Wastewater Permit Discharge limit in August at outfall D-01C in D Area. More information on the exceedance is on Page 3-14.

Remediation Activities (Environmental Restoration and Cleanup)

SRS completed the cleanup of 405 of the 515 waste units containing or having contained solid or hazardous waste at the end of FY 2016. An additional 12 units are being remediated.

Tank Closure Activities (Radioactive Liquid Waste Processing and Dispositioning)

- SRS completed operational closure of Tank 12H.
- The Defense Waste Processing Facility (DWPF) produced 136 canisters with approximately 490,000 pounds of glass waste mixture, immobilizing 2.6 million curies of high-level radioactive waste.
- The Saltstone facilities processed more than 1.5 million gallons of low-activity waste.

Atomic Energy Act/DOE Order 435.1, Radioactive Waste Management

The annual reviews for the E-Area Low-Level Waste Facility Performance Assessment (PA) and the Saltstone Disposal Facility PA showed that SRS continued to operate these facilities in a safe and protective manner.

Resource Conservation and Recovery Act (RCRA)

- TRU Pad 2 closure began in October.
- All 19 underground storage tanks containing usable petroleum fuel remained in compliance, marking 14 consecutive years without a violation.

Air Quality and Protection

SRS achieved a 100% compliance rate in FY 2016 with the five air permits governing operating facilities.

2016 Highlights (continued)

Radiation Protection of the Public and the Environment

SRS air and water discharges containing radionuclides were well below the DOE public dose limit of 100 mrem per year. (Chapter 5, *Radiological Environmental Monitoring Program*, provides details of the air and water discharges; Chapter 6, *Radiological Dose Assessment*, explains the public dose.)

Water Quality and Protection

- SRS sampled drinking water monthly to ensure drinking water quality met SCDHEC and U.S. Environmental Protection Agency (EPA) standards. In December, however, SRS failed to collect 3 of the 10 required samples and self-reported this to SCDHEC. The seven samples obtained and tested that month met drinking water quality standards.
- SRS monitored 28 industrial outfalls as the NPDES permit required. Except for the exceedance associated with the NOV, all analyses results complied with the NPDES permit and contributed to a 99.9% compliance rate.
- All 35 SRS stormwater outfalls covered under a Stormwater Pollution Prevention Plan (SWPPP) were 100% compliant. The SWPPP describes how SRS prevents contamination and controls sedimentation and erosion.

Environmental Protection and Resource Management

- SRS conducted 465 National Environmental Policy Act (NEPA) reviews to identify potential environmental impacts from proposed federal activities. Four hundred and fifteen of these were identified as categorical exclusions and did not require action from the Site under NEPA.
- SRS continued to comply with many other federal laws, including the Emergency Planning and Right-to-Know Act (EPCRA), the Superfund Amendments and Reauthorization Act (SARA) Title III, the Endangered Species Act (ESA), the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the National Historic Preservation Act (NHPA), and the Migratory Bird Treaty Act (MBTA).

Release Reporting

SRS reported one release exceeding the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Reportable Quantity (RQ). A follow-up investigation revealed that the asbestos release was below the RQ limit and did not need to be reported. More information on the release is on Page 3-20.

External Environmental Audits and Inspections

SCDHEC, EPA, and the Nuclear Regulatory Commission (NRC) conducted audits, inspections, and site visits of various SRS environmental programs to ensure regulatory compliance.

3.1 INTRODUCTION

Compliance with environmental regulations and DOE Orders is an integral part of SRS operations. This chapter provides a summary of SRS compliance with applicable environmental regulations and programmatic requirements.

3.2 FEDERAL FACILITY AGREEMENT

The 1993 *Federal Facility Agreement (FFA) for the Savannah River Site* integrates the CERCLA and RCRA requirements needed to achieve a comprehensive remediation strategy for SRS and to coordinate administrative and public participation requirements. The FFA governs the remedial action process, sets annual work priorities, and establishes milestones for cleanup and tank closure. Remediation and closure activities identified in the FFA are conducted in accordance with applicable regulations. These regulations can be either state or federal or both.

3.2.1 Remediation Activities (Environmental Restoration and Cleanup)

SRS has 515 waste units subject to the FFA, including RCRA/CERCLA units, Site Evaluation Areas, and facilities covered by the SRS RCRA permit. At the end of FY 2016, surface and groundwater cleanup of 405 of these units was complete, and 12 units were being remediated. All of SRS's 515 waste units are listed in FFA Appendix C, *RCRA/CERCLA Units List*; Appendix G, *Site Evaluation List*; and Appendix H, *Solid Waste Management Units Evaluation*. The *Federal Facility Agreement Annual Progress Report for Fiscal Year 2016* explains the status of FFA activities at SRS for FY 2016.

CERCLA requires reviews every five years for sites that have hazardous substances remaining at levels that do not allow for unrestricted use after a remedy is completed. Remedies are evaluated to determine if they are functioning as designed and are still protecting human health and the environment.

SCDHEC and the EPA approved the *Fifth Five-Year Remedy Review Report for Savannah River Site Operable Units with Groundwater Remedies* in August and September, respectively. DOE submitted the *Fifth Five-Year Remedy Review Report for Savannah River Site Operable Units with Engineered Cover Systems* and the *Fifth Five-Year Remedy Review Report for Savannah River Site Operable Units with Geosynthetic or Stabilization/Solidification Cover Systems* to EPA and SCDHEC in December. Regulators will review and comment on these two reports, which are expected to be issued to the public by 2018.

The FFA also governs how the Site closes the ash basins associated with the shutdown of the D-Area coal-fired powerhouse. The ash basins, which are adjacent to the powerhouse, held ash that was a byproduct of generating power at SRS.

In 2016, all construction for the installation of the multilayer protective SCDHEC Class Three landfill cover was completed for 488-4D Ash Landfill. To illustrate this progress, in February 2015, the 488-2D basin contained water and ash, and the 488-1D basin was still heavily vegetated, as Figure 3-1 shows. Both the 488-2D basin and the 488-4D landfill closures were nearing completion in October.

The Removal Action Report for the 488-2D Ash Basin and the 488-4D Ash Landfill (Revision 0) was under internal review at the end of 2016. This report must be submitted to SCDHEC and the EPA as part of the closure requirements.



Figure 3-1 D-Area Ash Project

3.2.2 Tank Closure Activities (Radioactive Liquid Waste Processing and Dispositioning)

Liquid radioactive waste is generated at SRS as a byproduct of the processing of nuclear materials (legacy liquid waste). The waste is stored in underground waste tanks grouped into two tank farms (F-Tank Farm and H-Tank Farm). The liquid waste in tank storage exists in two forms: sludge and salt. The waste removed from the tanks feeds the sludge and salt waste processing programs as depicted in Figure 3-2.

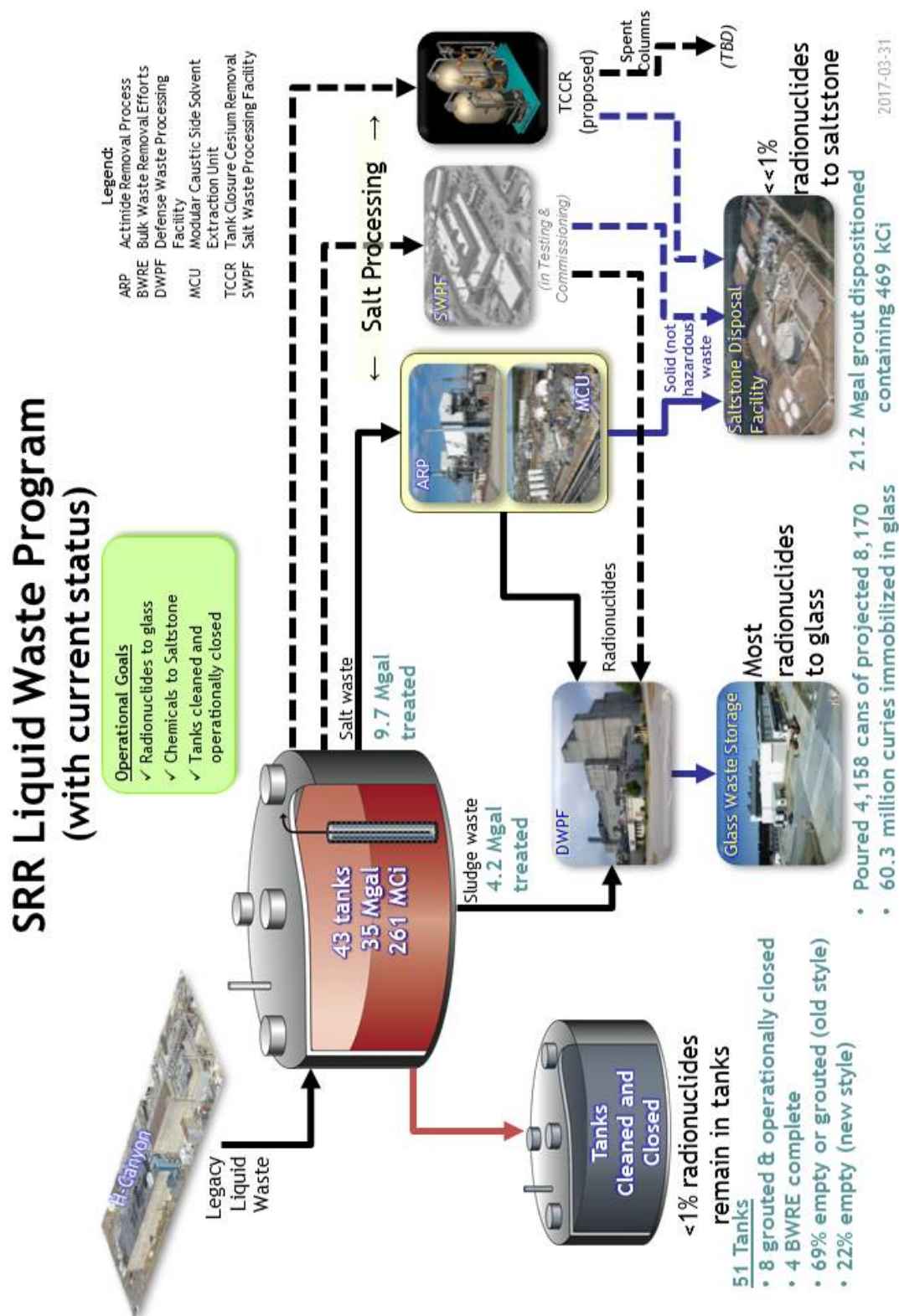


Figure 3-2 Pathway for Processing and Dispositioning of Radioactive Liquid Waste at SRS

3.2.2.1 Tank Closure

SCDHEC permits the F-Tank Farm and H-Tank Farm under the industrial wastewater regulations through the provisions of the FFA, Section IX, *High-Level Radioactive Waste Tank System(s)*. The FFA contains enforceable closure schedules for the liquid waste tanks. In addition, tank closures are subject to DOE Order 435.1, *Radioactive Waste Management*; federal regulations; and the Ronald W. Reagan National Defense Authorization Act (NDAA) for Fiscal Year 2005 Section 3116.

Prior to closure, the tanks undergo an extensive waste removal process that includes specialized mechanical cleaning and isolation from the waste transfer and chemical systems. Once these activities are complete, there is regulatory confirmation that the tanks are ready for stabilization by grouting. In 2016, SRS completed the operational closure of Tank 12H.

NDAA Section 3116(a) is legislation that allows the Secretary of Energy, in consultation with the NRC, to determine that certain waste from spent fuel reprocessing is not high-level radioactive waste and does not require deep geologic disposal. The NRC in coordination with SCDHEC monitors the disposal actions taken by DOE for the purposes of assessing compliance with the performance objectives of 10 CFR Part 61, Subpart C. Additionally, EPA may participate in NRC monitoring activities. [Section 3116 Determination for Closure of F-Tank Farm at the Savannah River Site](#) and [Section 3116 Determination for Closure of H-Tank Farm at the Savannah River Site](#) demonstrate that the stabilized tanks and ancillary structures in the F-Tank Farm and H-Tank Farm meet the necessary criteria and will not require permanent isolation in a deep geologic repository.

During 2016, the NRC performed an onsite observation visit for both F- and H-Tank Farms and reviewed various documents. The NRC did not identify any issues resulting from the visit and review of the provided documentation. More information on the February 2–3 visit is available in the [NRC Onsite Observation Visit Report](#). Ongoing communication between the NRC and SRS about the observation report is detailed on the [NRC Technical Review Letter](#).

You will find more information on Tank Closure activities on the [Tank Farms at the Savannah River Site](#) web page.

3.2.2.2 Salt Processing

The Actinide Removal Process and Modular Caustic Side Solvent Extraction Unit (ARP/MCU) is an interim salt waste processing system. SCDHEC permitted ARP/MCU under South Carolina industrial wastewater regulations. The salt form of the liquid waste comprises more than 90% of the volume and contains about half of the radioactivity in the tank farms. The ARP/MCU process removes actinides, strontium, and cesium from the salt waste taken from the liquid waste tank farms. In FY 2016, MCU processed about 1.1 million gallons of salt solution. The higher activity portion of the salt waste—a very small stream—is sent to the Defense Waste Processing Facility. The remaining portion is a decontaminated salt solution sent to the Saltstone facilities. The Salt Waste Processing Facility (SWPF) will replace the ARP/MCU process, as Figure 3-2 shows. The SWPF construction was completed on April 29, 2016. This facility is currently undergoing testing and commissioning to prepare for startup and operation.

More information is available in the [Liquid Waste Disposition](#) fact sheet on the SRS web page.

3.2.2.3 Salt Disposition

The low-activity salt solution is sent to the Saltstone Production Facility after ARP/MCU for processing into grout for disposition in the Saltstone Disposal Facility (SDF). SCDHEC permits operation of the SDF under the South Carolina solid waste landfill regulations. SRS disposes of treated low-level salt waste in the SDF based on the Secretary of Energy's determination pursuant to Section 3116 of the NDAA legislation. The basis for this determination is found at [Section 3116](#)



Figure 3-3 Salt Disposal Unit 6 (SDU-6)

[Determination for Salt Waste Disposal at the Savannah River Site](#). NDAA Section

3116(b) requires that NRC, in coordination with SCDHEC, monitor the disposal actions taken by DOE for the purposes of assessing compliance with the performance objectives of 10 CFR Part 61. Additionally, EPA may participate in NRC monitoring activities, as depicted in Figure 3-2.

In FY 2016, more than 1.5 million gallons of waste was processed and disposed of through the Saltstone facilities. In 2016, SRS continued to use cylindrical Saltstone Disposal Units (SDUs) for disposal operations. In 2016, SRS completed the construction of SDU-6, a new design for cylindrical SDUs (see Figure 3-3). The 32 million-gallon concrete rubber-lined tank completed hydro testing in December and is expected to be placed into operation in 2018.

More information on salt disposition, NDAA Section 3116(a) activities is available on the [Salt Waste Disposal at the Savannah River Site](#) web page.

3.2.2.4 Sludge Waste Processing—Vitrification of High-Activity Waste

SCDHEC permits DWPF to operate under South Carolina industrial wastewater regulations. The sludge waste comprises less than 10% of the volume of waste stored in the tanks and contains about half of the radioactivity, as shown in Figure 3-2. DWPF receives the high-activity portion of both the sludge and salt wastes, where it is combined with frit and sent to the plant's melter. In the melter, electricity is used to heat the waste/frit mixture to nearly 2,100 degrees Fahrenheit, until molten. This molten glass-waste mixture is poured into stainless steel canisters to cool and harden. This process is known as vitrification. SRS temporarily stores these canisters in the Glass Waste Storage Buildings, in preparation for final disposal in a federal repository.

In FY 2016, DWPF produced 136 canisters with more than 490,000 pounds of vitrified glass, immobilizing approximately 2.6 million curies of radioactivity. Since operations began in March 1996, more than 15.8 million pounds of vitrified glass have been produced, and 59.9 million curies have been immobilized.

More information is available in the [Waste Solidification](#) fact sheet on the SRS web page.

3.2.2.5 Low-Level Liquid Waste Treatment

Low-level radioactive wastewater from the tank farms is treated in the F- and H-Area Effluent Treatment Project (ETP). ETP removes chemical and radioactive contaminants before releasing the water into Upper Three Runs Creek, an onsite stream that flows to the Savannah River. The point of discharge is a South Carolina NPDES permitted outfall. ETP processed 6.7 million gallons of treated wastewater in FY 2016. SCDHEC permitted the ETP under the South Carolina industrial wastewater regulations. ETP remained in compliance with the industrial wastewater permit and the NPDES permit throughout 2016.

3.3 REGULATORY COMPLIANCE

This section provides a summary of SRS compliance with the applicable federal and state environmental laws and regulations.

3.3.1 Atomic Energy Act/DOE Order 435.1, *Radioactive Waste Management*

SRS waste and materials management is complex and includes numerous facilities that are governed by DOE Orders and federal and state regulations. SRS manages, treats, and stores low-level, high-level, and transuranic (TRU) waste in compliance with DOE Order 435.1. Only low-level waste is disposed of at SRS, at the E-Area Low-Level Waste Facility and the Saltstone Disposal Facility. Low-level waste is radioactive waste not classified as high-level or TRU waste.

As required by [DOE Manual 435.1-1, *Radioactive Waste Management Manual*](#), DOE prepares performance assessments (PAs) to evaluate the potential impacts of low-level radioactive waste disposal and closure activities (for example, Tank Farms) to the workers, the public, and the environment. The PAs provide the technical basis and evaluation needed to demonstrate compliance with DOE Order 435.1. The order also requires completion of a composite analysis (CA) to assess the combined impact of multiple low-level waste disposal facilities and other interacting sources of radioactive material after closure.

SRS performs a comprehensive annual PA review for disposal facilities to ensure any developing information does not alter the original PA conclusions and there is a reasonable expectation the facility will continue to meet the performance objectives of the DOE Order. In addition, SRS performs an annual CA review evaluating the adequacy of the 2010 SRS CA and verifying that SRS activities were conducted within the bounds of the 2010 analysis. The FY 2016 annual reviews for the disposal facilities and the CA determined that SRS continues to be in compliance with the performance objectives of DOE Order 435.1.

SRS generates another category of radioactive waste: transuranic (TRU) waste. DOE Orders define TRU waste as waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes (elements with atomic numbers greater than uranium) per gram of waste with half-lives greater than 20 years. At SRS, examples of TRU waste include clothing, tools,



Waste Removal at TRU Pad 2

rags, residues, debris, and other items associated with trace amounts of plutonium. SRS TRU waste will be sent to the Waste Isolation Pilot Plant (WIPP), a deep geologic repository for the permanent disposal of TRU waste. Many different federal and state agencies (EPA, NRC, DOE, and the State of New Mexico), along with multiple regulations, govern TRU waste management and disposal.

SRS manages TRU waste under DOE Orders and federal and state hazardous and toxic waste regulations. There were no TRU waste shipments to the WIPP in 2016, as the facility did not accept any shipments.

3.3.2 Resource Conservation and Recovery Act (RCRA)

RCRA establishes regulatory standards for generating, transporting, storing, treating, and disposing of hazardous waste, such as flammable or corrosive liquids. The EPA authorizes SCDHEC to regulate hazardous waste and the hazardous components of mixed waste. SCDHEC issued a RCRA hazardous waste permit to SRS. In 2016, the Site received approval for RCRA permits for the operational TRU pads and the Solvent Storage Tanks S33-S36 Facilities.

In 2016, SRS operated active treatment, storage and disposal facilities, and maintained closed facilities in compliance with SRS RCRA permit requirements. Subtitle I of RCRA regulates 19 underground storage tanks (USTs) containing usable petroleum products. These tanks require an annual compliance certificate from SCDHEC. A SCDHEC inspection and audit on October 25 found all 19 tanks to be in compliance, marking 14 consecutive years without a violation.

SRS began a RCRA closure and waste removal from TRU Pad 2 in 2016. The RCRA Closure Plan was submitted to SCDHEC on May 16 and was approved on September 15. SRS notified the regulators that the last waste on the pad had been removed on September 9. Closure began in early October and is projected to continue into 2017.

3.3.3 Federal Facility Compliance Act (FFCA)

The Federal Facility Compliance Act (FFCA) was signed into law in October 1992 as an amendment to the Solid Waste Disposal Act. It adds provisions for the application of certain requirements and sanctions to federal facilities. A Site Treatment Plan (STP) Consent Order (95-22-HW, as amended) was obtained and implemented in 1995, as required by the FFCA. SCDHEC executed *A Statement of Mutual Understanding for Cleanup Credits in October 2003*, allowing SRS to earn credits for certain accelerated cleanup actions. Credits can then be applied to the STP commitment schedules. In 2011, DOE requested a revision to the annual frequency for updating the STP. SCDHEC agreed that DOE must submit an annual STP update to SCDHEC for 2011 and prepare updates every five years.

SRS and SCDHEC held STP Cleanup Credit validation meetings in May, August, and October. A total of 2,546 Cleanup Credits were earned and validated during FY 2016.

In November, SRS submitted the *Savannah River Site Approved Site Treatment Plan, 2016 Update*, the first STP on the five-year update frequency, to SCDHEC. The STP 2016 update documents the storage of 135,113 cubic meters (m³) of mixed waste as of July 1, 2016 versus 146,262 m³ stored in 2011. Numerous waste streams originally contained in the STP have been treated or disposed offsite, or both. SRS does not anticipate generating additional waste that meets the criteria of these former waste streams. Therefore, SRS eliminated them from the STP 2016 update.

3.3.4 Toxic Substances Control Act (TSCA)

SRS complies with Toxic Substances Control Act (TSCA) regulations for the storage and disposal of lead, asbestos, and organic chemicals including polychlorinated biphenyl compounds (PCBs). SRS disposes of routinely generated nonradioactive PCBs at an offsite EPA-approved disposal facility within the regulatory defined period of one year from the date of generation. SRS also generates radioactive waste contaminated with PCBs. Low-level radioactive PCB bulk product waste is disposed of onsite. PCB waste that is contaminated with TRU requires disposal at the WIPP, located in New Mexico. SRS did not send any PCB TRU waste to WIPP in 2016.

SRS completed the 2016 annual PCB document log on March 20, 2017 and submitted the 2016 annual report of onsite PCB disposal activities to EPA on June 14, 2017, meeting applicable requirements.

3.3.5 South Carolina Infectious Waste Management Regulation

SRS is a large-quantity generator of infectious waste registered under the SCDHEC Infectious Waste Management program. SRS contracts with a vendor for monthly pickup of infectious waste. Once offsite, the waste is then treated and disposed of in accordance with the SCDHEC regulations. In 2016, SRS managed all infectious wastes in compliance with the requirements for treatment, storage, transportation, and disposal or destruction. In 2016, SCDHEC did not perform an inspection of the SRS Infectious Waste Management Program.

3.3.6 Air Quality and Protection

3.3.6.1 Clean Air Act (CAA)

EPA has delegated regulatory authority for all types of air emissions to SCDHEC. SRS is required to comply with SCDHEC Regulation 61-62, *Air Pollution Control Regulations and Standards*. SRS currently has the following five air permits regulating activities on the Site:

- Part 70 Air Quality Permit (TV-0080-0041),
- 784-7A Biomass Boiler Construction Permit (TV-0080-0041a-CG-R1),
- 784-7A Oil Boiler Construction Permit (TV-0080-0041a-CF-R1)
- Ameresco Federal Solutions, Inc. ("Ameresco") Biomass Facilities Permit (TV-0080-0144)
- Mixed Oxide Fuel Fabrication Facility (MFFF) (TV-0080-0139-CA-R1)

Under the CAA, SRS is considered a "major source" of nonradiological air emissions and, therefore, falls under the CAA Part 70 Operating Permit Program. The Part 70 Operating Permit regulates stationary sources with the potential to emit five tons or more per year of any criteria pollutant (six of the most common air pollutants: ozone precursors, particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide, and lead). These major stationary sources are subject to operating and emission limits, as well as emissions monitoring and record-keeping requirements.

The EPA sets the National Ambient Air Quality Standards air pollution control standards, and SCDHEC regulates them. The Part 70 Operating Permit requires SRS to demonstrate compliance through air dispersion modeling and submitting an emissions inventory of air pollutant emissions every three years.

The current CAA Permit expired on March 31, 2008. SRS submitted a complete renewal application of the current permit prior to the expiration date. SCDHEC granted an application shield, effective on September

21, 2007, allowing the Site to continue operating under the expired permit. In 2016, the Site continued to operate under the expired Part 70 Air Quality Permit.

3.3.6.2 Accidental Release Prevention Program

The CAA Amendments of 1990, Section 112(r) requires any facility that maintains specific hazardous or extremely hazardous chemicals in quantities above specified threshold values to develop a risk management plan. SRS has maintained hazardous and extremely hazardous chemical inventories below the threshold value; therefore, SRS has not been required to develop a risk management plan. Additionally, no reportable 112(r)-related hazardous or extremely hazardous chemical releases occurred at SRS in 2016.

3.3.6.3 Ozone-Depleting Substance (ODS)

The CAA mandates air quality standards to protect the stratospheric ozone. Releases of chemical gases widely used as refrigerants, insulating foams, solvents, and fire extinguishers cause ozone depletion. Some of these ODSs include chlorofluorocarbons, hydrofluorocarbons, and halons. SRS complies with the standards for emissions reduction and the systematic reduction of ODSs to ensure no ODS is knowingly or willfully released into the atmosphere. SRS reported no exceedances in 2016.

3.3.6.4 Air Emissions Inventory

SCDHEC Regulation 61-62.1, Section III (*Emissions Inventory*), requires compiling an air emissions inventory in order to locate all sources of air pollution and to define and characterize the various types and amounts of pollutants. The schedule for submitting the inventory is either every year or every three years, depending on the emission thresholds the regulations establish.

SRS submitted the 2015 electronic emissions inventory on March 31, 2016. SCDHEC confirmed, based on the maximum potential controlled values in the SRS permit, that SRS is not required to submit an annual emissions inventory for 2016. SRS will submit the next inventory for 2017 before March 31, 2018. The most recent information on the EPA [National Emission Inventories](#) is available on the website.

3.3.6.5 National Emission Standard for Hazardous Air Pollutants (NESHAP)

The National Emission Standards for Hazardous Air Pollutants (NESHAP) is a CAA-implementing program that sets air quality standards for hazardous air pollutants, such as radionuclides, benzene, Reciprocating Internal Combustion Engines (RICE) emissions, and asbestos.

3.3.6.5.1 NESHAP Radionuclide Program

SRS maintains compliance with the NESHAP Radionuclide Program by performing all required inspections and maintaining monitoring systems. Subpart H of the NESHAP regulations requires SRS to determine and report annually (by June 30) the highest effective dose from airborne emissions to any member of the public at an offsite point. SRS transmitted the *SRS Radionuclide Air Emissions Annual Report for 2015* on June 23, 2016 to EPA, SCDHEC, and DOE Headquarters.

During 2016, the maximally exposed individual (MEI) effective dose equivalent, calculated using the NESHAP-required CAP88 computer code, was estimated to be less than 1% of the EPA standard of 10 millirem (mrem) per year. Chapter 6, *Radiological Dose Assessment*, contains details on this dose calculation.

3.3.6.5.2 NESHAP Nonradionuclide Program

In 2013, NESHAP emission standards applicable to stationary Reciprocating Internal Combustion Engine (RICE) equipment—such as portable generators, emergency generators, and compressors—became effective. These regulations impact numerous pieces of SRS's RICE equipment. RICE equipment must also comply with the New Source Performance Standards. In January and July 2016, SRS submitted the semiannual compliance reports demonstrating compliance with the regulations.

In August 2016, SCDHEC inspected SRS and identified items at the 784-7A Biomass Steam Plant that it referred to its Enforcement Office for review related to NESHAP Boiler Maximum Achievable Control Technology (MACT) compliance. The results of the Enforcement Office review will be discussed in the 2017 annual report.

3.3.6.5.3 NESHAP Asbestos Abatement Program

Asbestos activities at SRS fall under SCDHEC and federal regulations. These activities—operation and maintenance repairs, removing asbestos, and demolishing buildings—require an asbestos notification, a renovation permit, or a demolition permit.

SRS issued 132 asbestos notifications and conducted 110 permitted renovations and demolitions involving asbestos in 2016. Table 3-1 summarizes these removals. Certified personnel removed and disposed of friable (easily crumbled or pulverized) and nonfriable asbestos. Both disposal sites for nonradiological asbestos waste are SCDHEC-approved landfills for the disposal of regulated and nonregulated asbestos.

SRS maintains a SCDHEC Temporary Storage Containment Area License that facilitates removing and disposing of waste generated from nonradiological operations and maintenance activities and minor and small projects. Additionally, SRS maintains a SCDHEC Asbestos Group License that allows SRNS and SRR to operate as a long-term, in-house asbestos abatement contractor for DOE-Savannah River.

Table 3-1 Summary of Quantities of Asbestos Materials Removed in 2016

Asbestos Type	Nonradiological, Friable	Nonradiological, Nonfriable	Radiologically Contaminated Asbestos
Linear Feet Disposed	244	147	101
Square Feet Disposed	93	8499	539
Cubic Feet Disposed	29	148	0
Disposal Site	Three Rivers Solid Waste Authority Landfill	SRS Construction and Demolition Landfill	SRS E-Area Low-Level Waste Facility

3.3.7 Water Quality and Protection

3.3.7.1 Clean Water Act (CWA)

With the exception of Ameresco, which has its own CWA National Pollutant Discharge Elimination System (NPDES) permit, SRS operated pursuant to the following CWA permits in 2016:

- Land Application Permit (ND0072125)
- General Permit for Storm Water Discharges Associated with Industrial Activities (Except Construction) (SCR000000)
- Permit for Discharge to Surface Waters (SC0000175)
- Permit for Discharge to Surface Waters (SC0047431)
- General Permit for Stormwater Discharges from Construction Activities (SCR100000)
- General Permit for Utility Water Discharges (SCG250000)
- General Permit for Discharges from Application of Pesticides (SCG160000)
- General Permit for Vehicle Wash Water Discharges (SCG750000)
- General Wastewater Construction Permit (SCG580000)
- General Construction Permit for Water Supply Distribution Systems (151218)
- General Permit for Land Disturbing Activities at SRS.

Information on these permits is available at the [EPA's Enforcement and Compliance History Online \(ECHO\)](#) database.

3.3.7.1.1 National Pollutant Discharge Elimination System (NPDES)

SCDHEC administers the NPDES program. The program protects surface waters by limiting releases of pollutants into streams, reservoirs, and wetlands. As shown in the previous section, multiple permits issued to SRS govern different types of discharges to surface water. A major goal of the NPDES program is to control or eliminate discharges of toxic pollutants, oil, hazardous substances, sediment, and contaminated storm water to protect the quality of our nation's water. To achieve this goal, SRS is required to prepare a Best Management Plan to identify and control the discharge of hazardous and toxic substances, a Storm Water Pollution Prevention Plan (SWPPP) to address the potential discharge of pollutants in stormwater, and a Spill Prevention, Control, and Countermeasure (SPCC) plan to minimize the potential for discharges of oil, including petroleum, fuel oil, sludge, and oily wastewater.

SRS has two NPDES permits for industrial activities that discharge to surface water: one covering D-Area (Permit No. SC0047431 NPDES Permit for Discharge to Surface Waters) and the other for the remainder of the Site (Permit No. SC0000175 NPDES Permit for Discharge to Surface Waters). Throughout the year, SRS monitors 28 NPDES-permitted industrial wastewater outfalls across SRS on a frequency specified by the permits. Monitoring requirements vary from as much as once a day at some locations to once a quarter at others, although typically they are conducted once a month. For each outfall, physical, chemical, and biological parameters are determined and reported to SCDHEC in SRS monthly discharge monitoring reports, as required by the permit. Chapter 4, *Nonradiological Environmental Program*, provides additional information about sampling as required to remain compliant with SRS's NPDES permits.

The following are highlights under the NPDES program in 2016:

- In August, the SRS D-Area NPDES program had a permit exceedance at the D-01C outfall. SCDHEC issued a Notice of Violation (NOV) in December to SRS for the exceedance of the Total Suspended Solids (TSS) permit limit for the D-01C outfall.
- Heavy rains in September caused a flow limit exceedance at K-12 outfall, which did not result in an NOV.
- In September, SCDHEC conducted the annual compliance evaluation inspection and issued a satisfactory rating, the highest grade possible. The inspection included records and procedures reviews; personnel interviews; and outfall, treatment facility, and land application site inspections.
- In October, DOE mailed an outline plan for the submittal of the NPDES Industrial Wastewater renewal application identifying which outfalls will not require updates and listing outfalls that will require updates. In December, SRS and DOE submitted revised NPDES Wastewater 2C applications to renew three outfalls and create one new industrial wastewater outfall.
- SRS SWPPP contains information on all SRS outfalls and outfall facilities. SRS currently has 35 outfalls that this SWPPP covers.
- SCDHEC did not require construction stormwater monitoring of the eight active construction projects underway at SRS.
- The construction, operation, and closure of industrial wastewater treatment facilities are permitted under the NPDES program. Facilities permitted are broad in scope and include those involved with groundwater remediation, radioactive liquid waste processing, and nuclear nonproliferation. In November, SCDHEC inspected the Waste Solidification Building and Tank 26, both permitted industrial wastewater treatment facilities.
- SRNS submitted a Notice of Intent for the NPDES General Permit for Discharges from the Application of Pesticides in 2015 for woody vegetation control of approximately 35 acres at various ponds and lakes at SRS. The state issued a certificate of coverage SCG160155 under the existing NPDES General Permit. The State of South Carolina then issued a new NPDES General Permit for Discharges from the Application of Pesticides effective April 1, 2016 through March 31, 2021. SRS pesticide application activities are now covered under this new general permit.

You will find the results from sampling of both industrial and stormwater outfalls in the 2016 Environmental Monitoring Program Data Report (SRNS 2017a).

3.3.7.1.2 Section 404(e) Dredge and Fill Permits

Wetlands comprise 48,973 acres on SRS, which is 25% of the total SRS area. SRS wetlands account for over 80% of the wetlands across the entire DOE complex. Permits under Section 404 are required when work will be conducted in a wetland area. The Nationwide Permits (NWP) program (general permits under Section 404[e]) are within the jurisdiction of the U.S. Army Corps of Engineers. Permits issued under the NWPs program are for projects that have minimal impact on the aquatic environment. In 2016, SRS had five open permits under the NWPs program, as follows:

- SRS completed dam construction on an unnamed tributary to Fourmile Branch for the Mixed Waste Management Facility Groundwater Interim Measures project in 2000 under NWP 38, *Hazardous Waste Cleanup*. However, mitigation for the impact to wetlands was pending in 2016.

Additional regulatory correspondence is ongoing to provide updated NWP 38 compliance information.

- SRS installed wells for attenuation-based sampling for I-129 and Tc-99 at four locations in wetlands along Four Mile Branch. This activity was permitted by rule under NWP 5—*Scientific Measurement Devices* in January.
- The U.S. Forest Service installed exclusions in wetlands at research plots for quantifying insect contribution to wood decomposition. This activity was permitted by rule under NWP 5—*Scientific Measurement Devices* in January.
- SRS installed a wooden deck in wetlands and aluminum dock ladder in Steel Creek at the SC-2A environmental sampling station. This activity was permitted by rule under NWP 5—*Scientific Measurement Devices* in April.
- The U.S. Forest Service replaced a wooden boat dock on L-Lake with a prefabricated plastic floating dock. This activity was permitted by rule under NWP 18—*Minor Discharges* in May.

3.3.7.2 Safe Drinking Water Act (SDWA)

SCDHEC regulates drinking water facilities under the SDWA. SRS uses groundwater sources to supply onsite drinking water facilities. The A-Area drinking water system supplies most Site areas. Remote facilities, such as field laboratories, barricades, and pump houses, use small drinking water systems or bottled water.

SCDHEC requires SRS to collect 10 bacteriological samples each month from the domestic water system that supplies drinking water to most areas at SRS. SRS exceeds this requirement by collecting 15 samples each month from various areas. Bacteriological analyses are performed on all samples. The sample results consistently meet SCDHEC and EPA drinking water quality standards, confirming the absence of harmful bacteria. In December, SRS collected 7 samples instead of the required 10. SRS notified SCDHEC of this failure to collect the required number of samples. SRS has identified corrective actions to prevent a reoccurrence. Results for the seven bacteriological samples taken met drinking water quality standards.

SRS samples domestic water systems for lead and copper on a three-year, rotating cycle. In 2016, SRS sampled the A-Area water system for lead and copper. The results did not exceed action levels for lead and copper.

3.3.8 Environmental Protection and Resource Management

3.3.8.1 National Environmental Policy Act (NEPA)

The NEPA process identifies the potential environmental consequences of proposed federal activities and the alternatives to support informed environmentally sound decision-making regarding the design and implementation of the proposed activities.

The NEPA program complies with DOE Order 451.1B. SRS initiates the evaluation NEPA requires by completing an Environmental Evaluation Checklist (EEC) for new projects or changes to existing projects. SRS uses the EEC to review the proposed action, identify any potential environmental concerns, and determine the appropriate level of NEPA review required for the proposed activity.

SRS conducted 465 NEPA reviews in 2016 (Table 3-2). Categorical exclusion (CX) determinations accounted for 89% of completed reviews. Additional information on SRS NEPA activities is on the [SRS NEPA](#) web page.

Table 3-2 Summary of 2016 NEPA Reviews

Type of NEPA Review	Number
CX Determinations ^a	415
“All No” Environmental Evaluation Checklist (EEC)	35
Actions Tiered to Previous NEPA Reviews	10
Environmental Impact Statement (EIS)	1
Supplement Analysis (SA)	2
Interim Action	0
Revised Finding of No Significant Impact (FONSI)	0
Environmental Assessment (EA)	2
Total	465
Note: ^a Proposed actions that require no further NEPA action	

SRS completed the following major NEPA reviews in 2016:

- Final Environmental Impact Statement for the Disposal of Greater-than-Class-C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste (DOE/EIS-0375) (In progress). DOE is evaluating disposal of GTCC low-level radioactive waste (LLRW) and GTCC-like LLRW in a geologic repository, in intermediate-depth boreholes, and in enhanced near-surface disposal facilities. SRS is an alternative location for these disposal facilities.
- Supplement Analysis of the Mark-18A Target Material Recovery Program at the Savannah River Site (DOE/EIS-0220-SA-02, DOE/EIS-0279-SA-06)(In progress). This SA evaluates whether the proposed action requires supplementing the existing *Final Environmental Impact Statement: Interim Management of Nuclear Materials at the Savannah River Site (IMNM EIS)* (DOE/EIS-0220) and the *Savannah River Site Spent Nuclear Fuel Management Environmental Impact Statement (SRS SNF EIS)* (DOE/EIS-0279).
- Supplemental Analysis for the Uranium Lease and Take-Back Program for Irradiation for Production of Molybdenum-99 for Medical Use (DOE/EIS-0279-SA-05, DOE/EIS-0387-SA-02) DOE determined that 1) no supplemental or new EIS's are required to establish and implement the ULTB Program, and 2) no further NEPA documentation is required to establish and implement the ULTB Program. The SA was signed on February 11, 2016.

An *Environmental Assessment for the South Carolina Army National Guard Proposal to Construct and Operate Training Facilities and Infrastructure on 750 Acres at the Department of Energy Savannah River Site* (DOE/EA-1999) and the *Draft Environmental Assessment for the Acceptance and Disposition of Spent Nuclear Fuel Containing U.S.-Origin Highly Enriched Uranium From The Federal Republic Of Germany* (DOE/EA-1977) are both in progress.

3.3.8.2 Emergency Planning and Community Right-to-Know (EPCRA)/Superfund Amendment Reauthorization Act (SARA) Title III

EPCRA requires facilities to notify state and local emergency planning entities about their hazardous chemical inventories and to report releases of hazardous chemicals. The Pollution Prevention Act of 1990 expanded the EPCRA-mandated Toxic Release Inventory (TRI) report to include waste management activities. SRS complies with the applicable EPCRA reporting requirements and incorporates the applicable TRI chemicals into its pollution prevention programs.

As required by Section 312, *Chemical Inventory Reporting*, of EPCRA, SRS completes an annual Tier II Chemical Inventory Report for all hazardous chemicals in excess of specified quantities present at SRS during the calendar year. SRS submitted the 2016 hazardous chemical storage information to state and local authorities electronically via the Homeland Security E-Plan on February 14, 2017. The report included 58 reportable chemical categories, down from 63 in the previous year.

As required by Section 313, *Toxic Chemical Release Inventory*, of EPCRA, SRS must file an annual TRI report each year by July 1 for the previous year. SRS calculates chemical releases to the environment for each regulated chemical and reports those above the threshold value to EPA. For 2016, SRS submitted the Toxic Release Inventory Report on June 12, 2017 for each of the following regulated chemicals: ammonia, chromium compounds, copper, formic acid, lead compounds, manganese, mercury compounds, naphthalene, nickel compounds, nitrate compounds, nitric acid, sodium nitrite, and sulfuric acid. Details are on the [EPA Toxic Release Inventory Program](#) website.

3.3.8.3 Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

The objective of FIFRA is to provide federal control of pesticide distribution, sale, and use. The EPA must register all pesticides used in the United States. Use of each registered pesticide must be consistent with use directions contained on the package's label. SRS must comply with FIFRA and, on a state level, the South Carolina Pesticide Control Act.

SRS must also comply with the South Carolina NPDES General Permit for discharges from the application of pesticides. This permit authorizes the application of pesticides to surface water in accordance to limitations set forth in the NPDES general permit.

SRS procedures implement the FIFRA requirements for pesticide application, application record keeping, storage, and disposal of empty containers and excess pesticides. General use pesticides (ready-to-use products that are available for public use) are applied at SRS per the label instructions. SRS applies restricted-use pesticides on a very limited basis per their label requirements using state-certified pesticide applicators. Application records for general use and restricted use pesticides are generated and maintained for each application.

3.3.8.4 Endangered Species Act (ESA)

The ESA designates and protects wildlife, fish, and plants in danger of becoming extinct. This federal law also protects and conserves their critical habitats. Several federally listed animal species exist at SRS, including the wood stork, the red-cockaded woodpecker, the shortnose sturgeon, and the Atlantic sturgeon; as well as plant species, including the pondberry and the smooth coneflower.

In addition, SRS is home to the gopher tortoise, a candidate for protection under the ESA. SRS is one of the first sites to conduct experimental translocations of gopher tortoises. Conservation organizations widely use protocols developed during the translocation to establish viable populations elsewhere in the species' range.

South Carolina has enacted legislation that lists additional plants and animals not on the federal list to encourage management of populations of those species of conservation concern. Those found on SRS include the Carolina gopher frog and the swallow-tailed kite. While the bald eagle is no longer on the federally listed endangered or threatened species list, nesting bald eagles and wintering golden eagles remain protected by the Bald and Golden Eagle Protection Act. Bald eagles nest on SRS and are considered year-round residents. Golden eagles use SRS as a wintering habitat. The U.S. Forest Service-Savannah River (USFS-SR) manages programs onsite to enhance the habitat and survival of these species.



Golden Eagle

The USFS-SR actively manages more than 65,000 acres in the red-cockaded woodpecker habitat management area using mechanical and chemical removal and prescribed fires to effectively create and improve habitat by restoring the natural fire regime, improving native plant diversity in the understory and enhancing native pine stands. Additionally, the USFS-SR inserts artificial cavities into living pine trees to supplement the available cavities for roosting and nesting. From 1985 through FY 2016, the number of active red-cockaded woodpecker clusters increased from 3 to 93 due to successful habitat restoration. As of 2016, the USFS-SR manages 111 cluster sites for the red-cockaded woodpecker with an average population growth rate of 5% each year.



Southern Hognose Snake
(photo courtesy of JD Wilson, SREL)

During FY 2016, while implementing the [United States Department of Energy Natural Resources Management Plan for SRS](#), USFS-SR developed two SRS watershed management plans resulting in three biological evaluation reviews for timber, research, and wildlife-related management. Two were for standard USFS-SR project plans, and one was for research of herbicide use in forest remnants. Two biological evaluations determined that forest implementation plans are not likely to adversely affect federally listed endangered or threatened species due to beneficial, insignificant, or discountable effects. One biological evaluation determined a potential to negatively impact the southern hognose snake, a species at risk. As a result, mitigation measures will be exercised.

3.3.8.5 National Historic Preservation Act (NHPA)

The NHPA requires that all federal agencies consider the impacts to historic properties in all their undertakings. SRS ensures compliance with the NHPA through several processes. SRS uses the Site Use Program, the *Cold War Programmatic Agreement*, and SRS's *Cold War Built Environment Cultural Resource Management Plan* to ensure compliance with NHPA. The Savannah River Archaeological Research Program (SRARP) provides cultural resource management guidance to DOE to ensure fulfillment of compliance commitments. SRARP also serves as a primary facility to investigate archaeological research problems associated with cultural development within the Savannah River valley. The results are used to help DOE manage more than 1,900 known archaeological sites at SRS.

SRARP evaluates and documents all locations being considered for activities, such as construction, to ensure that archaeological or historic sites are not impacted. In FY 2016, 443 acres of land on SRS were investigated for cultural resource management, including 31 field surveys and testing. Thirty-six newly discovered sites were recorded, and nine previously recorded sites were revisited.

3.3.8.6 Migratory Bird Treaty Act (MBTA)

The MBTA prohibits taking, possessing, importing, exporting, transporting, selling, purchasing, bartering, or offering for sale any migratory bird or its eggs, parts, and nests, except as authorized by the U.S. Department of the Interior under a valid permit. To support migratory bird monitoring, a Christmas Bird Count is conducted annually for one day in December. The 2016 count found 104 species. A bald eagle survey is conducted every year on one day in January. The 2016 eagle survey found 11 eagles.

In 2016, two northern mockingbird (*Mimus polyglottos*) nests, protected under the MBTA, were found in large mobile equipment around the Site. The equipment was barricaded until the hatchlings fledged or the nests were determined to be no longer in use.

Also in 2016, USFR-SR staff found an osprey (*Pandion haliaetus*) nest on a platform they built in 2014. This marked the second year that ospreys nested on the platform after their nest had been moved from a power pole at the L-Lake Dam.

3.3.9 **Release Reporting**

Federally permitted releases comply with legally enforceable licenses, permits, regulations, or orders. If an unpermitted release to the environment of an amount greater than, or equal to, a reportable quantity (RQ) of a hazardous substance (including radionuclides) occurs, EPCRA, CERCLA, CWA, and the CAA require notification be sent to the National Response Center and applicable state agencies.

SRS had one reportable CERCLA release in 2016. On May 19, six corrugated panels containing asbestos detached from a building and fell. The initial estimates indicated that 1.4 pounds of asbestos could have been released. A call was made to the National Response Center to report the release as required. On June 13, the incident was downgraded to a worst-case release of 0.5 pounds.

3.3.10 **Permits**

SRS had 424 construction and operating permits in 2016 that specified operating levels to each permitted source. Table 3-3 identifies the number of permit by the permit type. These numbers reflect permits for all organizations at SRS, with the exception of Ameresco.

Table 3-3 SRS Permits

Type of Permit	Number of Permits
Air	5
U.S. Army Corps of Engineers (USACE—Nationwide Permits)	5
Asbestos Demolition/Abatement/Temporary Storage of Asbestos Waste	110
Asbestos Abatement Group Permit	1
Asbestos Temporary Storage of Waste	1
Domestic Water	94
GA Department of Natural Resources Scientific Collecting Permit	1
Industrial Wastewater	77
NPDES Permits	11
Construction Stormwater Grading Permit	8
RCRA Hazardous Waste	1
RCRA Solid Waste	4
RCRA Underground Storage Tank	7
Sanitary Wastewater	88
SC Department of Natural Resources Scientific Collecting Permit	2
SCDHEC 401	0
SCDHEC Navigable Waters	0
Underground Injection Control	9
Total	424

3.4 MAJOR DOE ORDERS FOR ENVIRONMENTAL COMPLIANCE

SRS complies with the following major DOE Orders in addition to state and federal regulations for environmental compliance:

- DOE Order 451.1B, *Administrative Change 3, National Environmental Policy Act Compliance Program*. See the NEPA section of this chapter.
- DOE Order 436.1, *Departmental Sustainability*. See Chapter 2, *Environmental Management Systems*.
- DOE Order 458.1, *Administrative Change 3, Radiation Protection of the Public and the Environment*. See Chapter 5, *Radiological Environmental Monitoring Program*; and Chapter 6, *Radiological Dose Assessment*, of this report.
- DOE Order 435.1, *Change 1, Radioactive Waste Management*. See Radioactive Waste Management Section in this chapter.
- DOE Order 231.1B, *Environment, Safety and Health Reporting*, requires the preparation of this Annual Environmental Report.
- DOE Order 232.2, *Administrative Change 1, Occurrence Reporting and Processing of Operations Information*. This Order requires DOE to use the designated system called *Occurrence Reporting and Processing System (ORPS)*. The ORPS ensures that the DOE complex and the National Nuclear Security Administration are informed of events that could adversely affect the health and safety of

the public and workers, the environment, DOE missions, or the credibility of the Department. In 2016, there were no environmental ORPS reportable events from all contractors at SRS.

- DOE Order 226.1B, *Implementation of Department of Energy Oversight Policy*. This Order requires DOE to provide oversight related to protecting the public, workers, environment, and national security assets effectively through continuous improvement.

3.5 REGULATORY SELF-DISCLOSURES

SRS made one regulatory self-disclosure in 2016. SRS failed to collect 3 of the 10 samples of drinking water in December and self-reported the oversight to SCDHEC.

3.6 ENVIRONMENTAL AUDITS

SCDHEC, EPA, and the United States Army Corps of Engineers (USACE) inspected and audited the SRS environmental program for regulatory compliance. Table 3-4 summarizes the results of the 2016 audits and inspections.

**Table 3-4 Summary of 2016 External Agency Audits/Inspections
of the SRS Environmental Program and Results**

Audit/Inspection	Action	Results
632-G C&D Landfill, 288-F Ash Landfill, 488-4D Ash Landfill Inspections	SCDHEC conducted four quarterly inspections of the landfills.	No issues were identified.
Federal Energy Regulatory Commission (FERC) Inspection	FERC evaluated PAR Pond Dam; Steel Creek Dam (L Lake); and Ponds B, C, 2, 4, and 5 in May.	FERC has not sent the final report. FERC inspects SRS dams annually.
Comprehensive Groundwater Monitoring Evaluation	SCDHEC inspected groundwater facilities associated with the F- and H-Area Seepage Basins, M-Area Settling Basin, Metallurgical Laboratory Basin, Mixed Waste Management Facility, and Sanitary Landfill on April 20–21.	A records review of groundwater-related files was also completed. Inspectors identified two damaged groundwater monitoring well signs. SRS replaced the signs on April 27 and noted no other issues.
Industrial Wastewater Construction Permit Inspections	SCDHEC inspected the operation or closure of a variety of industrial wastewater treatment projects, including the Waste Solidification Building and Tank 16 in H Area.	No issues were identified.

**Table 3-4 Summary of 2016 External Agency Audits/Inspections
of the SRS Environmental Program and Results (continued)**

Audit/Inspection	Action	Results
Interim Sanitary Landfill and the F-Area Railroad Crosstie Pile Landfill Post-Closure Inspection	SCDHEC conducted an annual review of the landfills.	No issues were identified.
NPDES Industrial Wastewater 3560 Compliance Inspections	SCDHEC conducted an unannounced Compliance Evaluation Inspection and Compliance Sample Inspection of industrial wastewater outfalls beginning on September 12.	SCDHEC issued a satisfactory rating, the highest grade possible.
Air Compliance Inspection	SCDHEC conducted an unannounced inspection of SRS on August 1–2. It included the first-time review of Reciprocating Internal Combustion Engine and Boiler Maximum Achievable Control Technology standards.	SCDHEC identified items related to NESHAP Boiler Maximum Achievable Control Technology (MACT) compliance.
RCRA Compliance Evaluation Inspection (CEI)	SCDHEC inspected four facilities and reviewed hazardous waste program requirements (that is, notifications and reports to SCDHEC, plans, training records, internal inspections, and waste documentation) during its April 12–14 CEI.	SCDHEC and EPA identified deficiencies that were corrected before the end of the inspection. SCDHEC and EPA also noted potential deficiencies on one container on TRU Pad 15 and two containers on TRU Pad 17. SRS overpacked the three drums, and SCDHEC concurred that all cited deficiencies from the CEI were corrected.
Underground Storage Tank (UST) CEI	SCDHEC inspected 19 USTs.	No issues were identified.
Z-Area Saltstone Solid Waste Landfill Inspections	SCDHEC performed monthly inspections of the Saltstone Disposal Facility.	SCDHEC reviewed facility procedures and performed a walkdown of the SDF. No issues were noted.

3.7 KEY FEDERAL LAWS COMPLIANCE SUMMARY

Federal laws are implemented by regulations contained in the Code of Federal Regulations or state regulations if the program has been delegated to the state by the federal agency. You can find additional information online at epa.gov. Table 3-5 summarizes SRS's 2016 compliance status with applicable key federal environmental laws.

Table 3-5 Status of Key Federal Environmental Laws Applicable to SRS

Regulatory Program Description	2016 Status
The Atomic Energy Act/DOE Order 435.1 grants authority to DOE to develop applicable standards (documented in DOE Orders) for protecting the public and environment from radioactive materials.	The 2016 Performance Assessment review showed that radioactive low-level waste operations were within the required performance envelope, and the facilities continued to protect the public and environment.
The Clean Air Act (CAA) establishes air quality standards for criteria pollutants, such as sulfur dioxide and particulate matter, and for hazardous air emissions, such as radionuclides and benzene.	SRS continues to operate under a CAA Permit that expired on March 31, 2008. SRS continues to operate in accordance with all permit requirements of the CAA.
The Clean Water Act regulates liquid discharges at outfalls (e.g., drains or pipes) that carry effluent to streams (NPDES, Section 402); and regulates dredge and fill operations in waters of the United States (Section 404) and water quality for those activities (Water Quality Criteria, Section 401).	The SRS NPDES program maintained a 99.9% compliance rate. SCDHEC issued a Notice of Violation (NOV) for a TSS exceedance at D-01C.
The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) establishes criteria for liability and compensation, cleanup, and emergency response requirements for hazardous substances released to the environment.	SRS continues to comply with CERCLA and the requirements of the FFA.
The Emergency Planning and Community Right-to-Know Act (EPCRA), also referred to as SARA, Title III, requires reporting of hazardous substances and their releases to EPA, state emergency response commissions, and local planning units.	SRS complied with all reporting and emergency planning requirements.

Table 3-5 Status of Key Federal Environmental Laws Applicable to SRS (continued)

Regulatory Program Description	2016 Status
The Endangered Species Act (ESA) prevents the extinction of federally listed endangered or threatened species and conserves critical habitats.	SRS continued to protect these species and their habitats as outlined in the Natural Resource Management Plan for SRS.
The Federal Facility Agreement (FFA) for the Savannah River Site between the EPA, DOE, and SCDHEC integrates CERCLA and RCRA requirements to achieve a comprehensive remediation of high-level radioactive waste tanks at SRS.	SRS met all the commitments contained within the FFA.
The Federal Facility Compliance Act (FFCA) requires federal agencies to comply with all requirements of federal, state, and local solid and hazardous waste laws.	SRS continues to be in compliance with the FFCA.
The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates restricted-use pesticides through a state-administered certification program.	SRS continues to operate in compliance with FIFRA requirements.
The Migratory Bird Treaty Act (MBTA) provides for the protection of migratory birds, including their eggs and nests.	SRS continues to comply with the MBTA.
National Defense Authorization Act, Section 3116(a) (NDAA) allows the Secretary of Energy, in consultation with the Nuclear Regulatory Commission (NRC), to determine that certain waste from reprocessing is not high-level radioactive waste requiring deep geologic disposal if it meets the criteria set forth in Section 3116. Section 3116(b) addresses monitoring by NRC and SCDHEC.	NRC continues to monitor SRS facilities in accordance with NDAA 3116(a) and visited the Site twice.

Table 3-5 Status of Key Federal Environmental Laws Applicable to SRS (continued)

Regulatory Program Description	2016 Status
The National Environmental Policy Act (NEPA) requires federal agencies to identify potential environmental consequences of proposed federal actions and alternatives to ensure informed, environmentally sound decision-making regarding design and implementing programs and projects.	SRS is in full compliance with NEPA.
The National Historic Preservation Act (NHPA) protects historical and archaeological sites.	The Savannah River Archaeological Research Program (SRARP) provides cultural resource management guidance to DOE to ensure continued compliance with the NHPA.
The Resource Conservation and Recovery Act (RCRA) governs the management of hazardous and non-hazardous solid waste and underground storage tanks (USTs) containing petroleum products, hazardous materials, and wastes. RCRA also regulates universal waste and recyclable used oil.	SRS continues to manage hazardous, nonhazardous solid waste and USTs in compliance with RCRA.
The Safe Drinking Water Act (SDWA) protects drinking water and public drinking water resources.	In December, SRS collected 7 samples instead of the required 10. SRS self-reported this occurrence to SCDHEC. All of the 7 drinking water samples taken in December met drinking water quality standards.
The Toxic Substances Control Act (TSCA) regulates polychlorinated biphenyls (PCBs), radon, asbestos and lead and requires users to evaluate and notify EPA when new chemicals are used and significant new uses of existing chemicals occur.	SRS managed all TSCA-regulated materials in compliance with all requirements.

3.8 ENVIRONMENTAL COMPLIANCE SUMMARY

SRS was not involved in any environmental lawsuits during 2016. SRS received one NOV in 2016. Table 3-6 summarizes the NOVs received from 2012–2016.

Table 3-6 NOV Summaries, 2012–2016

Program Area	Notice of Violation (NOV)				
	2012	2013	2014	2015	2016
Clean Air Act (CAA)	0	0	0	1	0
Clean Water Act (CWA)	1	2	0	0	1
Resource Conservation and Recovery Act (RCRA)	0	0	0	0	0
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)	0	0	0	0	0
Others	0	0	0	0	0
Total	1	2	0	1	1

Chapter 4

Nonradiological Environmental Monitoring Program

The Savannah River Site (SRS) nonradiological environmental monitoring program is twofold in that it confirms that the Site is complying with state and federal regulations and permits and it monitors any effects SRS has on the environment, both onsite and offsite. SRS monitors permitted point-source discharges from onsite facilities for nonradiological parameters to ensure compliance with regulations and permit requirements. SRS collects and analyzes environmental media such as air, water, sediment, and fish for nonradiological parameters to evaluate the effect of Site operations on the environment.

2016 Highlights

Effluent Releases

- Nonradiological effluent releases for all categories except industrial wastewater were below permit limits and applicable standards.
- Only 2 of approximately 3,275 analyses at SRS industrial wastewater outfalls exceeded National Pollutant Discharge Elimination System (NPDES) permit limits, a 99.9% compliance rate.
- All SRS industrial stormwater outfalls under the NPDES permit were compliant.

Onsite Drinking Water

All SRS drinking water systems complied with South Carolina Department of Health and Environmental Control (SCDHEC) and U.S. Environmental Protection Agency (EPA) water quality standards. However, in December, SRS collected 7 of the required 10 samples from SRS drinking water systems. SRS notified SCDHEC of this shortage. Chapter 3, *Compliance Summary*, on Page 3-15 provides additional information.

Surveillance Program

- SRS discharges are not significantly affecting the water quality of onsite streams and the Savannah River.
- Sediment results from SRS streams, stormwater basins and the Savannah River were consistent with the background control locations and were comparable with historical levels.
- Fish flesh sample results indicated the majority of measured metals were not detectable. Zinc, found in 146 (99%) of the samples, was at levels consistent with the background control location. Mercury, detected and quantified in 74 (50%) of the samples, was consistent with 5-year trends for catfish, bream, mullet, sea trout, and red drum. Mercury levels in bass were similar to results from 2014 and 2015.

4.1 INTRODUCTION

Environmental monitoring programs at SRS examine both radiological and nonradiological constituents that SRS activities could release into the environment. Chapter 5, *Radiological Environmental Monitoring Program*, discusses the radiological components of this monitoring program.

The nonradiological monitoring program collects and analyzes air, water, sediment, and fish samples from numerous locations throughout SRS and the surrounding area. The program is divided into two focus areas: 1) effluent monitoring, and 2) environmental surveillance. The effluent monitoring sample results demonstrate permit compliance, as discussed in the respective sections of this chapter. The environmental surveillance sample results assess the environmental impacts of Site operations on the surrounding area. SRS determines sampling frequency and analyses based on permit-mandated monitoring requirements and federal regulations.

SRS conducts nonradiological environmental monitoring on the following categories:

- Atmospheric (airborne emissions and precipitation with a special focus on mercury deposition)
- Water (wastewater, stormwater, sludge, onsite drinking water, and river and stream water quality)
- Stream and river sediment
- Fish

Figure 4-1 shows the types and typical locations (for example, upstream and downstream of SRS influence) of the nonradiological sampling SRS performs.

This chapter summarizes the nonradiological environmental monitoring programs and data results. The *2016 Environmental Monitoring Data Report* (SRNS 2017a) documents all data associated with the SRS sampling this chapter describes. Appendix Table B-1 of this document summarizes the nonradiological surveillance sampling media and frequencies.

Chapter 4—Key Terms

Effluent is a release of treated or untreated water or air from a pipe or a stack to the environment. Liquid effluent flows into a body of water such as a stream or lake. Airborne effluent (also called emission) discharges into the air.

Effluent monitoring is the collection of samples or data from the point a facility discharges liquids or releases gases.

Environmental surveillance is the collection of samples beyond the effluent discharge points and from the surrounding environment.

Outfall is a place where treated or untreated water flows out of a pipe or ditch.

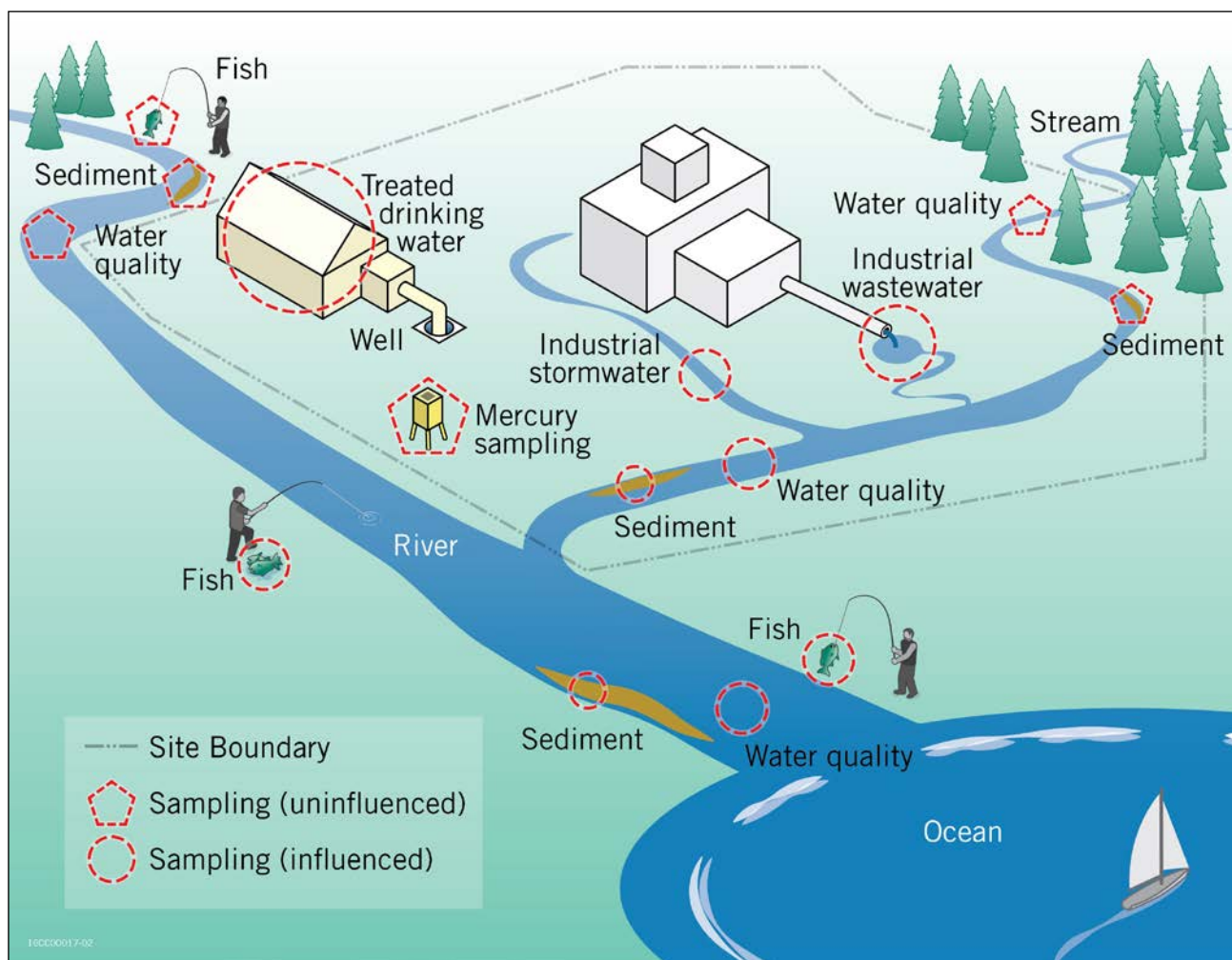


Figure 4-1 Types and Typical Locations of Nonradiological Sampling

4.2 CALCULATED AIR EMISSIONS

Airborne contaminants can present a risk to public health and the environment. Thus, identifying and quantifying these contaminants is essential to a nonradiological monitoring program. SCDHEC regulates nonradioactive air pollutant emissions from SRS sources. The regulations list pollutants, compliance limits, and methods to use to demonstrate compliance.

SRS uses nonradioactive volatile chemicals, fuels, and combustion products that can adversely impact the environment if released into the air in sufficient quantities. However, the Site uses most of these materials in very small quantities, and the environmental impact from their potential release is negligible. Because of the nature and quantity of potential air emissions, SRS is not required to sample or monitor the ambient air for chemical pollutants. Following SCDHEC requirements, SRS uses process data to calculate emissions.

Many of the applicable regulatory standards are source-dependent (that is, applicable to certain types of industries, processes, or equipment). The SCDHEC-issued [Title V](#) operating permit provides the source-specific limits for facility operation, source sampling, testing, monitoring, and reporting frequency. SRS demonstrates it is complying with these regulations by performing air dispersion modeling and submitting

an annual emissions inventory of air pollutant emissions. SRS uses standard calculations using source-operating parameters, such as hours of operation, process throughput, and EPA-approved emission factors to determine emissions. However, many of the SRS processes are unique sources requiring nonstandard, complex calculations. SRS compares the hourly and total actual annual emissions for each source against their respective permit limitations. Chapter 3, *Compliance Summary*, Section 3.3.6.4, *Air Emissions Inventory*, discusses emissions reporting.

4.3 WATER MONITORING

SRS nonradiological water monitoring includes collecting water and sediment samples from various water sources onsite and from the Savannah River. The analysis performed from the sample collection evaluates whether there is long-term buildup of pollutants downstream of discharge points and whether SRS is complying with permit requirements. SRS also collects and analyzes fish from the Savannah River to evaluate metal uptake in the flesh. SRS conducts groundwater monitoring as is discussed in Chapter 7, *Groundwater Management Program*.

4.3.1 Wastewater and Stormwater Monitoring

Nonradiological surface water monitoring primarily consists of sampling water discharges (industrial wastewater and industrial stormwater) associated with SRS NPDES-permitted outfalls. SRS monitors nonradiological liquid discharges to surface waters through the NPDES program, as mandated by the Clean Water Act. The NPDES permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States.

SCDHEC administers the NPDES permit program and is responsible for permitting, compliance tracking, monitoring, and enforcing the program. The permits SCDHEC issues to SRS provide specific requirements for sampling locations, parameters to be tested, monitoring frequency, and analytical and reporting methods.

NPDES samples are collected in the field according to 40 CFR 136, *Guidelines*

Establishing Test Procedures for the Analysis of Pollutants. This document lists specific methods for sample collecting, preserving, and analytical methods acceptable for the type of pollutant.

In 2016, SRS monitored 28 industrial wastewater outfalls for various physical and chemical properties including flow, dissolved oxygen, pH, ammonia, biochemical oxygen demand, fecal coliform, metals, oil and grease, volatile organic compounds, and total suspended solids (TSS). Figure 4-2 shows these locations. The permits specify how often the outfalls are to be monitored. Typically, SRS took samples at the locations once a month, although some locations require monitoring as frequently as once a day and others as infrequently as once a quarter. As specified by permits, SRS collected either composite or grab samples. SRS reported results to SCDHEC in required monthly discharge monitoring reports.



A Technician Measures the Amount of Dissolved Oxygen in a Water Sample

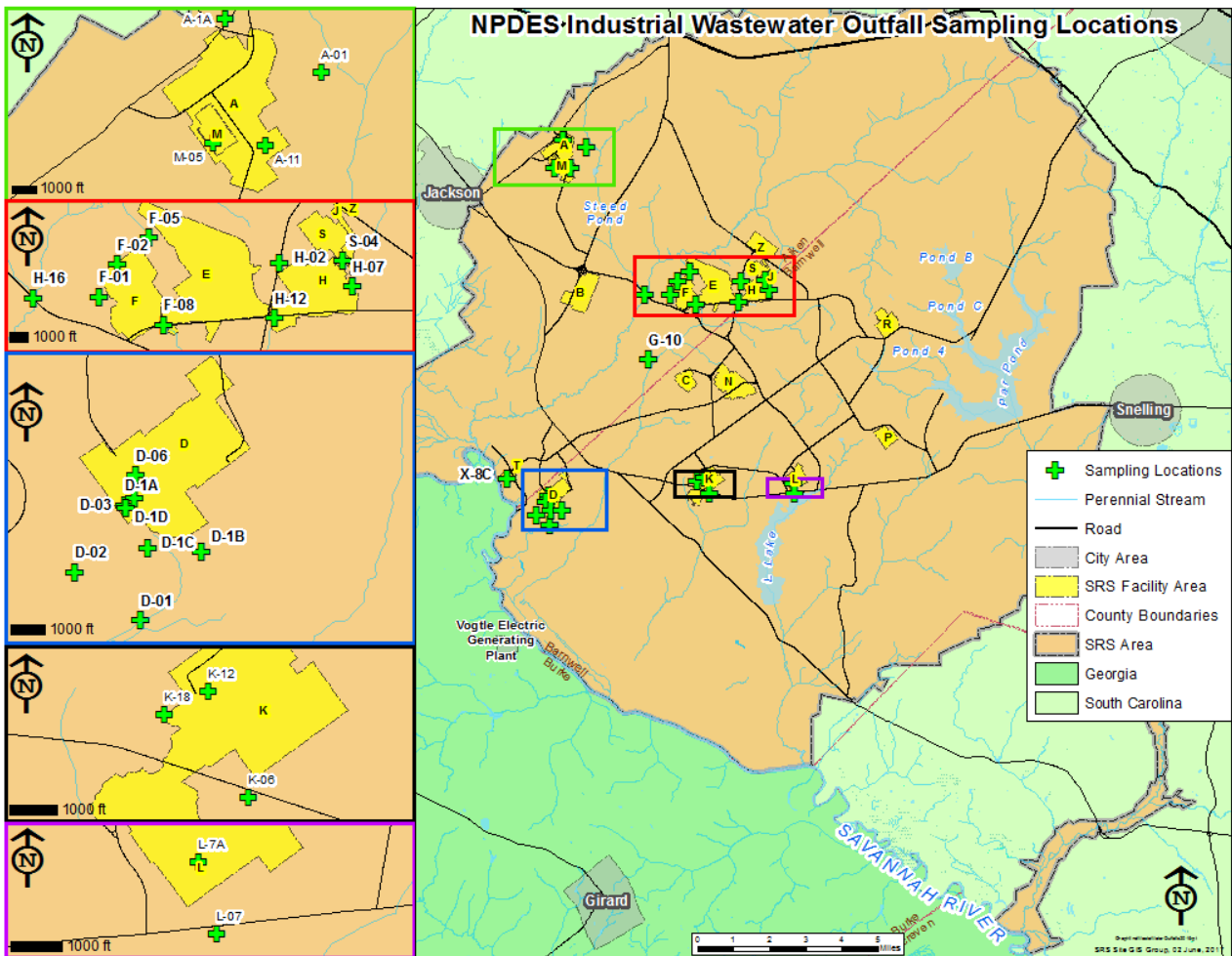


Figure 4-2 NPDES Industrial Wastewater Outfall Sampling Locations

In 2016, SRS monitored 35 industrial stormwater outfalls for copper, zinc, fecal coliform, and pH. In addition, sampling personnel visually assessed the water in these outfalls for color, odor, solids, foam, and oil sheen. Figure 4-3 shows these locations. SRS monitored the outfalls on the frequency the permit specified, varying from quarterly to annually. It used grab-sample techniques to collect the stormwater samples.

SRS can collect stormwater samples only during a qualifying rain event. In order to collect a sample, two conditions must be met: 1) At least 72 hours must have elapsed



SCDHEC Personnel Collect a Sample at an Industrial Wastewater Outfall

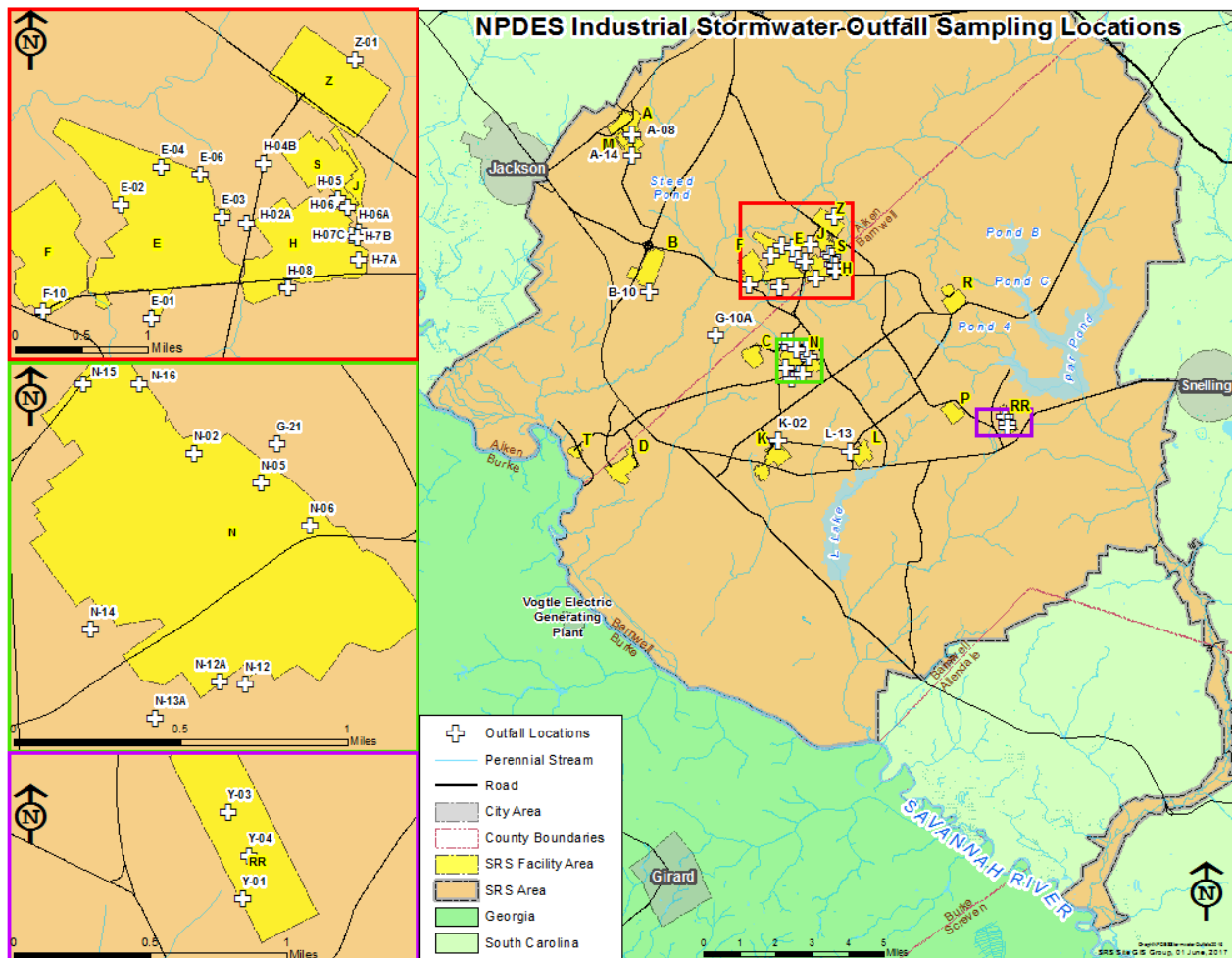


Figure 4-3 NPDES Industrial Stormwater Outfall Sampling Locations

since the previous flow event and 2) The sample should be collected during the first 30 minutes of the initial flow. SRS continued to use wireless technology to send immediate text notifications of rain events and to start automated samplers at specific locations. This allows SRS to comply with the SCDHEC permit requirements of sampling within 30 minutes of rain flow.

4.3.1.1 Wastewater and Stormwater Results Summary

SRS reports NPDES industrial wastewater analytical results to SCDHEC through monthly discharge monitoring reports. Only 2 of the approximately 3,275 analyses performed during 2016 exceeded NPDES permit limits, a 99.9% compliance rate. SRS had one permit limit exceedance for monthly average of TSS at D-01C Outfall and one permit limit exceedance for daily maximum flow at K-12 Outfall (due to 7 inches of recorded rainfall). The sample for TSS was collected at D-01C on August 4 during dewatering for the closure of the 488-1D ash basin. The TSS result was above the monthly average permit limit but below the daily maximum permit limit. There were no impacts to Waters of the State. The water with the elevated TSS would have had to travel roughly an additional 1,000 feet to reach Waters of the State. SRS collected another TSS sample from the basin about two weeks later for permit applications, and results were significantly lower (seven times below the monthly average permit limit). On August 9, SRS collected a TSS sample for the water-quality program at location river mile (RM) 150.4. This location is downstream of the

D-01C sampling location. The results at RM 150.4 were seven times below the monthly average permit limit. While the August 4 result was above permit conditions, subsequent sampling at that location and downstream indicates this was an isolated event. On December 9, SCDHEC issued a Notice of Violation (NOV) for the TSS exceedance but did not assess a penalty. Chapter 3, *Compliance Summary*, Section 3.3.7.1.1, *National Pollutant Discharge Elimination System*, provides additional information regarding the NOV.

SRS monitored all industrial stormwater outfalls according to the requirements of the permit. Sample results demonstrated the outfalls complied with permit requirements.

4.3.2 Onsite Drinking Water Monitoring

SRS uses groundwater sources to supply onsite drinking water facilities. The A-Area treatment plant supplies most of the drinking water at SRS. The Site also has four smaller drinking water facilities, each of which serves fewer than 25 people. These systems are not required to be sampled for lead and copper due to their small populations.

SCDHEC requires SRS to collect 10 bacteriological samples each month from the A-Area treatment plant to ensure that domestic water from that system meets SCDHEC and EPA bacteriological drinking water quality standards. SRS exceeds this requirement by collecting 15 samples each month from various areas. These samples consistently meet SCDHEC and EPA drinking water quality standards, confirming the absence of harmful bacteria.

In December, SRS collected 7 samples instead of the required 10. SRS has begun corrective actions to ensure that all samples are being collected as scheduled. Results from each of the seven samples were within drinking water quality standards.

SRS samples domestic water systems for lead and copper on a three-year, rotating cycle. It sampled the A-Area water system for lead and copper in 2016. Sample results met SCDHEC water-quality standards for lead and copper and were in the 90th percentile. The A-Area water system is not due for lead and copper sampling again until 2019. Chapter 3, *Compliance Summary*, Section 3.3.7.2, *Safe Drinking Water Act*, provides additional information regarding the omission of the December samples.

4.3.3 River and Stream Water Quality Surveillance

South Carolina Regulation 61-69, *Classified Waters*, classifies SRS streams and the Savannah River as “freshwaters.” Freshwaters as defined in Regulation 61-68, *Water Classifications and Standards*, (SCDHEC 2014) support the following:

- 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

SRS surveys river and stream water quality to identify: 1) any degradation that could be attributed to the water discharges regulated by Site NPDES permits, and 2) materials that may be released inadvertently from sources other than routine release points.

SRS samples 10 streams onsite and 5 Savannah River locations for various physical and chemical properties, including dissolved oxygen, pH, temperature, hardness, metals, pesticides and herbicides, and total organic carbon. Figure 4-4 illustrates the sampling locations. River and stream sampling sites are upstream, adjacent to, and downstream from the Site to compare the SRS contribution of pollutants with background levels of chemicals from natural sources and from contaminants produced by municipal sewage plants, medical facilities, and other upstream industrial facilities. The water quality locations are sampled at monthly and quarterly frequencies by the conventional grab-collection technique. SCDHEC also collects samples at several onsite stream locations; most of them are co-located with SRS sample locations as a quality control check of the SRS program.

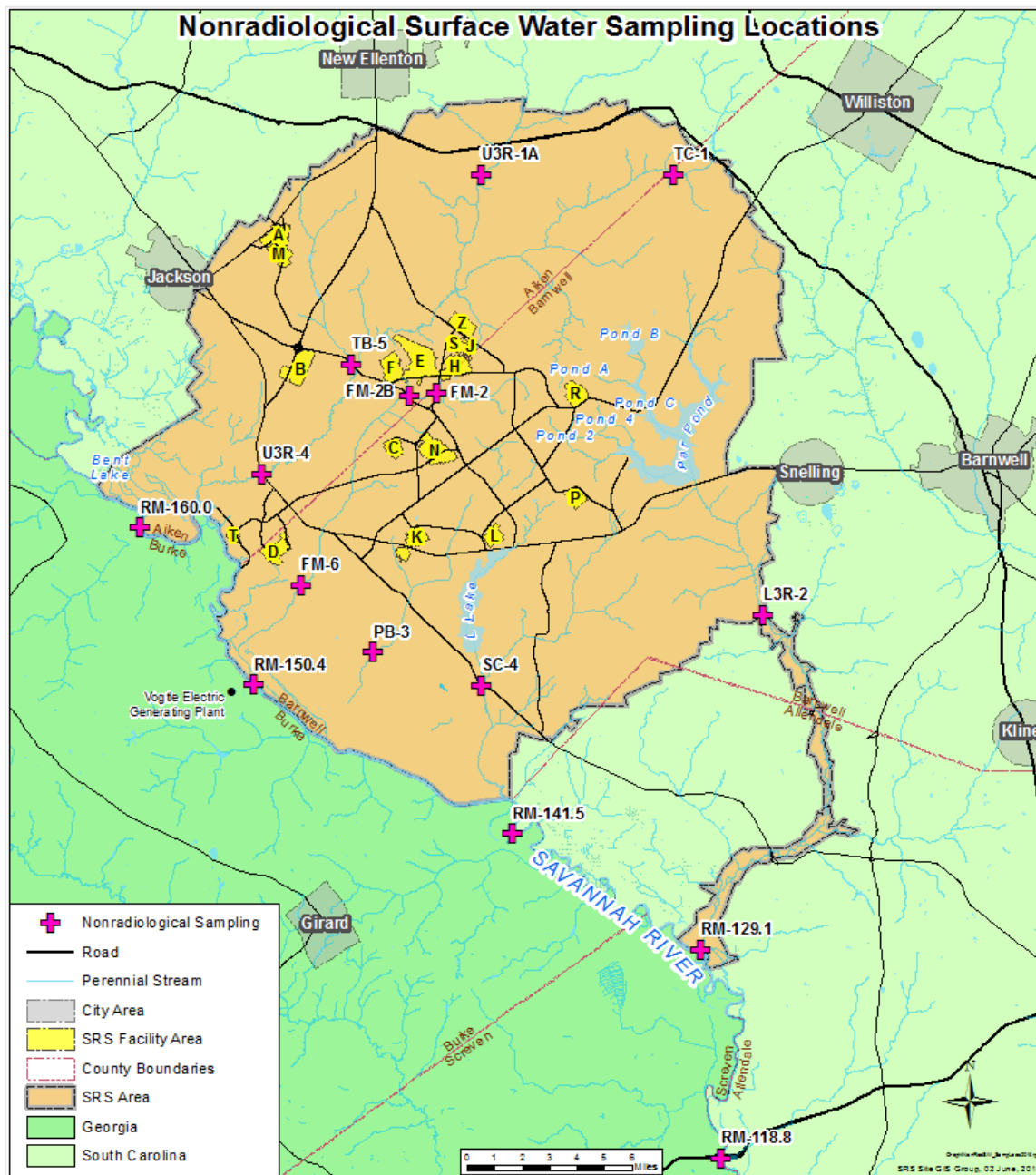


Figure 4-4 Nonradiological Surface Water Sampling Locations

4.3.3.1 River and Stream Water Quality Results Summary

SRS performed 5,400 individual analyses on samples collected from the 15 stream- and river-water quality locations during 2016. Rain events that occurred during January resulted in river water levels deemed unsafe for SRS personnel to collect water samples at five river locations. Instead, SRS collected samples at alternate locations. Metals, such as iron and zinc, were detected in at least one sample at each location. The herbicide Silvex was detected at stream location FM-2B in October. Its origin is unknown. Silvex has never been used onsite, according to the records. No other sample results showed detectable levels of pesticides, herbicides, or polychlorinated biphenyls (PCBs). Appendix Table C-1 summarizes the analytical results. These results continue to indicate that SRS discharges are not significantly affecting the water quality of onsite streams or the Savannah River.

4.3.4 **Sediment Sampling**

SRS's nonradiological sediment surveillance program provides a method to determine nonradiological contaminants that are deposited and accumulate in stormwater basins, stream systems, and in the Savannah River. One of the important contaminants measured is mercury. Mercury is a contaminant that could pose a health exposure risk to humans through various pathways, including drinking water and eating fish. Mercury enters bodies of water naturally through volcanic activity and mineral weathering of rocks over time, as well as through industrial and urban sources such as coal-burning power plants. Mercury that is released into the air may eventually settle into or be washed into water, where it deposits onto streambeds and wetlands.

The nonradiological sediment program collects sediment samples at various stream, stormwater basin, and Savannah River locations (Figure 4-5). The locations vary from year-to-year, depending on the rotation schedule agreed upon with SCDHEC. SCDHEC performs duplicate sampling at various locations onsite as a quality control check of the SRS program.

4.3.4.1 Stream and River Sediment Results Summary

In 2016, SRS sampled 12 onsite stream locations, 3 stormwater basin locations, and 9 Savannah River locations. The laboratory analyzed the samples for various inorganic contaminants (metals and cyanide) to determine if there was a human health risk from exposure to sediments. The Site used EPA Regional Screening Levels for Residential Soil for comparison.

In 2016, all mercury results for river and stormwater basin sediment samples were below the lowest levels the laboratory could detect. Five samples from onsite stream basin locations contained mercury that ranged from 0.0125 mg/kg at L3R-2 to 0.0632 mg/kg at L3R-1A. All mercury results were well below the EPA Regional Screening Level for resident soil (Figure 4-6).

Results for metals in river, stream and stormwater basin sediments showed aluminum, arsenic, barium, chromium, copper, iron, lead, magnesium, manganese, nickel, uranium, and zinc. Levels were greater than the practical quantitation limit for 2016, but were still consistent with those seen in the background control locations (river location River Mile [RM]-160 and stream location Upper Three Runs U3R-1A) and comparable to those of the previous five years. Appendix Table C-2 summarizes the analytical results.

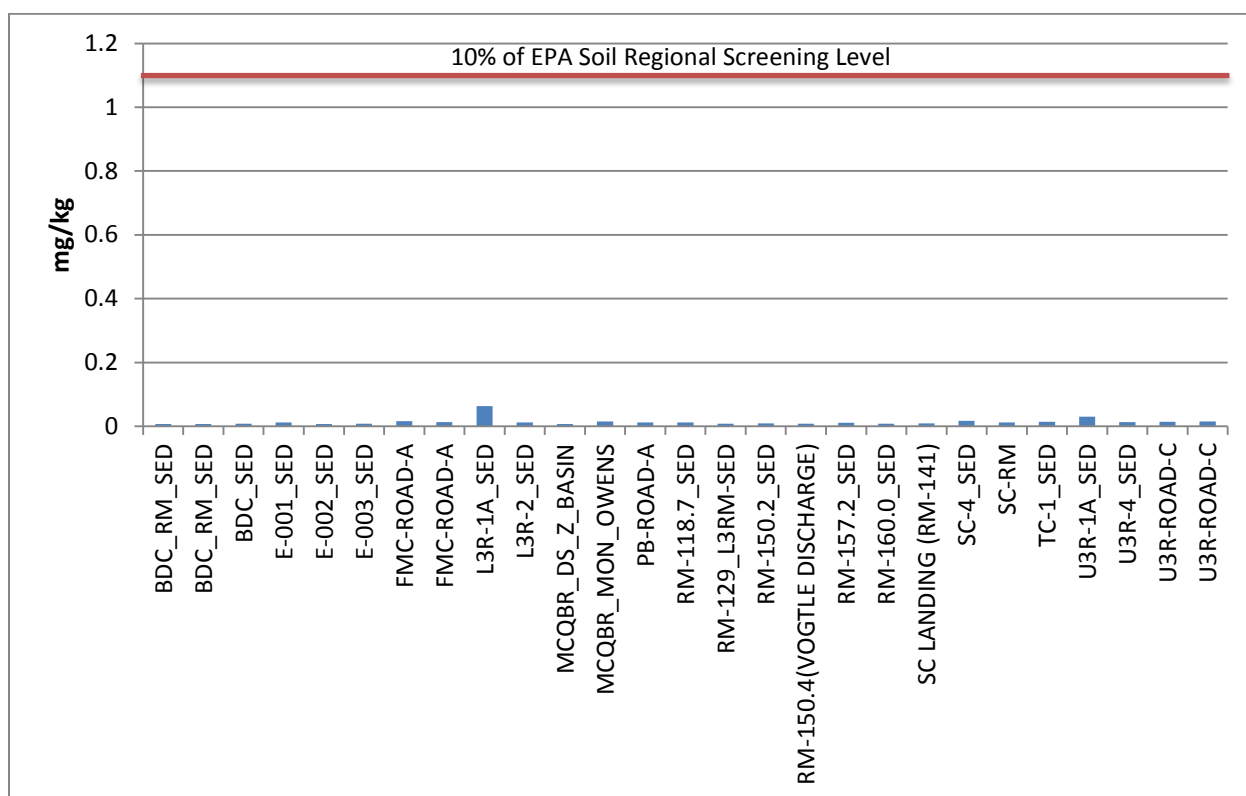


Figure 4-6 Mercury in Sediment Locations

4.3.5 Fish Monitoring

SRS samples aquatic species to identify and evaluate any impact of Site operations on contaminant levels in fish. Freshwater fish (that is, bass, catfish, and panfish) are collected at six locations on the Savannah River from above SRS at Augusta, Georgia to the coast of Savannah, Georgia. Freshwater fish are collected at the mouth of the streams that flow through the Site. Saltwater fish (red drum and mullet) are collected at the Savannah River mouth near Savannah, Georgia. SRS analyzes samples of the edible flesh for metals uptake. SRS performs nonradiological analyses for mercury, arsenic, cadmium, chromium, copper, lead, manganese, nickel, zinc, and antimony.

4.3.5.1 Fish Results Summary

In 2016, SRS performed 1,470 individual analyses on 147 fish flesh samples (10 analyses per sample). The majority (54%) of the results were nondetected (less than the method detection limit). Appendix Tables C-3 and C-4 present summaries of the analytical results. Fifteen percent, or 217 results of the 1,470 individual analyses, were detected and quantified (15%), with the majority of these results being for mercury (68) and zinc (146).



Fish Collection Using Electrofishing Equipment

A review of the 2016 zinc data indicates the results for the SRS creek mouths are comparable with the results for the control location at the New Savannah Bluff Lock and Dam. Review of mercury data for the period 2012 through 2016 (Figure 4-7) indicates lower concentrations in catfish and panfish than in bass. Mercury data for bass collected in 2016 are within the expected range based on the previous four-year period (2012–2015).

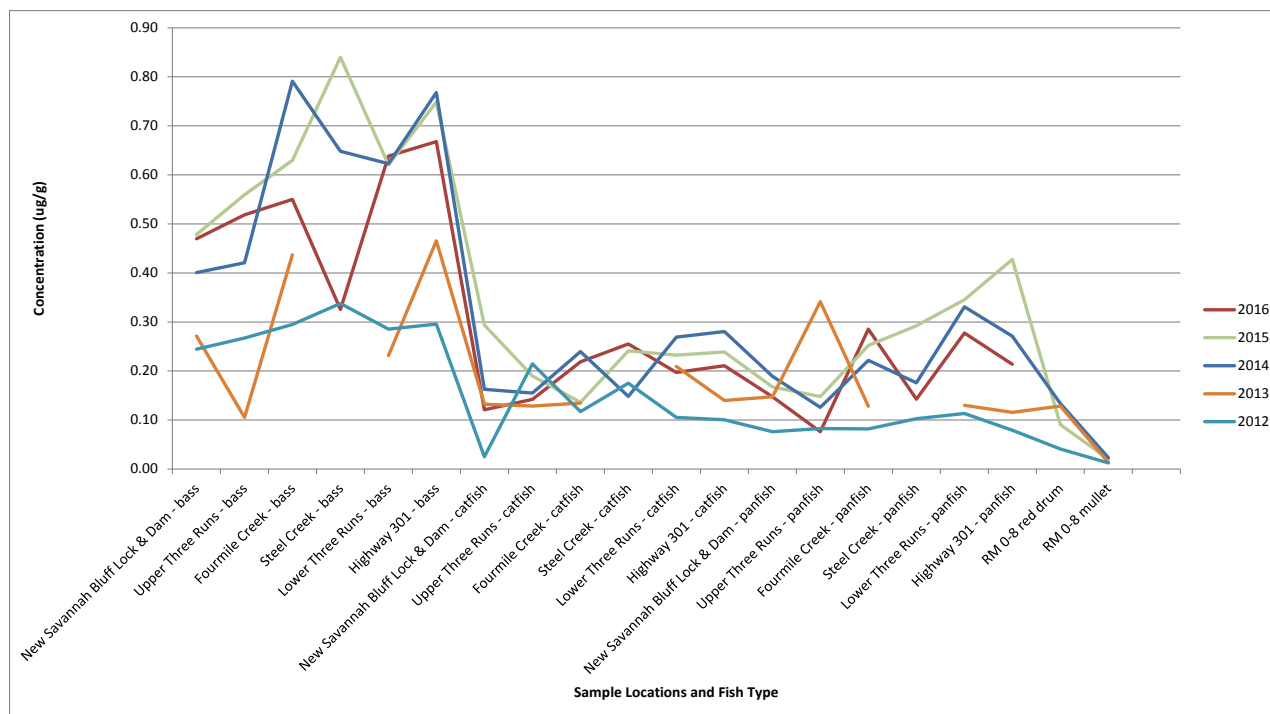


Figure 4-7 Mercury in Fish by Location and Species

4.4 PRECIPITATION CHEMISTRY AND DEPOSITION

The SRS nonradiological air monitoring program includes collecting samples and data to calculate air emissions from Site sources and for the National Atmospheric Deposition Program (NADP). The NADP monitors the geographic distribution of specific airborne contaminants to better understand their effects on the environment. The NADP publishes data one year after completing analyzes of all samples from their network of collection locations. Thus, this section reports 2015 data, which is publicly available.

SRS sponsors a collection station to support the NADP. This station, located near the center of SRS at the Savannah River National Laboratory (SRNL) Central Climatology facility, collects weekly precipitation (rain, sleet, and snow) samples and submits them to NADP laboratories for chemical analysis. Since 2001, this station has been part of the Mercury Deposition Network (MDN) of the NADP. The MDN provides data on the geographic distributions and trends of mercury in precipitation. Mercury is emitted into the atmosphere and surface waters from natural sources, including volcanoes and wildfires. It also occurs naturally in some soils. Yet most of the attention on mercury in the environment has focused on anthropogenic sources: coal combustion, medical waste incineration, and chlorine production, among others. The MDN 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. Beginning in 2012, the National Trends Network (NTN) added the station at SRS. This network tracks changes in acid rain.

Sample analysis associated with the NTN network includes free acidity (pH), conductivity, calcium, magnesium, sodium, potassium, sulfate, nitrate, chloride, and ammonium. In addition to supporting national-scale observations relating to trends in precipitation chemistry, results from this surveillance provide specific information related to the chemistry of precipitation at SRS.

4.4.1 Precipitation Chemistry and Deposition Results Summary

The 2015 average (volume-weighted) concentration of total mercury in precipitation was 8.6 ng/L, and the wet deposition rate was 11.7 $\mu\text{g}/\text{m}^2$. These observations were consistent with historical observations associated with this surveillance and are consistent with other observations from the southeastern United States. Data from 2016 will be available in the fall of 2017. The NAPD provides [additional information on the MDN](#), as well as the location and data from surrounding stations.

In 2015, the average pH of precipitation was 5.07. Appendix Table C-5 presents the precipitation results that the NTN reported for 2015. These observations are consistent with other observations from other locations in the southeastern United States. The NAPD provides [additional information on the NTN](#).

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The purpose of the Savannah River Site (SRS) Radiological Environmental Monitoring Program (REMP) is two-fold in that it monitors any effects SRS has on the environment, and it demonstrates compliance with applicable U.S. Environmental Protection Agency (EPA), South Carolina Department of Health and Environmental Control (SCDHEC), and U.S. Department of Energy (DOE) standards. As part of this program, the Site collects thousands of samples throughout the year and analyzes them for radionuclides that could be present from releases due to SRS operations. Samples are collected both onsite and in the communities surrounding SRS. State and federal regulations drive some of the monitoring SRS conducts, such as limitations on discharges to air and water. DOE Orders 231.1B, *Environment, Safety and Health Reporting*, and 458.1, *Radiation Protection of the Public and the Environment*, also address environmental monitoring requirements.

2016 Highlights

Air and Water Pathways—Air and water contaminants SRS released were all below applicable permit limits and standards. Radiological results for surveillance media associated with the airborne and liquid pathways were within expected historical levels when compared to background.

Wildlife Surveillance—SRS monitors animals harvested during the annual onsite hunts to ensure the total dose to any hunter from ingesting the meat is below the SRS Annual Administrative Game Animal Release Limit of 22 mrem/yr. SRS monitored the deer, feral hogs, turkeys, and coyotes harvested during the hunts and released 366 animals. Based on field measurements, SRS found that one animal, a male deer, exceeded the SRS administrative limit and did not release it.

5.1 INTRODUCTION

Environmental monitoring programs at SRS examine both radiological and nonradiological constituents that SRS activities could release to the environment. This chapter discusses the radiological monitoring program at SRS; Chapter 4, *Nonradiological Environmental Monitoring Program*, presents the nonradiological monitoring program.

The SRS REMP monitors radiological contaminants from both air and liquid point sources, as well as collects and analyzes environmental samples from numerous locations throughout the Site and the surrounding area.

Chapter 5—Key Terms

Actinides are a group of elements with an atomic number between 89 through 103. Within this chapter, laboratory analysis of actinides generally refers to the elements uranium, plutonium, americium, and curium. When neptunium or thorium is also included, the text states that.

Derived concentration standard (DCS) is the concentration of a radionuclide, measured at the discharge point, in air or water effluents that—under conditions of continuous exposure for one year (that is, annual ingestion of water, submersion in air, or inhalation)—would result in a dose of 100 mrem (1 mSv). This assumption of direct exposure to discharge point effluents is extremely unlikely and ensures that the DCSs are highly conservative.

Dose is a general term for the quantity of radiation (energy) absorbed.

Effluent monitoring collects samples or data from the point a facility discharges liquids or releases gases.

Environmental monitoring encompasses both effluent monitoring and environmental surveillance.

Environmental surveillance collects samples beyond the effluent discharge points and from the surrounding environment.

Exposure pathway is the way that releases of radionuclides into the water and air could impact a person.

The REMF is divided into two focus areas: 1) Effluent monitoring, and 2) Environmental surveillance. SRS determines sampling frequency and analyses based on permit-mandated monitoring requirements, federal regulations, and DOE Orders.

In accordance with DOE Order 458.1, SRS gauges the effluent monitoring program against DOE-derived concentration standards (DCSs) by comparing the annual average concentrations of continuously sampled sources to the DOE DCSs, which DOE's *Derived Concentration Technical Standard* (DOE 2011) documents. The DCS requirement is that the sum of the ratios of the observed concentration of each radionuclide to its corresponding DCS must not exceed 1.00. This sum is referred to as the sum of fractions. The DCSs are applicable at the point of discharge, and SRS uses them to screen existing effluent treatment systems to determine if they are appropriate and effective. SRS uses the same DCSs as reference concentrations to conduct environmental protection programs. All DOE sites use these DCSs.

The SRS surveillance program samples the types of media that routine releases observed in the effluent monitoring program may impact. Figure 5-1 shows the liquid and airborne pathways, as well as the types of media sampled through those pathways.

SRS conducts environmental monitoring of the following:

- Air (stack emissions and ambient air)
- Rainwater
- Vegetation
- Soil
- Surface water (stream, river, and stormwater basins)
- Drinking water
- Stream and river sediment
- Aquatic food products
- Wildlife
- Food products (milk, meat, fruit, nuts, and green vegetables)

Sampling results provide the data needed to assess the exposure pathways for the people living near SRS, as documented in Chapter 6, *Radiological Dose Assessment*.

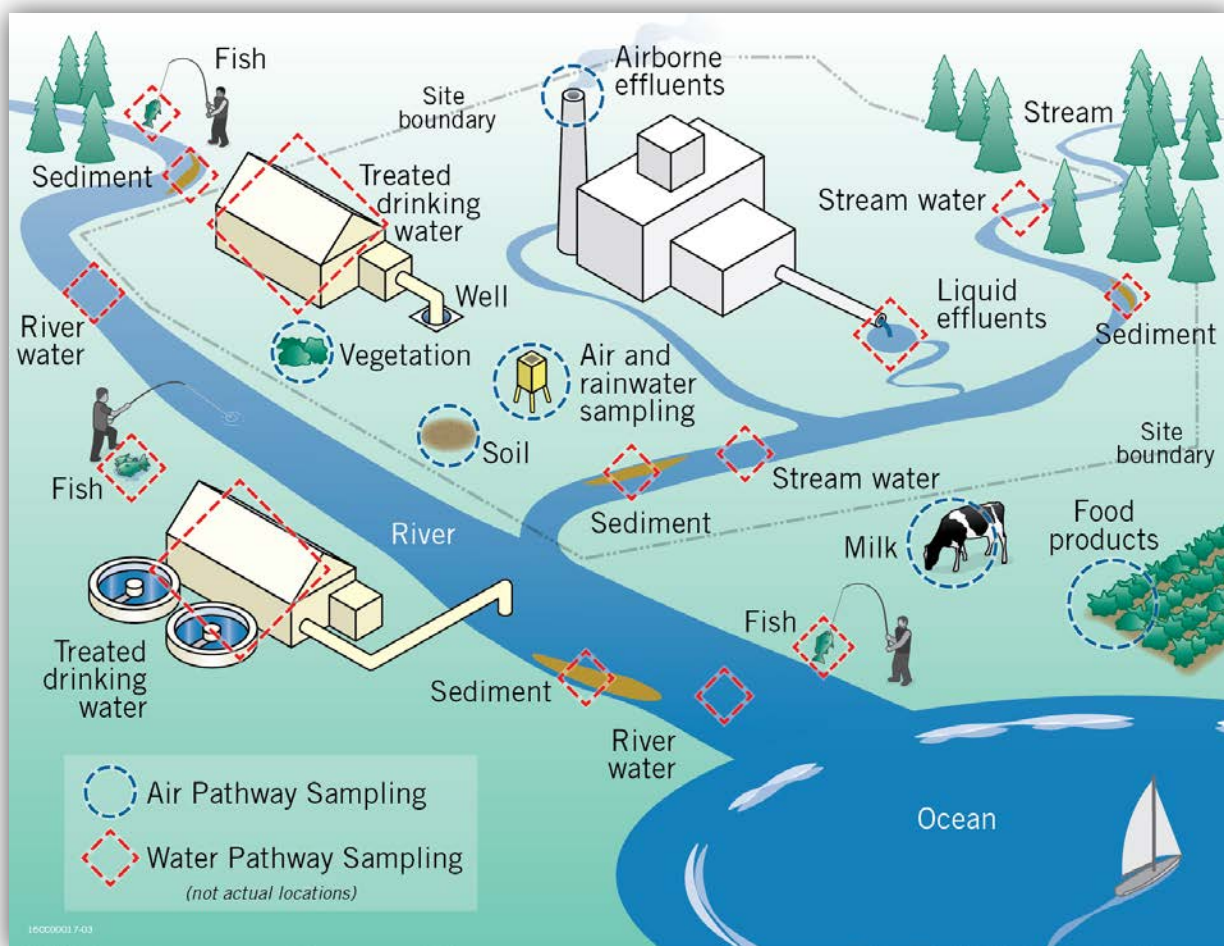


Figure 5-1 Types and Typical Locations of Radiological Sampling

Appendix Table B-2 of this document summarizes the radiological surveillance sampling media and frequencies. *The 2016 Environmental Monitoring Program Data Report* (SRNS 2017a) documents all raw data associated with SRS.

5.2 SRS OFFSITE MONITORING

Offsite monitoring involves collecting and analyzing samples of air, river water, soil, sediment, vegetation, milk, food products, fish, and other media from many locations. SRS analyzes these samples for radioactive contaminants to monitor any effects the Site has on the environment and to assess long-term trends of the contaminants in the environment. SRS collects samples beyond the Site perimeter in Georgia and in South Carolina at 25 and 100 miles from the Site. Additionally, SRS collects samples at several population centers in Georgia and in South Carolina.

SRS monitors the Savannah River at River Mile 118.8 (Georgia Welcome Center at Highway 301), locations downriver of each SRS stream entry point, and above the Site at River Mile 160 as a control location. Media-specific chapter figures and [Environmental Maps](#) show offsite environmental sampling locations. Chapter 7, *Groundwater Management Program*, provides information on SRS groundwater monitoring. Table 5-1 summarizes SRS offsite radiological sampling performed in Georgia and South Carolina, excluding samples collected in the Savannah River.

Table 5-1 SRS Offsite Radiological Sample Distribution by State

Environmental Sampling Media	Approximate Number of Samples (Number of Locations)	
	South Carolina	Georgia
Air Filters	26 (1)	52 (2)
Silica Gel	26 (1)	52 (2)
Ambient Gamma Radiation Monitoring	160 (7)	80 (4)
Rainwater	12 (1)	24 (2)
Food Products	20 (20)	5 (5)
Milk	16 (4)	16 (4)
Soil	1 (1)	2 (2)
Grassy Vegetation	1 (1)	2 (2)
Drinking Water	24 (2)	0 (0)
Total	286 (38)	233 (23)

Note: This table excludes groundwater monitoring locations and samples that Chapter 7, *Groundwater Management Program*, discusses, as well as samples collected from the Savannah River.

5.3 AIR PATHWAY

The media in this section supports the air pathway dose assessment discussed in Chapter 6, *Radiological Dose Assessment*.

5.3.1 Air Monitoring

SRS conducts air monitoring to determine whether airborne radionuclides from SRS emissions have reached the environment in measurable quantities and to ensure that radiation exposure to the public remains below regulatory limits. In order to comply with radiation dose standards the EPA and DOE establish for public protection, SRS performs effluent monitoring of airborne radionuclides at the point of discharge from operating SRS facilities. SRS conducts additional air sampling at monitoring stations onsite and along the SRS perimeter and within communities surrounding SRS.

Radionuclides present in and around the SRS environment are from sources such as natural background, fallout from past atmospheric testing of nuclear weapons, offsite nuclear power plant operations, and SRS operations. "Fallout" is the term for the settling to the ground of airborne particles emitted into the atmosphere from the earth by explosions, eruptions, forest fires, etc. or from production activities such as those found at nuclear facilities. Tritium in the elemental (hydrogen gas) and oxide (water vapor) forms make up the majority of the radionuclide emissions from SRS to the air. The amount of tritium released from SRS varies yearly, based on mission activities and on the annual production schedules of the tritium-processing facilities.

5.3.2 Airborne Emissions

EPA's National Emission Standards for Hazardous Air Pollutants (NESHAP) program establishes the limits for radionuclide emissions, detailing the methods for estimating and reporting radioactive emissions from DOE-owned or operated sources. SCDHEC issues Clean Air Act Part 70 Air Quality Permits to regulate radioactive airborne pollutant emissions for each major source of airborne emissions on SRS. Each permit has specific limitations and monitoring requirements.

SRS quantifies the total amount of radioactive material released to the environment by the following methods:

- Data obtained from monitored air effluent release points (stacks or vents)
- Calculated releases of unmonitored radioisotopes from the dissolution of spent fuel
- Estimates for unmonitored sources based on approved EPA calculation methods

SRS monitors the emissions from process area stacks at facilities that release, or have the potential to release, airborne radioactive materials. SRS typically uses laboratory analyses of samples to determine concentrations of radionuclides in airborne emissions. Airborne effluent samples are collected on filter papers for particulates, on charcoal sampling media for gaseous iodine, and in a bubbler solution for airborne tritium. Depending on the processes involved, SRS may also use real-time instrumentation to monitor instantaneous and cumulative releases (of tritium, for example) to the air.

The dissolution of spent nuclear fuel in the H-Canyon facility releases krypton-85, carbon-14, and tritium. These emissions are calculated and included with the monitored releases.

Each year, SRS calculates radionuclide release estimates (in curies [Ci]) from unmonitored diffuse and point sources. Point sources include stacks or other exhaust points, such as vents. In contrast, emissions from diffuse sources are not actively ventilated or exhausted. Diffuse emissions may not originate from a single location, but are released over a larger area. SRS diffuse sources include research laboratories, disposal sites and storage tanks, and deactivation and decommissioning activities. The emissions calculated from unmonitored releases use the methods contained in Appendix D of EPA's NESHAP regulations (EPA 2002). Because these methods employ conservative assumptions, they generally overestimate actual emissions. Although SRS does not monitor these releases at their source, it uses onsite and offsite environmental surveillance to assess the impact, if any, of unmonitored releases.

In 2016, SRS began analytical compositing for two airborne sources. SRS is planning to implement compositing at additional airborne sources in 2017. Compositing increases analytical accuracy by reducing the minimum detectable concentrations (MDCs) in airborne effluent samples.



Air Emission Stack in L Area

5.3.2.1 Airborne Emissions Results Summary

The continuous airborne effluent particulate sampling system for the F-Canyon stack was out of service from June until mid-November. A stack flow transmitter was inoperable and did not ensure representative sampling. SRS restarted the sampling system after replacing the flow transmitter. The facility obtained filter paper samples and analyses from an alternate sampling location to provide an estimate of stack releases during the sample system downtime and to ensure worker safety and health. Because the data from the alternate location were not from the approved sampling location, SRS did not use them to determine the annual releases from this source. For annual reporting, SRS calculated the releases using analytical data from the months that the sampling system was operating and estimated releases when the system was not operating. The analytical results from the period the sample system was operating were greater than the analytical results from the alternate location sampled during the system downtime. Thus, the calculated releases reported are conservative.

Appendix Table D-1 presents SRS radioactive release totals from monitored and unmonitored (calculated) sources. During the past 10 years, as Figure 5-2 shows, the total annual tritium release has ranged from about 17,000 to 41,000 Ci per year with an annual average tritium release of 28,000 Ci. The 2016 tritium emissions of 21,700 Ci is significantly below this 10-year average. Compared to the 19,100 Ci of tritium released in 2015, SRS tritium releases increased about 14% in 2016. However, for the past 10 years, the general trend has been a reduction in tritium releases to the air. As stated previously, the amount of tritium released from SRS fluctuates due to changes in SRS missions and in the annual production schedules of the tritium-processing facilities.

In 2016, tritium accounted for more than 84% of the total radioactivity SRS operations released to the air. Tritium processing facilities are responsible for 85% of SRS tritium releases, while the spent nuclear fuel dissolution in H Canyon accounted for less than 1% of SRS tritium releases. Tritium releases from the separations areas comprise the combination of releases from the tritium processing facilities and the dissolution in H Canyon. Appendix Table D-1 and Figures 5-2 and 5-3 show the tritium releases from the separations areas, reactors and spent nuclear fuel facilities, and unmonitored sources.

Appendix Table D-2 summarizes the 2016 air effluent-derived concentration standards (DCS) sum of the fractions. The raw data includes the specific radionuclide average concentrations and associated DOE DCS for each monitored discharge point within the facilities (SRNS 2017a). These concentrations correspond only to isotopic emissions that occur during sampling. The average concentration is determined only if there is at least one statistically significant result for the isotope. The radionuclide dose assessment includes concentrations for other periods, including any time between stack samples, unidentified alpha and unidentified beta results, and emissions estimated using calculations (that is, unmonitored diffuse and point) (Jannik, Minter, and Dixon, 2017a). The raw data (SRNS 2017a) contains calculated concentrations for tritium from the reactor areas and the tritium processing facilities, and for krypton-85, carbon-14, and

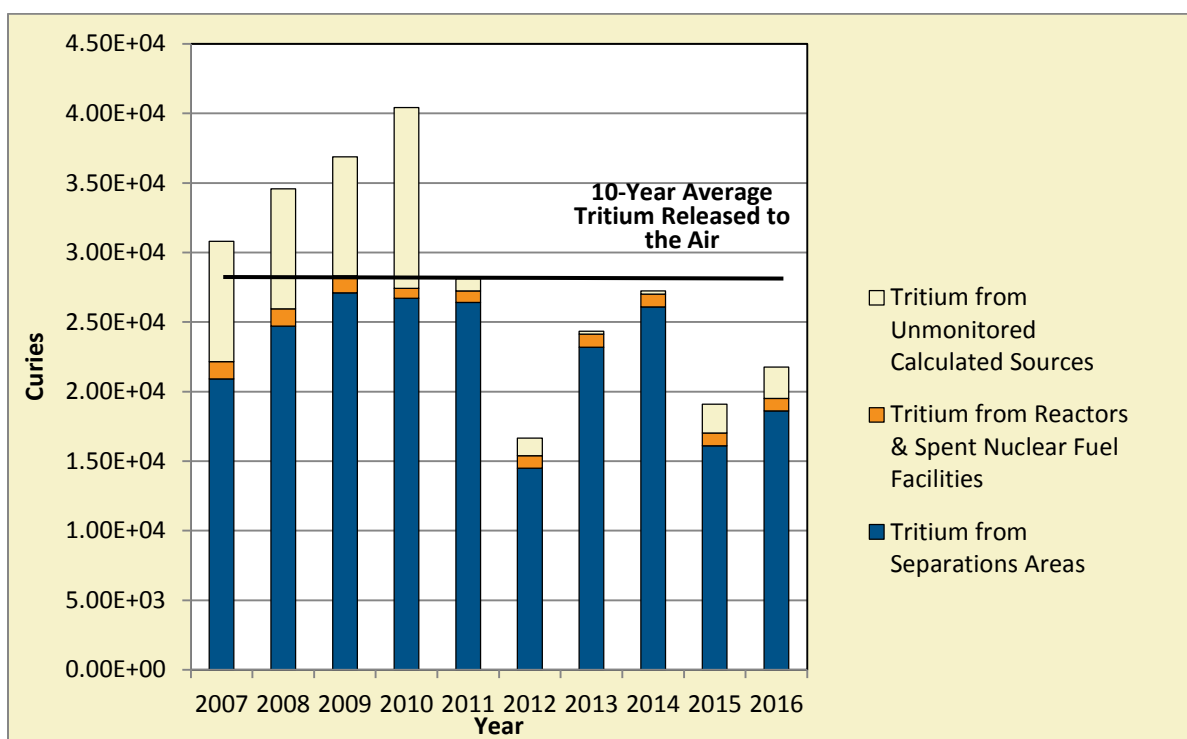


Figure 5-2 Ten-Year History of SRS Annual Tritium Releases to the Air

tritium from the H-Canyon facility during the dissolving process. These calculated concentrations are based on the annual releases in curies and the annual stack flow volume.

Most SRS stacks and facilities release small quantities of radionuclides at concentrations below the DOE DCSs. Because of the nature of the operations and the comparison of DCSs to measured concentrations at the release point, C Area, K Area, L Area, and the tritium processing facilities exceed DOE's tritium DCS. However, tritium releases are maintained as low as reasonably achievable to be compliant with DOE Order 458.1. Additionally, the offsite dose from all airborne releases remained well below the DOE and EPA annual air pathway dose standard of 10 mrem (0.1 mSv). Chapter 6, *Radiological Dose Assessment*, discusses this further.

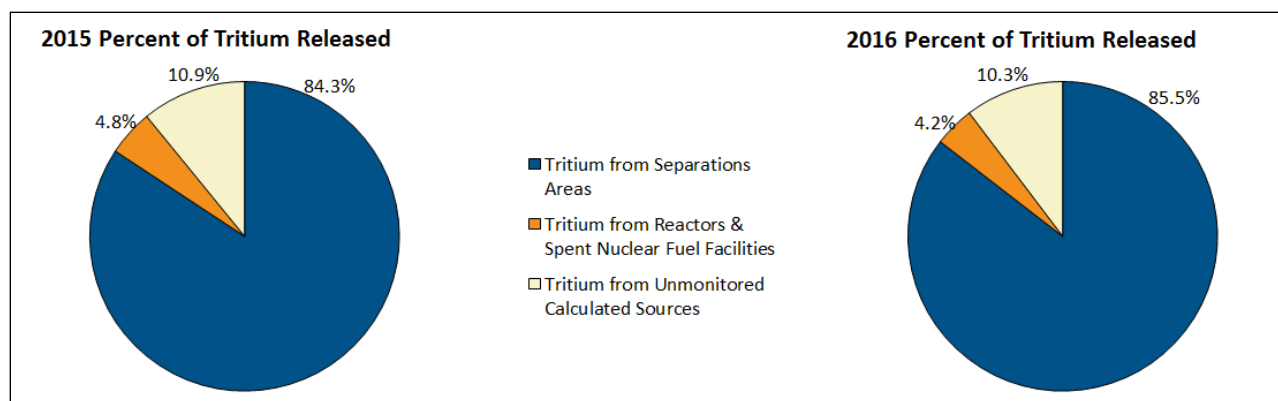


Figure 5-3 Percent of Tritium Released to the Air for 2015 and 2016

5.3.3 Air Surveillance

Beyond the operational facilities, SRS maintains a network of 14 air sampling stations (Figure 5-4 and [Environmental Maps, Radiological Air Surveillance Sampling Locations](#)) in and around SRS to monitor concentrations of tritium and radioactive particulate matter in the air and rainwater. The air contains radionuclides in various forms (gaseous, particulate matter, water vapor). Rainwater can redeposit particulate matter from the air onto the ground, and the radionuclides can eventually be absorbed into vegetation or soil.

The sampling stations are at locations on and off the Site. Onsite stations are at the center of the Site and around the perimeter. Offsite, sampling stations are 25 miles from the Site in population centers and at a control location, the U.S. Highway 301 Bridge at the Georgia Welcome Center in Screven County. SRS operations are not likely to affect the control location. SRS placed air-sampling stations near the Site boundary and beyond to be representative of the atmospheric distribution of airborne releases into the environment. Each air sampling station is set up to collect media that Table 5-2 lists.

SRS selected the radionuclides presented in Table 5-2 based on known SRS airborne emission sources. Background levels in the air consist of naturally occurring radionuclides (for example, uranium, thorium, and radon) and radionuclides from global fallout due to historical nuclear weapons testing related to the Cold War (for example, strontium-90, cesium-137).

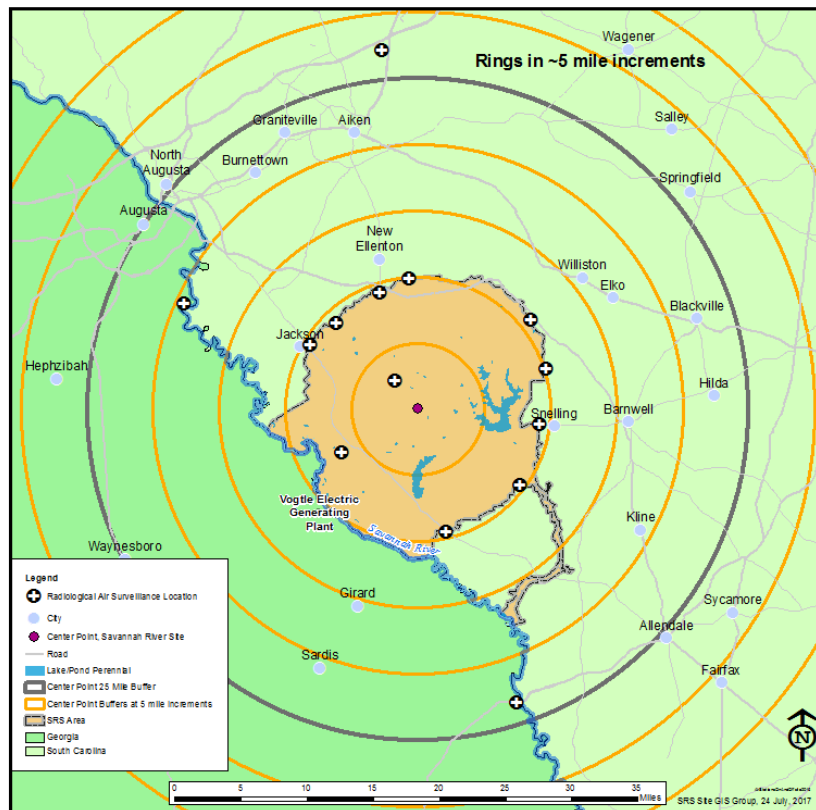


Figure 5-4 Air Sampling Locations Surrounding SRS up to 25 Miles

Table 5-2 Air Sampling Media

Media	Purpose	Radionuclides
Glass-Fiber Filter	Airborne Particulate Matter	Gamma-emitting radionuclides, gross alpha/beta emitting radionuclides
Charcoal Canister	Gaseous States of Radioiodine	Iodine-129, gamma-emitting radionuclides
Silica Gel	Tritiated Water Vapor	Tritium
Rainwater	Tritium in Rainwater	Tritium

5.3.3.1 Results Summary

Appendix Tables D-3 and D-4 summarize tritium results and the comparison to the background control location at the U.S. Highway 301 Bridge. All radionuclides for onsite surveillance air sampling media (Table 5-2) were within the trend levels for the previous 10 years, with the exception of tritium measured at the Barnwell Gate location in October. All offsite location results were near the levels observed at the control location at the U.S. Highway 301 Bridge.

The 2016 results for tritium in air showed detectable levels in 56 of the 363 samples (15%) with levels similar to the previous 5 years, with the exception of the Barnwell Gate location during October. This result from the Barnwell Gate showed tritium in air more than seven times the maximum observed over the previous five years. The tritium concentrations at the other sampling locations were consistent with historical levels. Taking into account there were no unexpected releases from SRS facilities during October and there was an east-northeast prevailing wind direction during this time, SRS determined that the elevation in concentration at the Barnwell location was due to an offsite source.



Technician Installing Silica Gel Column at Air Surveillance Sampling Station

The 2016 results for tritium in rainwater showed detectable levels in 18 of the 168 rainwater samples (11%) with levels similar to the previous 10 years. Concentrations from all locations were below the EPA drinking water standard of 20 pCi/mL. As in previous years, values were highest near the center of SRS and decreased with distance from the Site (SRNS 2017a). Appendix Table D-4 summarizes the results of tritium in rainwater.

5.3.4 Ambient Gamma Surveillance

Since 1965, SRS has been monitoring ambient (surrounding) environmental gamma exposure rates with thermoluminescent dosimeters (TLDs), which are passive devices that measure the exposure from ionizing radiation. The Site uses data from the TLDs to determine the impact of Site operations on the gamma exposure to the public and the environment and to evaluate trends in exposure levels. Other uses include support of routine and emergency response dose calculations.

An extensive network of TLDs in and around SRS monitors external ambient gamma exposure rates (Environmental Maps, [SRS Thermoluminescent Dosimeter \(TLD\) Sampling Locations](#)). The SRS ambient gamma radiation-monitoring program has four subprograms: 1) Site perimeter stations, 2) population centers, 3) air surveillance stations, and 4) Vogtle (stations on SRS that monitor exposures from Georgia Power's Vogtle Electric Generating Station). SRS conducts most gamma exposure monitoring onsite and at the SRS perimeter.

SRS monitors offsite in population centers located near the Site boundary, with limited monitoring beyond this distance at the three 25-mile air surveillance stations.

5.3.4.1 Ambient Gamma Results Summary

Ambient gamma exposure rates at all TLD monitoring locations show some variation based on normal location and annual variations in the components of natural ambient gamma radiation exposure levels. In 2016, ambient gamma exposure rates varied between 64.3 mR/yr at location NRC2 (onsite southwest) and 125 mR/yr at location Burial Ground North (center of the Site) (SRNS 2017a). Rates at population centers ranged from 93.4 mR/yr at the McBean location to 125 mR/yr at the Williston location.

Consistent with the previous five-year trends, ambient gamma results indicate that no significant difference in average annual dose rates exists between monitoring networks. Ambient dose rates in population centers are slightly elevated compared to the other monitoring networks, as expected, because of higher natural background radiation levels emitted from materials present in buildings and roadways

5.3.5 Soil Surveillance

SRS conducts soil surveillance to provide the following:

- Data for long-term trending of radioactivity deposited from atmospheric fallout (both wet and dry deposition)
- Information on the concentrations of radioactive materials in the environment

In 2016, SRS collected soil samples from 5 onsite locations, 10 Site perimeter locations, and 3 offsite locations ([Environmental Maps, Radiological Soil Sampling Locations](#)). Radionuclide concentrations in soil vary greatly among locations because of differences in the patterns, retention, and transport of rainfall in different types of soils. Therefore, a direct comparison of year-to-year data could be



Technician Retrieving Soil Sample

misleading. However, SRS evaluates the data for long-term trend analysis.

Soil sampling involves using hand augers, shovels, or other similar devices to collect to a depth of 3 inches. SRS analyzes these samples for gamma-emitting radionuclides, strontium-89,90, and actinides including neptunium.

5.3.5.1 Soil Results Summary

In 2016, SRS detected radionuclides in soil samples from all 18 sampling locations. The uranium isotopes (U-234, U-235, and U-238) are detected in the soil samples each year. Uranium is naturally occurring in soil and expected to be present in the environment. The concentration range for naturally occurring uranium in soil is typically from about 1 to 5 pCi/g with an average concentration of 2 pCi/g in soils in the United States. Five-year trends for uranium-234, uranium-235, and uranium-238 are increasing at many of the locations. However, uranium-238 had a maximum level onsite of 1.64 pCi/g observed near F Area and a maximum level offsite at the control location (Highway 301) of 2.10 pCi/g (uranium-238). These levels are within the typical range for soils and are at or below the average concentration in U.S. soils. Many factors affect the uranium concentration in soil over time. These include the pH of the soil, the type of soil, and deposits from the air transferred through rainfall. Organic matter and clay minerals provide exchange sites in soil, which can increase the uranium sorption. All measured uranium levels were below the concentration at the control location. SRS will continue to monitor these data; however, at this point, results have not exceeded action levels.

The concentrations of other radionuclides at these locations are consistent with historical results, with maximum cesium-137 concentrations of 0.427 pCi/g found at the Allendale Gate location and 0.134 pCi/g found at the control location (Highway 301). Appendix Table D-5 summarizes the results.

5.3.6 **Grassy Vegetation Surveillance**

SRS analyzes grassy vegetation samples from onsite and offsite locations ([Environmental Maps, Radiological Vegetation Sampling Locations](#)) to complement soil and sediment sample results used to evaluate the environmental accumulation of radionuclides and to help validate SRS dose models. Radioactive contaminants can contaminate vegetation externally, as can the uptake from soil or water by the roots. Bermuda grass is preferred for surveillance because of its importance as a pasture grass for dairy herds. Vegetation samples are collected from the following:

- Locations where soil radionuclide concentrations are expected to be higher than normal background levels
- Locations receiving water that has the potential to be contaminated
- All air sampling locations

Vegetation sample analyses consist of tritium, gross alpha, gross beta, gamma-emitting radionuclides, strontium-89,90, technetium-99, and actinides including neptunium.

5.3.6.1 Grassy Vegetation Results Summary

SRS detected various radionuclides in the grassy vegetation samples collected during 2016 at all locations (1 onsite, 10 at the perimeter, and 3 offsite). Appendix Table D-6 summarizes the results. Results for all radionuclides are within the trends of the previous 10 years.

5.3.7 Terrestrial Food Surveillance

SRS personnel collect terrestrial food products grown and consumed in the communities surrounding the Site, as well as fish and shellfish caught from the Savannah River. They analyze these samples for radionuclides. The results reveal whether radionuclides are present in the environment. Tritium releases from SRS and non-SRS sources are the primary contributors to tritium in food products.

Agricultural products, livestock, and game animals for human consumption may contain radionuclides. Livestock and game animals may be exposed if the radionuclides are in the air. Radionuclides in the air can deposit on grass, which can then be eaten by the animals. If humans consume the meat of these exposed animals, they become exposed to radiation. Dairy cows are also livestock of concern to SRS because they produce milk that we consume, leading to a potential radiation exposure. SRS samples milk, meat, fruit, nuts, and green vegetables based on the potential to transport radionuclides to humans through the food chain.

Local gardens, farms, and dairies are the source of the terrestrial food products. SRS collects beef, watermelon, and greens annually. Site personnel also collect a variety of vegetables, grains, and nuts on a rotational schedule, resulting in two specific crops being collected each year. Once a quarter, the Site collects milk samples. Food product samples come from each of the four quadrants surrounding SRS and extending up to 10 miles from the Site boundary. Additionally, SRS collects a control sample to the southeast at a distance between 10 miles and 25 miles from the Site boundary.

5.3.7.1 Terrestrial Food Results Summary

In 2016, SRS sampled the following terrestrial foodstuffs: greens, watermelons, beef, wheat, and cabbage. All food types were collected from all four quadrants and the control area. Laboratory analysis of the food samples included gamma-emitting radionuclides, tritium, strontium-89,90, technetium-99, gross alpha, gross beta, and actinides including neptunium. Laboratory analysis of the dairy samples included gamma-emitting radionuclides, tritium, and strontium-90. The analytical results of the terrestrial foodstuffs and dairy are consistent with 10-year trends. A majority of results for foodstuffs (75% for terrestrial foodstuffs and 95% for dairy) did not detect radionuclides.

Appendix Tables D-7 and D-8 summarize the foodstuffs and dairy results. The detectable results are near the laboratory instrumentation method detection limits.

5.4 WATER PATHWAY

The media presented in this section support the water pathway dose assessment discussed in Chapter 6, *Radiological Dose Assessment*. The Environmental Maps, *Stream Systems*, identifies SRS stream systems included in the pathway.

5.4.1 Liquid Effluents Monitoring Program

SRS routinely samples, analyzes for radionuclides, and monitors flow at each liquid effluent discharge point that releases, or has potential to release, radioactive materials. Figure 5-5 shows the effluent sampling points near SRS facilities.

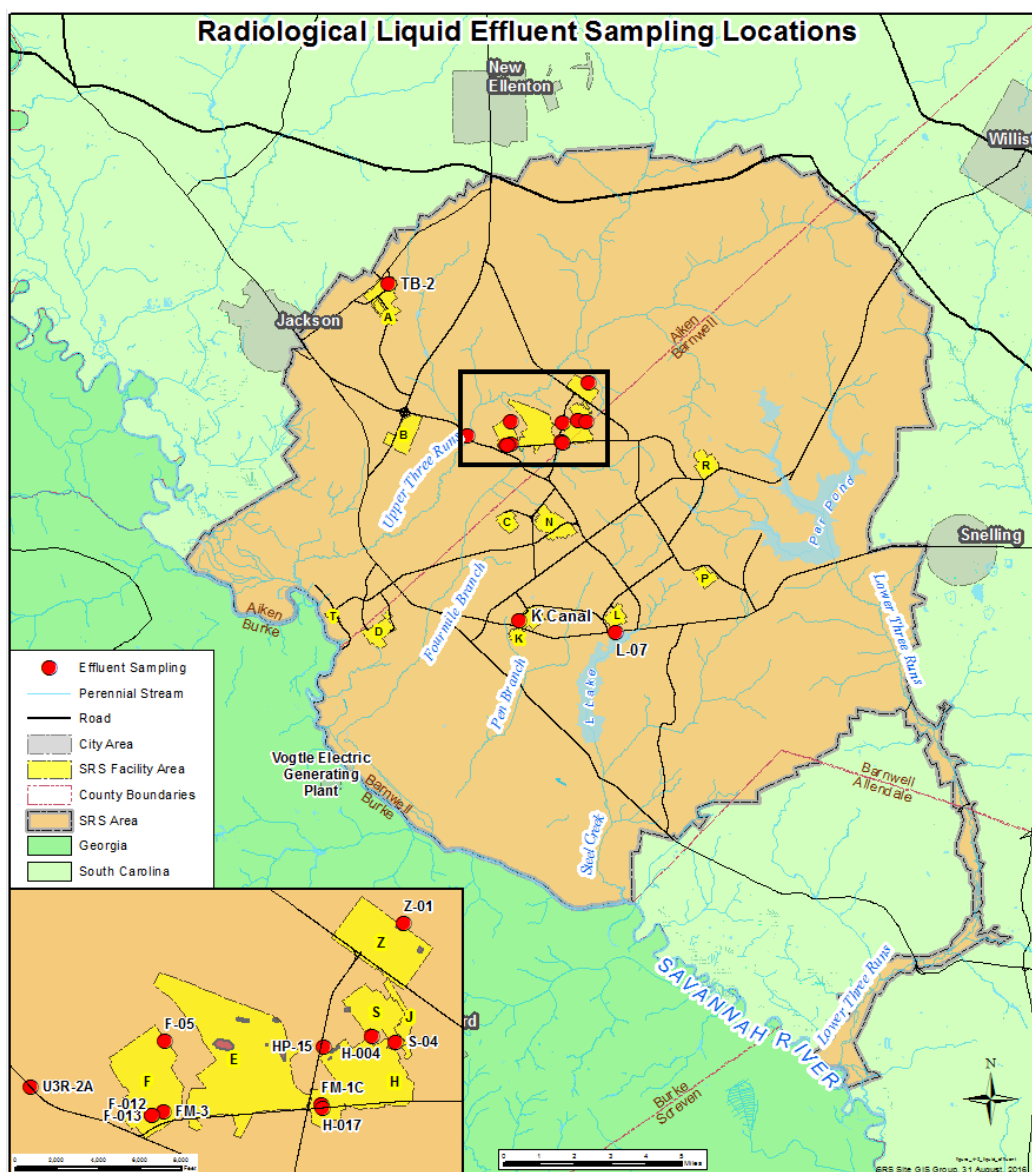
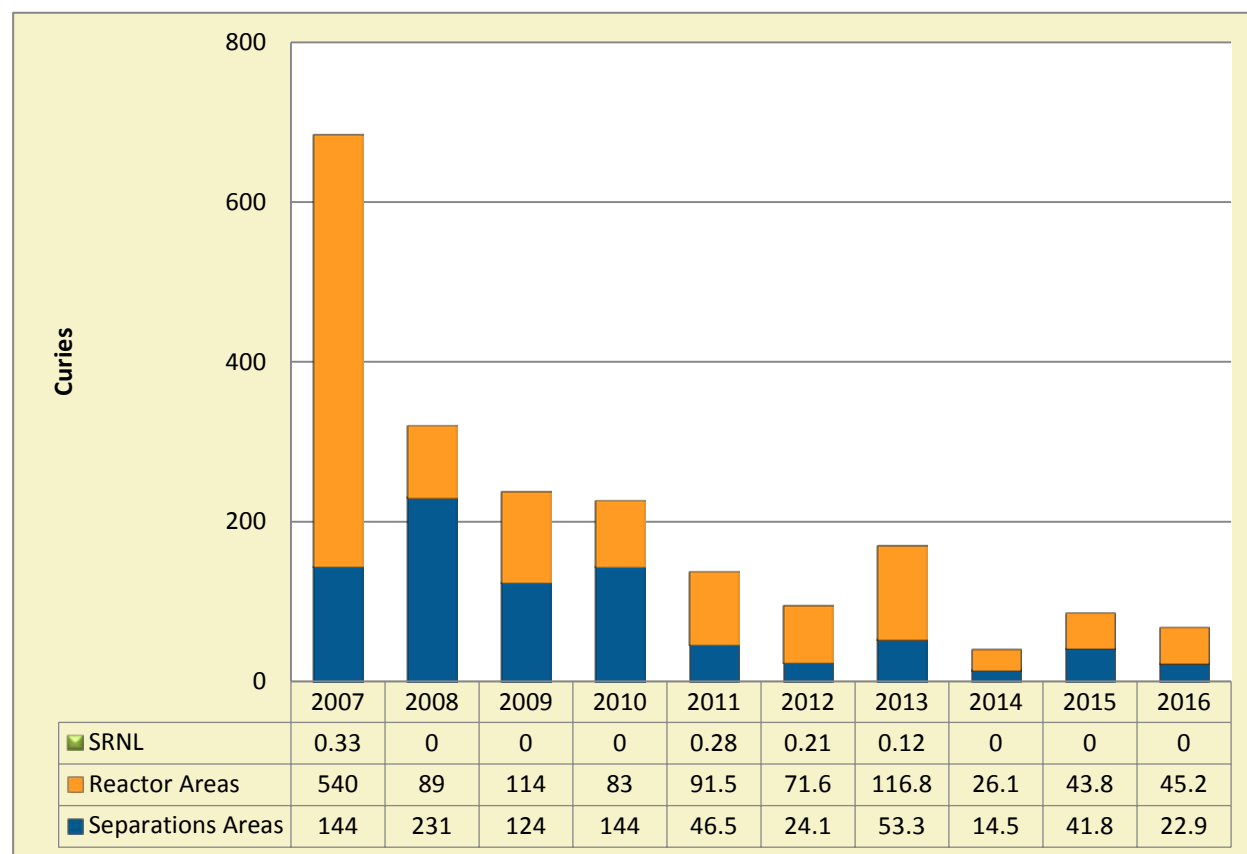


Figure 5-5 Radiological Liquid Effluent Sampling Locations

5.4.1.1 Liquid Effluent Results Summary

Appendix Table D-9 provides SRS liquid radionuclide releases for 2016 to include direct releases plus the shallow groundwater migration of radioactivity from SRS seepage basins and the Solid Waste Disposal Facility (SWDF). The total amount of tritium released directly from process areas to SRS streams during 2016 was 68.1 Ci. This is a decrease from the 85.6 Ci released in 2015. As seen in Figure 5-6, separations areas experienced an 18.9 Ci decrease. Tritium releases from the separations areas comprise the combination of releases from the separations, waste management, and tritium processing facilities. Reactor areas releases remained relatively the same as 2015. Just as the tritium released in 2016 was lower than in 2015, Figure 5-6 shows that the total direct release of tritium has had a general decreasing trend over the last 10 years.

The DCS sum of the fractions for all locations was less than 1.00. Appendix Table D-10 summarizes the 2016 liquid effluent sum of the fractions and radionuclides monitored for each outfall or facility. The raw data includes the specific radionuclide average concentrations and associated DOE DCS for each monitored facility and outfall (SRNS 2017a).



Note: The SRNL contribution to direct releases is minimal; thus, it is not visible on this figure.

Figure 5-6 Ten-Year History of Direct Releases of Tritium to SRS Streams

5.4.2 Stormwater Basin Surveillance

SRS samples the accumulated stormwater in the Site's stormwater basins (Figure 5-7) for gross alpha, gross beta, tritium, strontium, technetium, gamma-emitting radionuclides, and carbon. With no active processes discharging to SRS's stormwater basins, the accumulations in these basins are mainly stormwater runoff. Monitoring for specific radionuclides occurs where operational history indicates their possible presence. The E-Area basins receive stormwater from the SWDF, E-Area Vault, and stormwater from the controlled clean-soil pit on the east side of E Area. F-Area Pond 400 receives stormwater from F Area and the Mixed Oxide Fuel Fabrication Facility. Z-Area Stormwater Basin receives stormwater from Z Area (Saltstone processing and disposal facilities). Stormwater basins release to monitored outfalls during heavy rainfall.

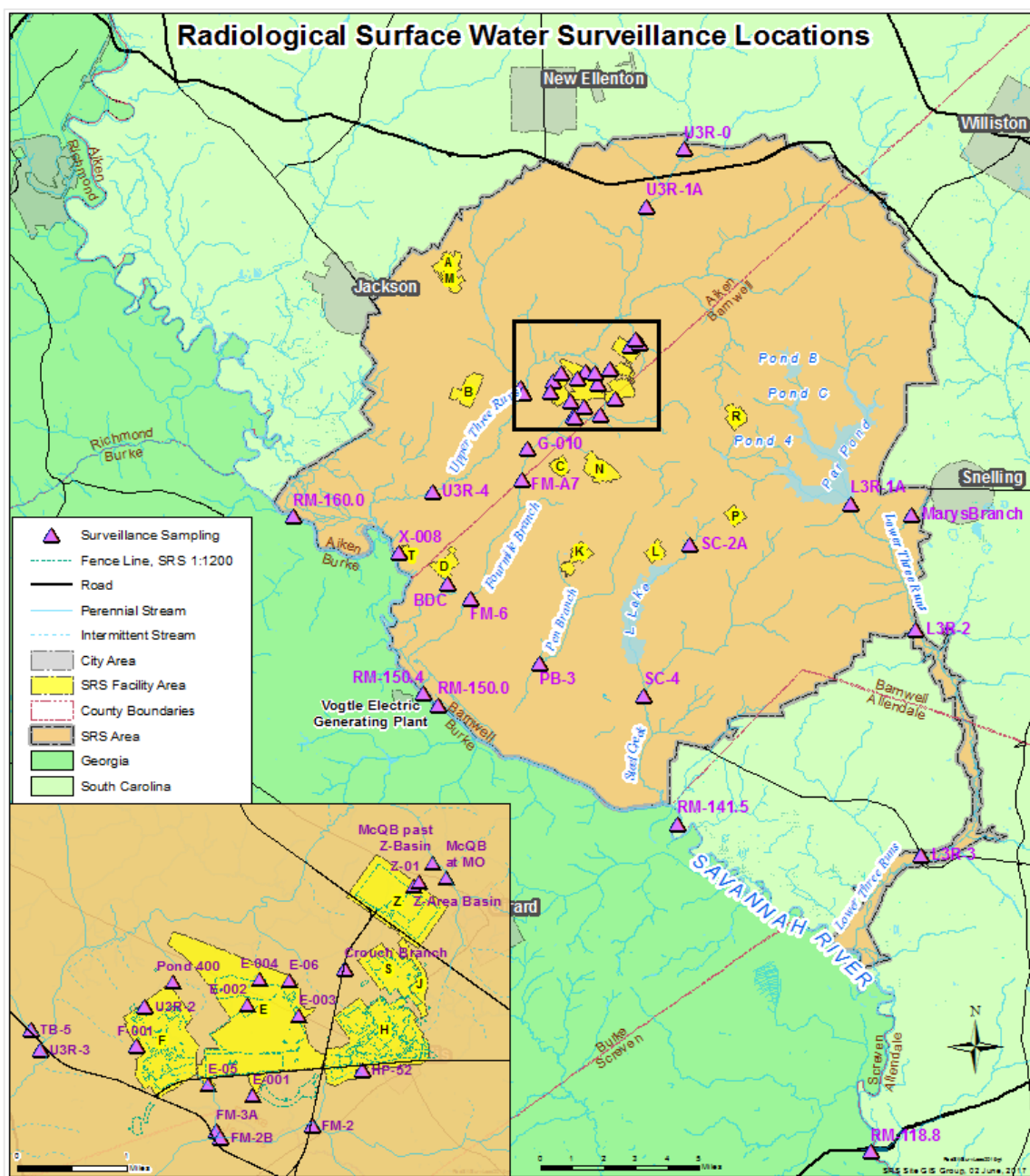


Figure 5-7 Radiological Surface Water Sampling Locations

5.4.2.1 Stormwater Basin Results Summary

In 2016, SRS sampled at five E-Area basins, as well as at the Z-Area Stormwater Basin and F-Area Pond 400. One E-Area basin was dry and, therefore, not sampled. Table 5-3 summarizes gross alpha, beta, and tritium results for stormwater basins, which SRS sampled in the following locations: E-001, E-002, E-003, E-004, E-005, Pond 400, and Z Basin. The highest tritium concentration, 21,400 pCi/L, was observed at the E-002 Basin, which is consistent with the previous five years of results.

Table 5-3 Radionuclide Concentrations Summary for Stormwater Basins (pCi/L)

Basin Location	Average Gross Alpha	Average Gross Beta	Average Tritium	Maximum Tritium
E-001	0.295	3.22	3,910	6,490
E-002	0.234	3.43	8,830	21,400
E-003	0.462	1.81	4,140	4,860
E-004	0.442	1.84	7,220	9,810
E-005	0.556	2.94	8,240	17,200
Pond 400	0.658	6.33	522	2,840
Z-Basin	0.715	228	2,240	4,350

5.4.3 SRS Stream Sampling and Monitoring

SRS continuously samples SRS streams downstream of several process areas to detect and quantify levels of radioactivity transported to the Savannah River by effluents and shallow groundwater migration. The five primary streams that deposit into the Savannah River are Upper Three Runs, Fourmile Branch, Pen Branch, Steel Creek, and Lower Three Runs. SRS monitors and quantifies radioactivity migration from SRS seepage basins and the Solid Waste Disposal Facility (SWDF) as part of its stream surveillance program. Seepage basins include the General Separations Area (F and H Area) Seepage Basins and the K-Area Seepage Basin, which have been closed. SRS closed the F-Area and H-Area Seepage Basins in 1991 and the K-Area Seepage Basin in 2002. Radioactivity previously deposited in the F-Area and H-Area Seepage Basins and SWDF in E Area continues to migrate through the groundwater and enter Fourmile Branch (also known as Four Mile Creek) and Upper Three Runs. Groundwater migration from



Technician Acquires Stream Flow Measurements at Steel Creek Sampling Location SC-4

the F-Area Seepage Basins enters Fourmile Branch at three monitoring locations (FM-3A, FM-2B, and FM-A7) located along the stream. Groundwater migration from the H-Area Seepage Basins enters Fourmile Branch at two monitoring stations (FM-2B and FM 3-A) and from SWDF at the FM 3-A monitoring station. Groundwater from K-Area Seepage Basin migrates into Pen Branch.

Figure 5-7 displays the radiological surface water sampling locations. The sampling frequency and types of analyses are dependent on the upstream discharges and groundwater migration history of radionuclides.

5.4.3.1 SRS Stream Results Summary

Table 5-4 presents the average 2016 concentrations of gross alpha, gross beta, and tritium in SRS streams. SRS found detectable concentrations of tritium at least once at all stream locations except Tim's Branch (TB-5), which had no detected tritium. The 10-year trend for the average tritium levels in the streams shows a decreasing trend, which is due to a combination of decreases in Site releases and the natural decay of tritium. Figure 5-8 indicates that average tritium levels in Fourmile Branch are trending closer to the EPA standard of 20 pCi/mL, although onsite streams are not a direct source of drinking water. In the surveillance program, the EPA standard is used as a benchmark for comparing stream surface water results. Tritium levels are higher in Fourmile Branch compared to the other streams due to shallow groundwater migration from the historical seepage basins and SWDF. SRS has taken active measures to reduce this migration. Section 7.3.3, *Remediating SRS Groundwater*, presents additional information on the groundwater remediation efforts to reduce tritium to Fourmile Branch.

Table 5-4 Radionuclide Concentrations in SRS Streams by Location

Location	Average Alpha (pCi/L)	Average Beta (pCi/L)	Average Tritium (pCi/L)	Maximum Tritium (pCi/L)
<i>Onsite Stream Locations</i>				
Tim's Branch (TB-5)	3.87	2.59	ND	ND
Lower Three Runs (L3R-3)	1.00	1.98	590	789
Steel Creek (SC-4)	0.239	1.09	1,710	2,250
Pen Branch (PB-3)	0.510	1.01	13,000	17,100
Fourmile Branch (FM-6)	0.959	4.29	26,500	32,400
Upper Three Runs (U3R-4)	3.25	1.87	598	943
<i>Onsite Control Locations (for comparison)</i>				
Upper Three Runs (U3R-1A)	2.99	2.08	ND	ND

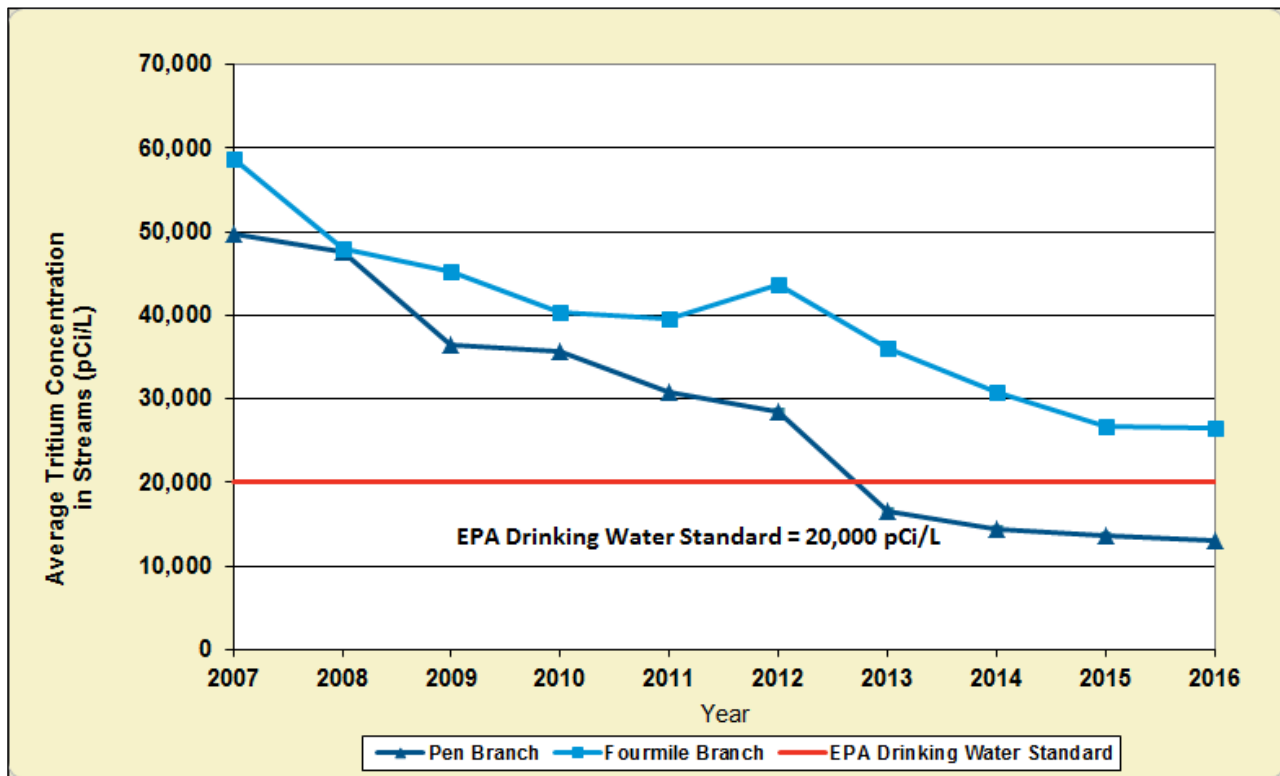


Figure 5-8 Ten-Year Trend of Tritium in Pen Branch and Fourmile Branch (pCi/L)

Figure 5-9 presents a graphical representation of releases of tritium via migration to Site streams from 2007 through 2016. As seen in the figure, migration releases of tritium generally have declined over the past 10 years, with year-to-year variability caused mainly by the amount of annual rainfall. During 2016, the total quantity of tritium migrating from SRS seepage basins and SWDF into SRS streams was 600 Ci compared to 652 Ci in 2015, which represents a greater than 7% decrease. The 10-year trend displays a decrease in tritium migration.

Of the 600 Ci of tritium migrating into SRS streams, 313 Ci (52%) was measured in Fourmile Branch. Migration releases of other radionuclides vary from year-to-year but have remained below 0.1 Ci the past 10 years. Sampling in Pen Branch measures the tritium migration from the K-Area Seepage Basin and the percolation field below the K-Area Retention Basin. It is estimated that 195 Ci migrated in 2016, which is the same amount as in 2015.

Stream transport accounts for tritium migration releases from C-Area, L-Area, and P-Area Disassembly Basins (see Section 5.4.5 *Tritium Transport in Streams and Savannah River Surveillance*, in this chapter).

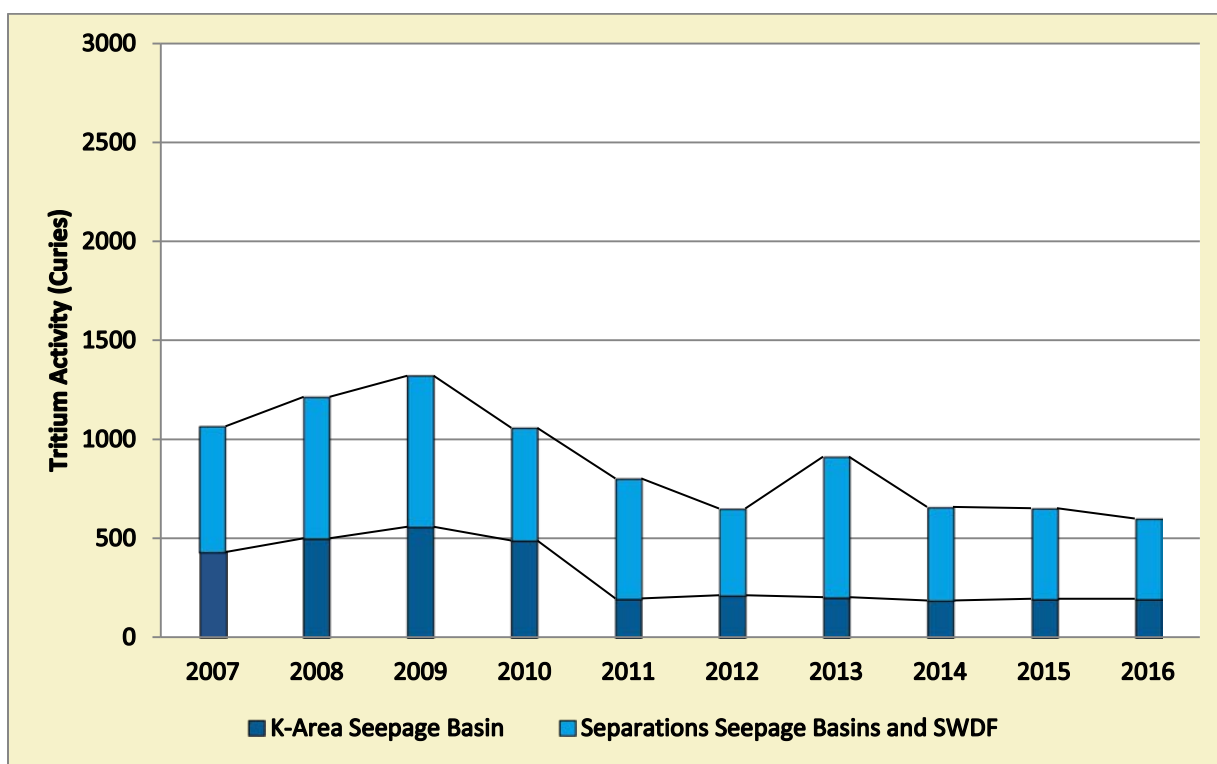


Figure 5-9 Tritium Migration from SRS Seepage Basins and SWDF to SRS Streams

SRS measures gross alpha concentrations in Site streams. If the results for any of the major stream locations, shown in Table 5-4, are greater than the EPA screening level, of 15 pCi/L gross alpha, then SRS measures for alpha-specific isotopes, such as the actinides (including neptunium). None of these stream locations exceeded this screening level in 2016. Alpha-specific isotopes are also measured annually for most stream locations. The alpha-specific isotopic (Pu-238, Pu-239, Am-241, Cm-244, Np-237, U-234, U-235, and U-238) results for 2016 showed no elevated levels and are consistent with historical measurements.

5.4.4 Savannah River Sampling and Monitoring

SRS conducts continuous sampling along the Savannah River at locations above and below SRS streams, including at a location where liquid discharges from Vogtle Electric Generating Plant (VEGP) enter the river.

Five locations (Figure 5-7) along the river continued to serve as environmental surveillance points in 2016. SRS collects samples at these river locations and analyzes them for gross alpha, gross beta, tritium, strontium, technetium, actinides, and gamma-emitting radionuclides.

5.4.4.1 Savannah River Results Summary

Table 5-5 lists the average 2016 concentrations of gross alpha, gross beta, and tritium and the maximum 2016 concentrations of tritium at river locations. The tritium concentration levels are well below the EPA drinking water standard of 20 pCi/mL.

Table 5-5 Radionuclide Concentrations in the Savannah River

Location	Average Gross Alpha (pCi/L)	Average Gross Beta (pCi/L)	Average Tritium (pCi/L)	Maximum Tritium (pCi/L)
RM-160 (CONTROL)	0.21	1.97	78.3	250
RM-150.4 (VEGP)	0.216	2.04	679	2570
RM-150	0.194	1.95	248	465
RM-141.5	0.215	1.98	361	916
RM-118.8	0.24	1.90	310	749

Tritium is the predominant radionuclide detected above background levels in the Savannah River. The combined SRS, VEGP, and Barnwell Low-Level Disposal Facility (BLLDF) tritium estimates based on concentration results and average flow rates at Savannah River Mile (RM) 118.8 were 1,698 Ci in 2016 compared to 2,394 Ci in 2015. In addition to the weekly samples collected for tritium, gross alpha, gross beta, and gamma analyses, SRS collects annual samples to provide a more comprehensive suite of radionuclides for analysis to include strontium-89,90, technetium-99, and actinides. The 2016 *Environmental Monitoring Program Data Report* (SRNS 2017a) provides the analytical results. Average radionuclide concentrations are consistent with the results from the previous 10 years.

5.4.5 Tritium Transport in Streams and Savannah River Surveillance

Because of the mobility of tritium in water and the quantities released during the more than 60 years of SRS operations, SRS performs a comparison of tritium concentrations at various SRS stream locations and Savannah River monitoring locations. The comparison uses the following methods of calculation:

- Direct releases measured at the source—Total direct tritium releases, including releases from facility effluent discharges and measured shallow groundwater migration of tritium from SRS seepage basins and SWDF
- Stream transport, which measures the amount of tritium leaving the Site—Tritium transport in SRS streams, measured at the last sampling point before entry into the Savannah River
- River transport—Tritium transport in the Savannah River, measured downriver of SRS (near RM 118.8) after subtraction of any measured contribution above SRS

The methods SRS uses for estimating releases are based on environmental data reporting guidance described in *Environmental Radiological Effluent Monitoring and Environmental Surveillance* (DOE 2015). General agreement between the three calculation methods of annual tritium transport—measurements at the source plus any measured migration, stream transport, and river transport—serves to validate that SRS is sampling at the correct locations and the accuracy of analytical results.

5.4.5.1 Tritium Transport in Streams and Savannah River Results Summary

In 2016, tritium levels in streams showed a slight decrease, while river transport showed a large decrease, specifically as described below:

- The direct releases of tritium decreased by 9.24% (from 736 Ci in 2015 to 668 Ci).
- The stream transport of tritium decreased by 7.00% (from 786 Ci in 2015 to 731 Ci). This is

quarterly summation totals vs. annual total.

- The river transport of tritium decreased by 29.07% (from 2,394 Ci in 2015 to 1,698 Ci). VEGP, BLLDF, and SRS contributed to these values. 56 Ci is attributed to the BLLDF.

SRS attributes the decreases observed from 2015 to 2016 for direct releases and stream transport to a decrease in shallow groundwater migration and a decrease in direct releases to Upper Three Runs from the Effluent Treatment Facility. The decrease for river transport from 2015 to 2016 is attributable to decreases from both VEGP and BLLDF.

SRS tritium transport data from 1960–2016 (Figure 5-10), shows the history of direct releases, stream transport, and river transports. The general trend over time is attributable to the following:

- Variations in tritium production and processing at SRS
- Implementing effluent controls beginning in the early 1960s
- SRS tritium inventory continuing to deplete and decay

Within the past five years, SRS has detected a measurable amount of tritium migrating from a non-SRS source, the BLLDF, which EnergySolutions, LLC operates. The tritium continues to enter the SRS stream system at Mary's Branch, which deposits into Lower Three Runs. The facility is privately owned and adjacent to SRS. The tritium currently in groundwater will continue to decay for about 12 years and dilute as it moves from the source toward Lower Three Runs. In 2014, SRS started monitoring at Mary's Branch, which is near BLLDF, to account for the amount of tritium BLLDF contributes. SRS estimated the amount of tritium from BLLDF to be 56 Ci, which was not included in SRS direct release or stream transport totals.

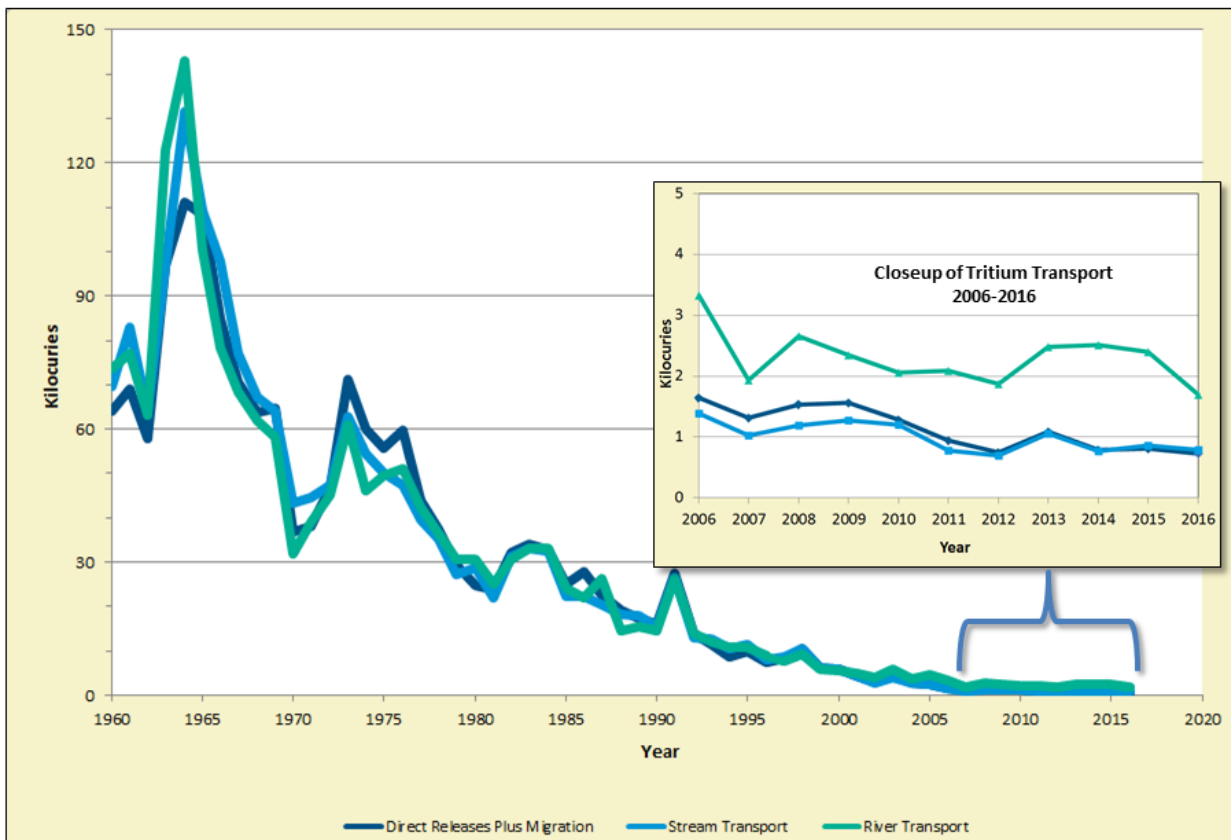


Figure 5-10 SRS Tritium Transport Summary

For compliance dose calculations, the value of SRS direct releases and of the stream transport measurements (which was 731 Ci from stream transport measurements in 2016) is used (see Chapter 6, *Radiological Dose Assessment*).

5.4.6 Settleable Solids Surveillance

Settleable solids are solids in water that are heavy enough to sink to the bottom of the collection container. SRS evaluates settleable solids in water to determine, in conjunction with routine sediment monitoring, whether a long-term buildup of radioactive materials occurs in stream systems. Accurately measuring radioactivity levels in settleable solids is impractical in water samples with low total suspended solids (TSS). SRS monitors for TSS as part of the routine National Pollutant Discharge Elimination System (NPDES) monitoring program from outfalls co-located at or near several radiological effluent points. In 1995, DOE provided an interpretation of the radioactivity levels in settleable solids requirement. The interpretation indicated that TSS levels below 40 parts per million were considered to be in compliance with the DOE limits. If TSS results are at or above 40 parts per million for TSS at the NPDES outfall that are co-located at or near radiological effluent points, samples are analyzed for alpha-emitting and beta/gamma-emitting radionuclides or additional samples may be collected and analyzed. The DOE limits for the radioactivity levels in settleable solids is 5 pCi/g above background for alpha-emitting radionuclides and 50 pCi/g above background for beta/gamma-emitting radionuclides.

5.4.6.1 Settleable Solids Results Summary

In 2016, all NPDES TSS sample results that are co-located at or near radiological effluent points were well below 40 parts per million with no results higher than 12 parts per million. The NPDES TSS results indicate that SRS remains in compliance with DOE's requirement related to radioactivity levels in settleable solids.

5.4.7 Sediment Sampling

In 1996, SRS incorporated the settleable solids program into the radiological environmental surveillance program for sediments. This was done to provide a more reliable and cost-effective method to determine radioactivity buildup in sediments. SRS added eight sample sites to the sediment program to compensate for the loss of the settleable solids sampling program.

Sediment sample analysis measures the movement, deposition, and accumulation of long-lived radionuclides in streambeds and in the Savannah River bed. Year-to-year differences may be evident because sediment is continuously moved and deposited at different locations in the stream and riverbeds (or because of slight variations in sampling locations), but the data obtained can be used to observe long-term environmental trends. During 2016, SRS implemented a composite sediment sampling strategy based on recommendations from the University of Georgia Savannah River Ecology Laboratory report *Technical Assessment of DOE Savannah River Site-Sponsored Radionuclide Monitoring Efforts in the Central Savannah River Area* (SREL 2014).



**Field Technician Collecting
Sediment Sample from a
Stream on SRS**

In 2016, SRS collected sediment samples at 8 Savannah River locations and 27 onsite streams, basins, ponds, or swamp discharge locations ([Environmental Maps, Radiological Sediment Sampling Locations](#)).

5.4.7.1 Sediment Results Summary

Appendix Table D-11 shows the maximum of each radionuclide compared to the applicable SRS control location. The Z-Area Stormwater Basin, a posted Soil Contamination Area, had the maximum cesium-137 concentration of 2,920 pCi/g. Soil Contamination Areas at SRS are locations where the contamination levels exceed 150 pCi/g for beta and gamma radionuclides. The lowest levels of cesium-137 in river, stream and basin sediments were below detection. Table 5-6 shows the maximum sediment concentrations.

Table 5-6 Maximum Cesium-137 Concentration in Sediments Collected in 2016

Location	Maximum Location	Maximum Concentration (pCi/g)
Savannah River Sediment	RM-150.2 Below Four Mile Creek	6.95E-01
SRS Stream Sediment	R-Area (Downstream of R-1)	4.19E+01
SRS Basin Sediment	Z-Basin	2.92E+03

The levels in SRS streams show a decreasing trend, which is due to a combination of decreases in Site releases and the natural decay of radionuclides. Results indicate the radioactive materials from effluent release points are not building up in the sediment at the sampling locations.

5.4.8 Drinking Water Monitoring

SRS collects drinking water samples from 10 locations at SRS and at 2 water treatment facilities that use water from the Savannah River as a source of drinking water ([Environmental Maps, Domestic Water Systems](#)).

Onsite drinking water sampling consists of samples from the large treatment plant in A Area and samples at four wells and five small systems.

SRS monitors potable water at offsite treatment facilities to ensure that SRS operations do not adversely affect the water supply and to provide assurance that drinking water does not exceed EPA drinking water standards for radionuclides. SRS collects samples offsite from the following two locations (Figure 5-11):

- Beaufort-Jasper Water and Sewer Authority's (BJWSA) Purrysburg Water Treatment Plant (WTP)
- North Augusta (South Carolina) WTP

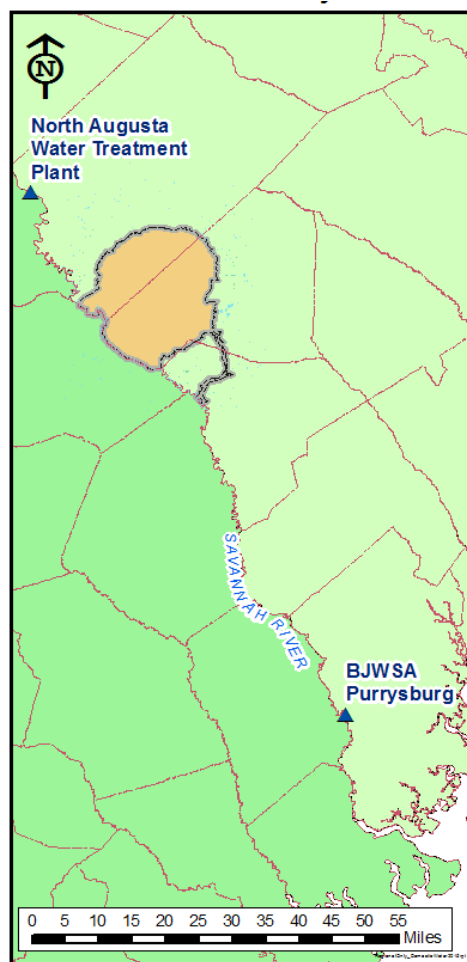


Figure 5-11 Offsite Drinking Water Sampling Locations

SRS collects treated water from these two WTPs, which supply water to the public. The North Augusta WTP is used to determine concentrations in drinking water upstream of SRS. The BJWSA Purrysburg WTP is the furthest downriver sampling location. SRS compares these locations to evaluate potential impacts from upstream sources that include SRS.

5.4.8.1 Drinking Water Results Summary

In 2016, SRS performed gross alpha and gross beta screening on all onsite and offsite drinking water samples. No results exceeded the EPA's 15 pCi/L alpha concentration limit or 50 pCi/L beta concentration limit. In addition, no onsite or offsite drinking water samples exceeded the 20 pCi/mL EPA standard for tritium or the 8 pCi/L strontium-89,90 maximum contaminant level.

Figure 5-12 presents the average drinking water tritium concentrations for the local water treatment plants upstream and downstream from SRS in comparison to the average of weekly river water samples collected at RM 118.8. The average tritium concentration at RM 118.8 is less than 2% of the EPA standard for tritium and decreases further at the downstream sampling location.

Sample results did not detect cobalt-60, cesium-137, strontium-89,90, uranium-235, plutonium 238, plutonium 239, and curium-244 in drinking water test locations. Sample results indicated detectable levels of americium-241 in 2 onsite samples, uranium-234 in 8 onsite samples, and uranium-238 in 10 onsite samples. Appendix Table D-12 summarizes the results. Concentrations are near the levels of detection for these three analytes. All analytical results are well below the EPA standard.

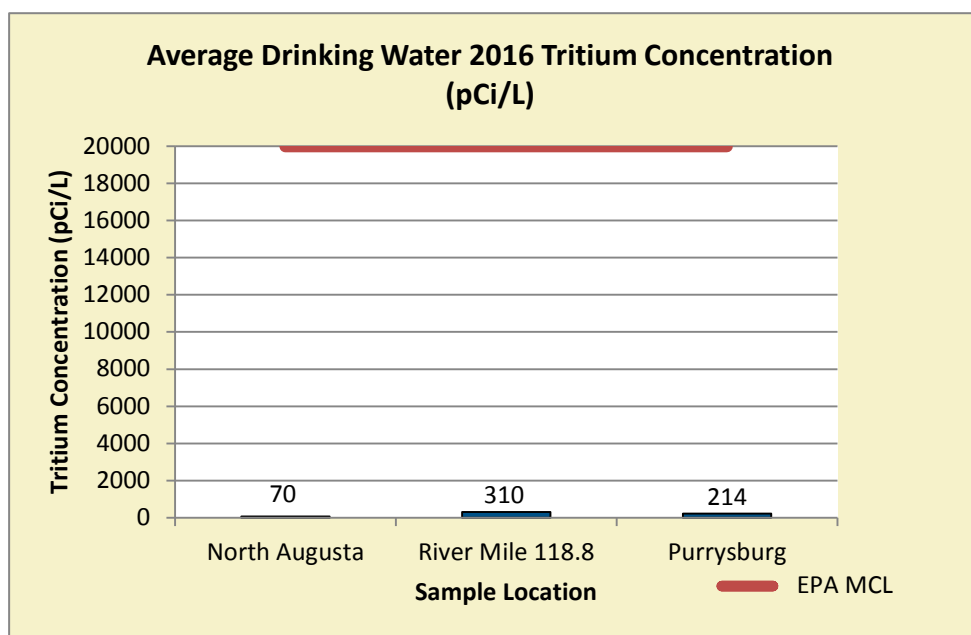


Figure 5-12 Tritium in Offsite Drinking Water and River Mile 118.8

5.5 AQUATIC FOOD PRODUCTS

5.5.1 Fish Collection in the Savannah River

SRS collects aquatic food from the Savannah River. Freshwater fish come from six locations on the Savannah River from above SRS at Augusta, Georgia, to the Highway 301 bridge ([Environmental Maps, Fish Sampling Locations](#)). Onsite, SRS collects freshwater fish at the mouth of the streams that traverse the Site. Saltwater fish come from the Savannah River mouth near Savannah, Georgia. Additionally, shellfish come from the Savannah River mouth near Savannah, Georgia, or SRS purchases them from vendors in the Savannah area that harvest from local saltwater that is potentially influenced by waters of the Savannah River. Table 5-7 identifies the aquatic products collected in 2016.

**Table 5-7 Aquatic Products Collected by SRS in 2016
for the Radiological Environmental Monitoring Program**

Freshwater Fish	Saltwater Fish	Shellfish
Bass	Mullet	Crab
Catfish	Red Drum	Shrimp
Panfish	Sea Trout	

SRS analyzes both edible (meat and skin only) and nonedible (bone) samples of freshwater and saltwater fish. Analyses of edible samples include tritium, gross alpha, gross beta, gamma-emitting radionuclides (that is cesium-137 and cobalt-60), strontium-89,90, technetium-99, and iodine-129. Strontium-89,90 is the only analysis SRS conducts on the nonedible samples. With shellfish, SRS analyzes only the edible portion of shellfish. SRS analyzes shellfish for gross alpha, gross beta, gamma-emitting radionuclides, strontium-89,90, technetium-99, and iodine-129.

5.5.1.1 Fish in Savannah River Results Summary

In 2016, SRS collected freshwater fish from the six locations, saltwater fish and shrimp from the Savannah River mouth, and purchased crabs in the Savannah area from a vendor that harvests from saltwater potentially influenced by Savannah River water. SRS analyzed 54 freshwater fish composites, 8 saltwater fish composites, and 2 shellfish composites. The freshwater and saltwater composites consisted of three to eight fish each. The shellfish composites consisted of one bushel of crab and about one-half bushel of shrimp. The analytical results of the freshwater and saltwater fish, and shellfish collected are consistent with 2011 through 2015 results. A majority of results for the specific radionuclides associated with SRS operations were nondetectable (62% for freshwater fish, 80% for saltwater fish, and 90% for shellfish). Table 5-8 lists the maximum concentration for those radionuclides detected in the flesh of all fish types sampled. The



Collecting Fish by Netting

table also identifies the fish type and the collection location associated with the maximum concentration for each radionuclide. Cobalt-60 and iodine-129 were not detected in any fish flesh samples. Appendix Tables D-13, D-14, and D-15 for freshwater fish, saltwater fish and shellfish, respectively, summarize results for all fish and shellfish.

The maximum gross alpha result for shellfish was detected at 0.476 pCi/g in crab. This value is less than the gross alpha trigger level of 0.951 pCi/g, which SRS uses as the basis for additional analyses of alpha-emitting radionuclides. Gross alpha results were below the MDC for all edible saltwater and freshwater fish composites. Gross beta activity was detectable in all freshwater and saltwater fish, as well as shellfish. The concentrations are consistent with 2011 through 2015 results and are most likely attributed to the naturally occurring radionuclide potassium-40.

The data from the fish monitoring is included in the determination of the potential dose and risk to the public, as reported in Chapter 6, *Radiological Dose Assessment*.

Table 5-8 Location and Fish Type for the Maximum Detected Concentration of Specific Radionuclides Measured in Flesh Samples

Radionuclide	Maximum Concentration	Location	Fish Type
Tritium	0.549 pCi/g	Four Mile Creek River Mouth	Bass
Cesium-137	0.414 pCi/g	Lower Three Runs Creek River Mouth	Panfish
Strontium-89,90	0.00976 pCi/g	Augusta Lock and Dam	Panfish
Technetium-99	0.126 pCi/g	Four Mile Creek River Mouth	Bass

5.6 WILDLIFE SURVEILLANCE

The wildlife surveillance program monitors wildlife harvested from SRS and subsequently released to the public. The purpose of the monitoring is to assess any impact of Site operations on the wildlife populations and ensure that the SRS Annual Administrative Game Animal Release Limit of 22 mrem/yr is not exceeded for any individual. Annual game animal hunts for deer, coyote, and feral hogs are open to members of the public. During 2016, SRS held one turkey hunt for Wounded Warriors and residents with mobility impairments in the spring and nine game animal hunts in the fall. SRS also conducted a roadside deer removal program in 2016. The Site holds the annual hunts and deer removal to reduce animal-vehicle collisions and control Site deer, coyote, and feral hog populations.

SRS monitors all animals harvested during the annual hunts to ensure the total dose to any hunter is below the SRS 22 mrem/yr limit. SRS uses portable sodium iodide detectors to perform field analyses for cesium-137. SRS began using newly designed field monitoring equipment in October. Chapter 8, *Quality Assurance*, presents information related to the upgraded field monitoring equipment.

SRS uses the cesium-137 concentration detected in the edible flesh of the animal to calculate dose. The edible flesh is that portion of the animal consumed. A dose is assigned to each hunter for every animal harvested if the cesium-137 concentration is above the background concentration of 3.25 picocurie per gram (pCi/g). In addition to the field monitoring, SRS collects samples of muscle for laboratory analysis of

cesium-137 concentrations in both deer and hogs based on (1) a set frequency, (2) the field measured cesium-137 levels, or (3) exposure limit considerations. These laboratory-analyzed data provide a quality-control check on the field monitoring results. Cesium-137 is chemically similar to and behaves like potassium in the environment. Cesium-137 has a half-life of about 30 years and tends to persist in soil, where it can readily enter the food chain through plants. It is widely distributed throughout the world from nuclear weapons detonations from 1945 to 1980 and is present at low levels in all environmental media. Flesh samples analyses also include cobalt-60, strontium 89,90, gross alpha, and gross beta. Bone samples are collected on the same frequency as the flesh samples and are analyzed for strontium-89,90.

5.6.1 Wildlife Results Summary

During the hunts in 2016, SRS monitored a total of 301 deer, 36 feral hogs, 5 coyotes, and 25 turkeys. No dose was assigned to any hunter during three of the nine game animals hunts conducted in 2016, as well as the turkey hunt. This indicates that all animals harvested during those hunts were at or below the background cesium-137 concentration of 3.25 pCi/g. During the hunt season, however, field monitoring results indicated one animal, a male deer, would have been above the administrative game animal release limit of 22 mrem and thus was not released to the hunter.

The Site released all 25 turkeys harvested during the spring hunt. Additionally, it released 212 deer and 36 hogs harvested during the 9 game animal hunts. Hunters chose not to keep the five coyotes they harvested and that SRS approved for release. Of the 88 deer that SRS harvested during the roadside deer removal project, 3 deer were not released because monitoring results indicated cesium-137 concentrations were above the background concentration of 3.25 pCi/g.

Appendix Table D-16 summarizes the muscle and bone sample results from a subset of the monitored deer and hogs. As seen in previous years, laboratory analysis detected cesium-137, a man-made gamma-emitting radionuclide, in muscle tissue. Analysis detected strontium-89,90, a beta-emitting radionuclide, in bone and in some muscle tissue.

Generally, the cesium-137 concentrations field detectors measure are similar to those of laboratory methods. Field measurements for cesium-137 from all released animals ranged from a minimum of 0.78 pCi/g to 14.17 pCi/g, while laboratory measurements ranged from nondetect to 11.8 pCi/g. Table 5-9 summarizes field and laboratory measurements. The maximum field and laboratory measurement for the deer from the regular hunts, as shown in Table 5-9, is for the male deer that was not released due to the dose associated with the animal being above the SRS Annual Administrative Game Animal Release Limit.



**Training Session on
the Use of the
Upgraded Wildlife
Monitoring System
(above)**

**Closeup of the New
Detector (left)**

Average cesium-137 concentrations in deer have indicated an overall decreasing trend for the past 50 years, with relatively little change in the last 10 years. Figure 5-13 shows the historical trend analysis.

Because its chemistry is similar to that of calcium, strontium exists at higher concentration in bone than in muscle tissue. In 2016, all 42 deer bone and 3 hog bone samples had detectable levels of strontium-89,90. Strontium-89,90 was detected in deer bone with an average of 3.83 pCi/g and a maximum of 6.73 pCi/g. Strontium-89,90 was detected in hog bone with an average of 2.08 pCi/g and a maximum of 2.50 pCi/g.

For the deer muscle tissue samples, 4 out of the 42 muscle tissue samples had levels greater than the MDC for strontium-89,90 with a maximum detectable concentration of 0.011 pCi/g. These average results are similar to those of previous years.

All cobalt-60 and gross alpha results were not detectable. Gross beta activity, detected in all samples, is consistent with 2011 through 2015 results.

Chapter 6, *Radiological Dose Assessment*, presents the calculation of dose from consuming wildlife harvested on SRS.

Table 5-9 Cesium-137 Results for Laboratory¹ and Field Measurements in Wildlife

2016	Number of Animals	Field Gross Average Cs-137 Concentration (pCi/g)	Field Maximum Cs-137 Concentration (pCi/g)	Lab Average Cs-137 Concentration (pCi/g)	Lab Maximum Cs-137 Concentration (pCi/g)
Deer—Game Hunts	213	2.11	27.26 ²	2.64	11.80 ²
Deer—Roadside Deer Removal	88	1.20	7.05	1.21	7.20
Hog	36	1.05	2.70	0.778	1.14
Coyote	5	3.22	6.40	-----	-----
Turkey	25	0.28	1.04	-----	-----

Notes:

1. In evaluating the upgraded monitoring equipment, samples collected for laboratory analyses were biased toward animals where field monitoring indicated a DOE-added dose.

2. The maximum values are from the animal that was not released. Field monitoring indicated the dose associated with the animal to be above the SRS Administrative Game Animal Release Limit.

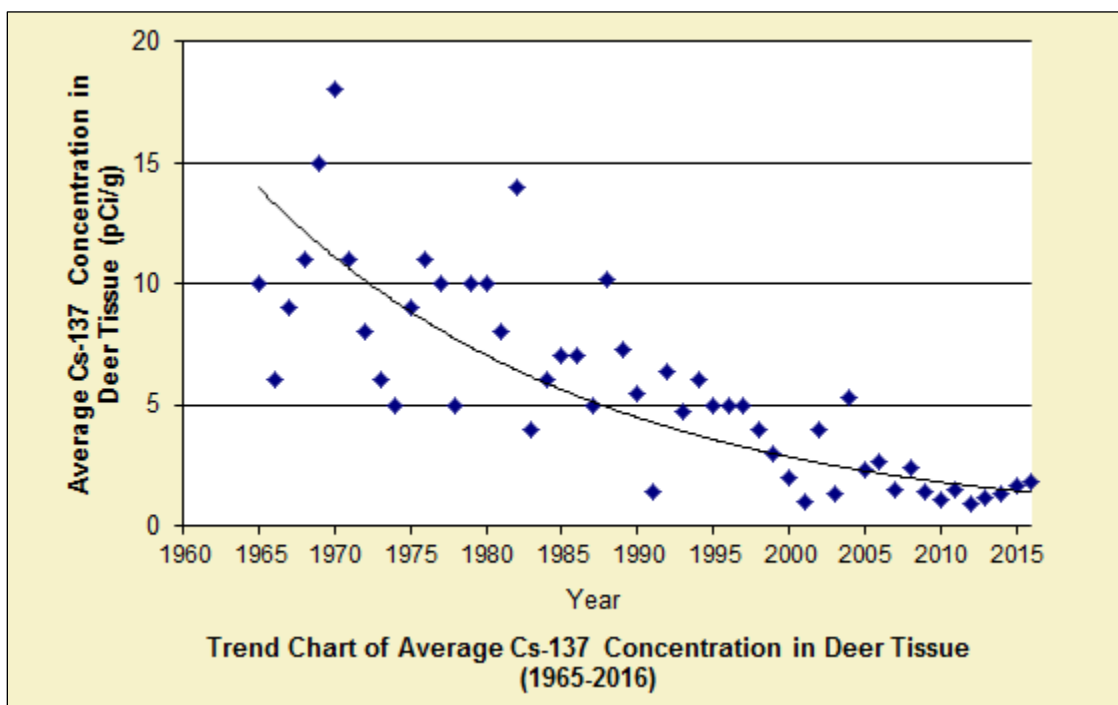


Figure 5-13 Historical Trend of Average Cesium-137 Concentration in Deer Tissue (1965–2016)

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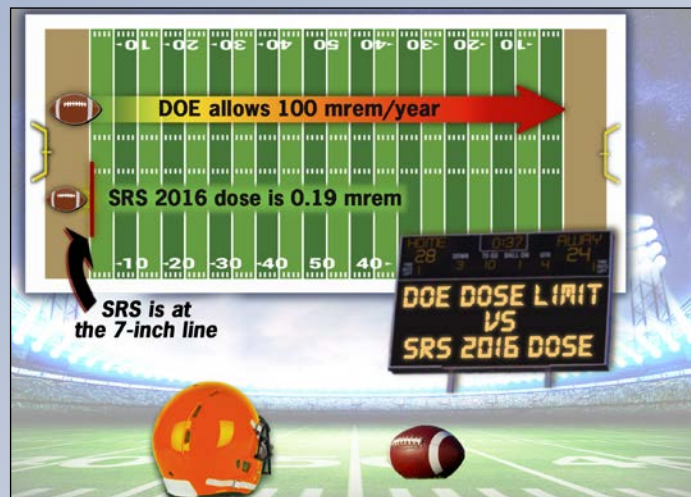
Chapter 6

Radiological Dose Assessment

Department of Energy (DOE) Order 458.1, *Radiation Protection of the Public and the Environment*, establishes dose limits for the public and onsite plants and animals. These dose limits protect the public and environment from the effect of radiation released during some DOE activities. To ensure that radiation exposure does not exceed the DOE public dose standard of 100 mrem/year (yr), the Savannah River Site (SRS) calculates the potential dose to the public from radioactive releases in air and water through all reasonable exposure pathways (direct, ingesting, absorbing, inhaling). SRS also considers and quantifies exposure pathways that are nontypical and not included in the standard dose calculations to the representative person. These apply to conservative and unlikely scenarios such as a member of the public eating fish caught only from the mouths of SRS streams or to special scenarios such as hunters who participate in onsite hunts. In addition, DOE Order 458.1 establishes authorized surface contamination limits, which allow SRS to release personal and real property unconditionally. SRS performs radiological surveys on all equipment considered for release and follows applicable procedures.

2016 Highlights

Dose to the Offsite Representative Person—The dose to the offsite representative person was 0.15 mrem from SRS liquid releases and 0.038 mrem from SRS air releases. To comply with the DOE all-pathway dose standard of 100 mrem/yr, SRS conservatively adds these two doses for a total representative person dose of 0.19 mrem, which is 0.19% of the 100 mrem/yr DOE dose standard.



Comparison of DOE's 100 mrem/year (yr) Dose Standard to SRS's 2016 All-Pathway Dose of 0.19 mrem

2016 Highlights (continued)

Sportsman Doses

- **Onsite Hunter**—SRS conducts annual hunts to control onsite deer and wild hog populations. SRS determines the estimated dose from eating harvested deer or hog meat for every onsite hunter. The maximum potential dose for an onsite hunter was 13.5 mrem, or 13.5% of the 100 mrem/yr DOE dose standard.
- **Creek Mouth Fisherman**—SRS estimated the maximum potential dose from fish consumption from bass collected at the mouth of Fourmile Branch at 0.22 mrem. This dose is 0.22% of the 100 mrem/yr DOE dose standard. SRS bases this hypothetical dose on the low probability that, during 2016, a fisherman consumed 53 pounds (lbs) of bass caught exclusively from the mouth of Fourmile Branch.

Release of Material Containing Residual Radioactivity—SRS did not release any real property (land or buildings) in 2016. SRS unconditionally released 11,516 items of personal property (such as tools) from radiological areas. Most of these items did not leave the Site, but were reused elsewhere on the Site. However, all of these items required no additional radiological controls post-survey, as they met DOE Order 458.1 release criteria.

Radiation Dose to Aquatic and Terrestrial Biota—SRS evaluates plant and animal doses for water and land systems. For 2016, all SRS water, sediment, and soil locations passed their Level 1 (using maximum measured concentrations) or Level 2 (using average measured concentrations) screenings and did not require further assessments.

6.1 INTRODUCTION

Routine SRS operations release controlled amounts of radioactive materials to the environment through air and water. These releases could expose people offsite to radiation. To confirm that this exposure is below public dose limits, SRS calculates annual dose estimates using environmental monitoring and surveillance data, combined with relevant Site-specific data (such as weather conditions, population characteristics, and river flow). SRS also confirms that the potential doses to plants and animals (biota) living onsite remain below the DOE biota dose limits. This chapter explains radiation doses, describes how SRS calculates doses, and presents the estimated doses from SRS activities for 2016.

Radiological Impact of 2016 Operations at the Savannah River Site (Jannik, Minter, and Dixon 2017a) details SRS dose calculation methods and results.

To calculate the potential doses to the public, SRS used the data from the monitoring programs Chapter 5, *Radiological Environmental Monitoring Program*, describes.

6.2 WHAT IS RADIATION DOSE?

Radiation dose to a person is the amount of energy absorbed by the human body from a radiation source located either inside or outside of the body. SRS typically reports dose in millirem (mrem), which is one-thousandth of a rem. A rem is a standard unit used to measure the amount of radiation deposited in human tissue.

Humans, plants, and animals potentially receive radiation doses from natural and man-made sources. The average annual background dose for all people living in the United States is 625 mrem; this includes an average background dose of 311 mrem from naturally occurring radionuclides found in our bodies, in the earth, and from cosmic radiation, such as from the sun.

Man-made sources and their doses include medical procedures (300 mrem), consumer products (13 mrem), and industrial and occupational exposures from facilities such as SRS (less than 1 mrem).

DOE has established dose limits to the public so that DOE operations will not contribute significantly to this average annual exposure. DOE Order 458.1 (DOE 2013) establishes 100 mrem/yr (1 mSv/yr) as the annual dose limit to a member of the public. Exposure to radiation primarily occurs through the following pathways, which Figure 6-1 illustrates:

- Inhaling air
- Ingesting water and food
- Absorbing through skin
- Direct (external) exposure to radionuclides in soil, air, and water

6.3 CALCULATING DOSE

To comply with DOE Order 458.1, dose can be calculated to the maximally exposed individual (MEI) or to a representative person. Since 2012, SRS has used the representative person concept for the DOE public dose limit.

SRS calculates the representative person dose using site-specific reference person parameters. The SRS representative person falls at the 95th percentile of national and regional data. The applicable national and regional data used are from the U.S. Environmental Protection Agency's (EPAs) *Exposure Factors Handbook*, 2011 Edition (EPA 2011).

The reference person is weighted based on gender and age. The International Commission on Radiation Protection Publication 89, (ICRP 2002) groups these ages as: Infant (0 years), 1 year, 5 years, 10 years, 15 years, and Adult (17 years and older). The reference person accounts for the fact that younger people are, in general, more sensitive to radioactivity than older people. SRS also developed human usage parameters at the 50th percentile for calculating dose to a "typical" person when determining population doses.

Chapter 6—Key Terms

Exposure pathway is the way that releases of radionuclides into the water and air could impact a person.

Reference person is a hypothetical person with average physical and physiological characteristics—including factors such as age and gender—used internationally to standardize radiation dose calculations.

Representative person is a hypothetical individual receiving a dose that is representative of highly exposed individuals in the population. The calculations incorporate age, gender, food and water consumption, and breathing rate. At SRS, the representative person equates to the 95th percentile of applicable national human-use radiation exposure data.

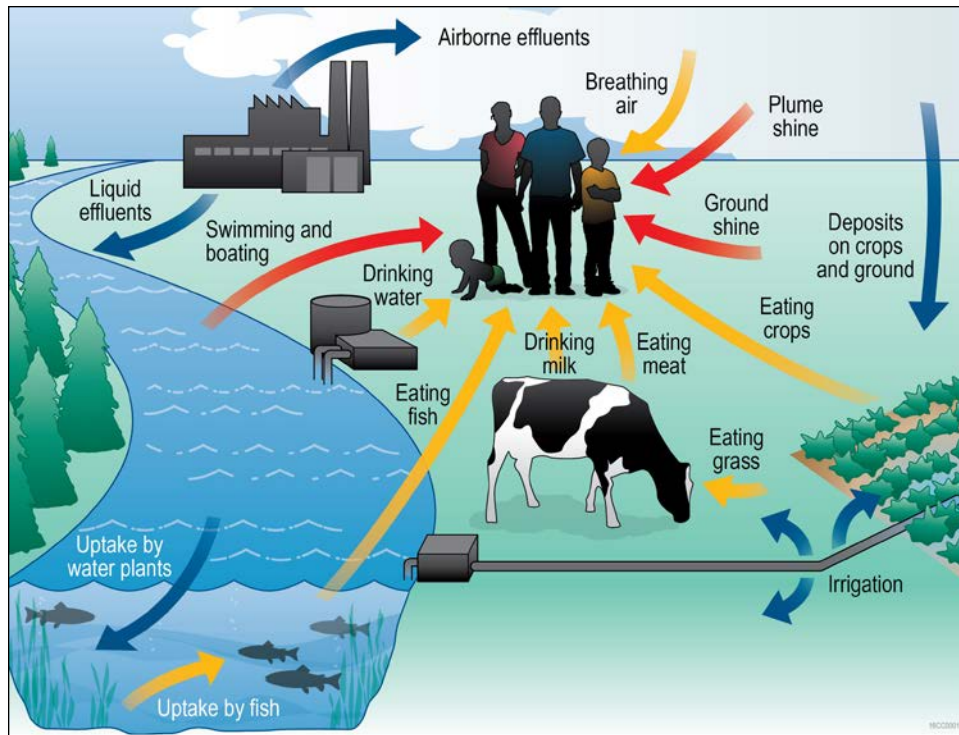


Figure 6-1 Exposure Pathways to Humans from Air and Liquid Effluents

The SRS report *Site-Specific Reference Person Parameters and Derived Concentration Standards for SRS* (Stone and Jannik 2013) documents SRS-specific reference and typical person usage parameters. The SRS report *Land and Water Use Characteristics and Human Health Input Parameters for Use in Environmental Dosimetry and Risk Assessments at the Savannah River Site* (Jannik et al. 2016) documents all other applicable land- and water-use parameters in the dose calculations. These parameters include local characteristics of food production, river recreational activities, and other human usage parameters required in SRS models to calculate radioactive dose exposure.

To determine the Site is complying with DOE public dose requirements, SRS calculates the potential offsite doses from Site effluent releases of radioactive materials (air and liquid) for the following scenarios:

- Representative person living near the SRS boundary
- Population living within a 50-mile (80-kilometer [km]) radius of SRS

For all routine environmental dose calculations, SRS uses environmental transport and dose models based on codes the Nuclear Regulatory Commission (NRC) developed (NRC 1977). The NRC-based transport models use DOE-accepted methods, consider all significant exposure pathways, and permit detailed analysis of the effects of routine operations. The SRS report *Environmental Dose Assessment Manual* (Jannik, Minter, and Dixon 2017b) describes the specific models SRS uses.

At SRS, the dose to a representative person is based on the following:

- 1) SRS-specific reference person usage parameters at the 95th percentile of appropriate national or regional data (Stone and Jannik 2013).
- 2) Reference person (gender- and age-averaged) ingestion and inhalation dose coefficients from the

DOE Derived Concentration Technical Standard, DOE-STD-1196-2011 (DOE 2011).

- 3) External dose coefficients from the DC_PAK3 toolbox, (accessed at <http://www.epa.gov/rpdweb00/federal/techdocs.html>). Currently, there are no age-specific external dose factors available.

6.3.1 Weather Database

Complete and accurate weather (meteorological) data are important to determine offsite contamination levels. SRS calculated potential offsite doses from radioactive releases to the air with quality-assured weather data from 2007 to 2011 (Viner 2013).

Figure 6-2 presents the H-Area wind rose plot for 2007-2011 and shows the direction and frequency the wind blows. As shown, the wind blows the most towards the East-Northeast sector (about 9% of the time), but there is no strongly prevalent wind direction.

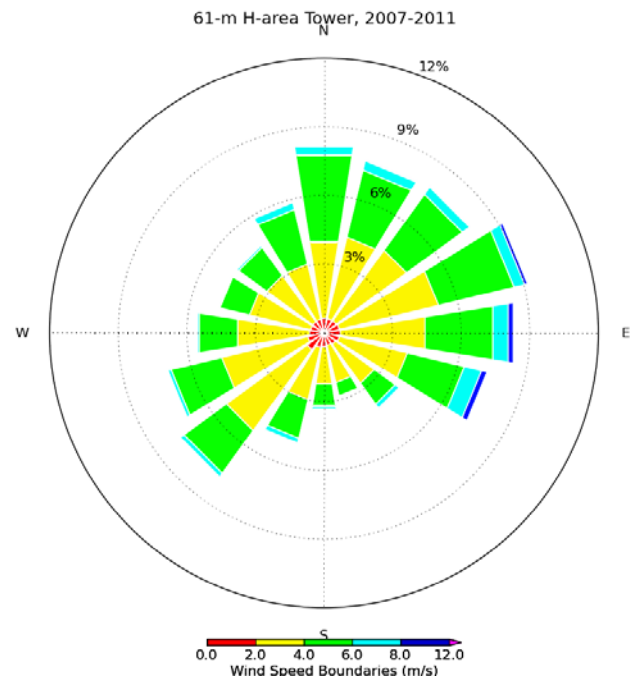


Figure 6-2 2007–2011 Wind Rose Plot for H Area (Showing Direction and Frequency Toward Which the Wind Blows)

6.3.2 Population Database and Distribution

SRS calculates the collective (population) doses from air releases for the population within a 50-mile radius of the Site. Based on the U.S. Census Bureau's 2010 data, the population within a 50-mile radius of the center of SRS is 781,060 people. This translates to about 104 people per square mile outside the SRS boundary, with the largest concentration in the Augusta metropolitan area.

Table 6-1 presents the collective doses from SRS liquid releases to the populations that three downriver drinking water supply plants serve.

The total population dose from routine SRS liquid releases is the sum of the following five contributing categories:

- 1) Beaufort-Jasper Water and Sewer Authority (BJWSA) water consumers
- 2) City of Savannah Industrial and Domestic (I&D) water consumers
- 3) Consuming fish and invertebrates of Savannah River origin
- 4) Recreational activities on the Savannah River
- 5) Irrigating foodstuffs with river water near River Mile (RM) 118.8 (U.S. Highway 301 bridge)

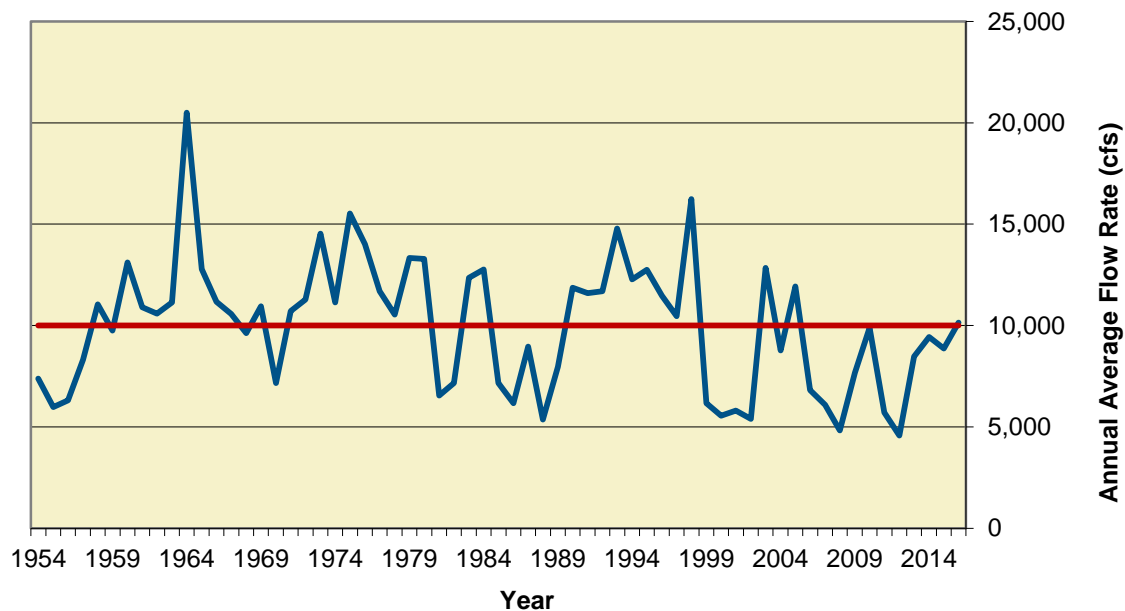
Table 6-1 Regional Water Supply Service

Water Supply Plant	Nearest City	Population Served
City of Savannah Industrial and Domestic Water Supply Plant (City of Savannah I&D)	Port Wentworth, Georgia	35,000 people
Beaufort-Jasper Water and Sewer Authority's (BJWSA) Chelsea Water Treatment Plant	Beaufort, South Carolina	83,700 people
BJWSA Purrysburg Water Treatment Plant	Beaufort, South Carolina	64,800 people

6.3.3 River Flow Rate Data

The annual rate of flow in the Savannah River, which varies greatly from year to year, is an important criterion for determining down-river concentrations of the contaminants SRS releases. The U.S. Geological Survey (USGS) measures Savannah River flow rates down river of SRS at its RM 118.8 gauging station, located near the U.S. Hwy 301 Bridge.

Figure 6-3 provides the river flow rates measured at this location from 1954 to 2016. It also shows that the average river flow rate for these years is about 10,000 cubic feet per second (cfs). However, recently, there has been a downward trend in these data with an average measured flow rate of just 7,567 cfs during the past 10 years.

**Figure 6-3 Savannah River Annual Average Flow Rates at River Mile 118.8**

For 2016, SRS used a calculated “effective” Savannah River flow rate of 6,426 cfs in the dose calculations. The 2016 effective flow rate is about 8% more than the 2015 effective flow rate of 5,972 cfs. This effective flow rate (based on actual measured tritium concentrations in the river) is more conservative than the 2016 USGS measured flow rate of 10,150 cfs (based on daily flow rates). By using a conservative method, the calculated effective flow rate assumes radioactive material is less diluted and, therefore, increases the estimated potential dose.

6.4 OFFSITE REPRESENTATIVE PERSON DOSE CALCULATION RESULTS

To determine the Site is complying with DOE public dose requirements, SRS calculates the potential offsite doses from Site effluent releases of radioactive materials in air and liquid pathways for a representative person living near the SRS boundary. SRS calculates the pathways individually and then adds the two results to obtain the representative person dose.

6.4.1 Liquid Pathway

6.4.1.1 Liquid Release Source Terms

Table 6-2 shows, by radionuclide, the amount of radioactivity in liquid form that SRS released in 2016. SRS uses these release amounts in the dose calculations. Discussions of the sources of these data are in Chapter 5, *Radiological Environmental Monitoring Program*.

Tritium accounts for more than 99% of the total amount of radioactivity released from the Site to the Savannah River. In 2016, SRS released a total of 731 curies of tritium to the river, a 7% decrease from the 2015 amount of 786 curies. For compliance dose calculations, SRS used the stream transport measurement (731 curies), which was higher than the direct release (668 curies). Refer to Chapter 5, *Radiological Environmental Monitoring Program*, Section 5.4.5 for details concerning these measurements.

During 2016, in addition to the 731 curies SRS released, the Georgia Power Company’s Vogtle Electric Generating Plant (VEGP) released 992 curies of tritium to the Savannah River, and 56 curies migrated from the Barnwell Low-Level Disposal Facility (BLLDF) for an overall total of 1,779 curies of tritium (SRS plus VEGP plus BLLDF). This is slightly more than the total of 1,698 curies measured in the Savannah River near RM 118.8, as Chapter 5 reports. The 2016 total of 1,779 curies is a 31% decrease from the combined total of 2,565 curies in 2015.

Table 6-2 2016 Radioactive Liquid Release Source Term and 12-Month Average Downriver Radionuclide Concentrations Compared to the EPA's Drinking Water Maximum Contaminant Levels (MCL)

Nuclide	Curies Released	12-Month Average Concentration (pCi/L)		
		Below SRS ^a	at BJWSA Purrysburg Plant ^b	EPA MCL ^c
H-3 ^d	7.31E+02	3.10E+02	2.14E+02	2.00E+04
C-14	5.82E-04	1.01E-04	7.00E-05	2.00E+03
Sr-90	1.95E-02	3.40E-03	2.34E-03	8.00E+00
Tc-99	1.88E-02	3.27E-03	2.26E-03	9.00E+02
I-129	1.82E-02	3.17E-03	2.19E-03	1.00E+00
Cs-137	4.79E-02	8.34E-03	5.76E-03	2.00E+02
U-234	3.30E-02	5.75E-03	3.97E-03	1.03E+01
U-235	1.04E-03	1.81E-04	1.26E-04	4.67E-01
U-238	3.68E-02	6.41E-03	4.42E-03	1.00E+01
Np-237	2.78E-06	4.84E-07	3.34E-07	1.50E+01
Pu-238	2.60E-04	4.53E-05	3.13E-05	1.50E+01
Pu-239	1.37E-05	2.39E-06	1.65E-06	1.50E+01
Am-241	1.80E-03	3.13E-04	2.16E-04	1.50E+01
Cm-244	1.54E-04	2.68E-05	1.85E-05	1.50E+01
Alpha	1.98E-02	3.45E-03	2.38E-03	1.50E+01
Beta	1.36E-01	2.37E-02	1.63E-02	8.00E+00

Notes:

^a Near Savannah River Mile 118.8, downriver of SRS at the U.S. Highway 301 bridge^b Beaufort-Jasper Water and Sewer Authority, drinking water at the Purrysburg Water Treatment Plant^c MCLs for uranium based on radioisotope specific activity X 30 µg/L X isotopic abundance^d The actual measurements of the Savannah River water at the various locations are the basis for the tritium concentrations and source term. They include contributions from VEGP and the Barnwell Low-Level Disposal Facility. SRS uses the effective or measured river flow rate to calculate all other radionuclide concentrations.

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

SRS measures the tritium concentrations in the river water and cesium-137 in fish at several locations along the Savannah River. SRS uses these direct measurements to make dose determinations. The amounts of all other radionuclides SRS released are so small that their concentration in the Savannah River usually cannot be detected using conventional analytical techniques. SRS calculates the concentrations in the river based on the annual release amounts and river flow rates.

Radionuclide Concentrations in River Water and Treated Drinking Water—Table 6-2 shows the measured concentrations of tritium in the Savannah River near RM 118.8 and at the BJWSA Purrysburg Water Treatment Facility, which is representative of the BJWSA Chelsea and the City of Savannah I&D water treatment plants. These downriver tritium concentrations include tritium releases from SRS and the VEGP and BLLDF. Table 6-2 also provides the calculated concentrations for the other released radionuclides and a comparison of these concentrations to the Safe Drinking Water Act, 40 CFR 141 (EPA 2000) maximum contaminant level (MCL) for each radionuclide.

In 2016, the 12-month average tritium concentration measured in Savannah River water near RM 118.8 was 310 picocuries per liter (pCi/L). This reflects a 36% decrease from the 481 pCi/L measured in 2015. SRS attributes this decrease to the 30% decrease in the combined (SRS plus VEGP plus BLLDF) total of tritium released to the Savannah River in 2016 and to the 8% increase in the effective river flow rate from 2015 to 2016, which caused more dilution to occur.



SRS Samples Savannah River Water at RM 118.8, Near the U.S. Highway 301 Bridge. SRS Uses the Tritium Concentrations Measured at this Location in the Annual Dose.

Radionuclide Concentrations in Fish—Consuming fish is an important dose pathway for the representative person. Fish exhibit a high degree of bioaccumulation for certain elements. For cesium (including radioactive isotopes of cesium, such as cesium-137), the bioaccumulation factor for Savannah River fish is 3,000, meaning that the cesium concentration 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).

Because of this high bioaccumulation factor, SRS can detect cesium-137 more easily in fish flesh than in river water. Therefore, when conservative to do so, SRS bases the fish pathway dose from cesium-137 directly on analyzing the fish collected near RM 118.8, the assumed location of the hypothetical representative person. In 2016, SRS analyzed fish in the river to determine the cesium-137 release value of 0.0479 Ci, which was a small (2%) increase from the 2015 value of 0.0468 Ci.

6.4.1.3 Dose to the Representative Person

The 2016 potential dose to the representative person from all liquid pathways (including irrigation) was estimated at 0.15 mrem (0.0015 mSv), which was the same as the comparable dose in 2015. Table 6-3 shows that the total liquid pathway dose is 0.15% of the DOE public dose standard of 100 mrem/yr (1 mSv/yr).

Table 6-3 Potential Dose to the Representative Person from SRS Liquid Releases in 2016

	Committed Dose (mrem)	Applicable Standard (mrem)	Percent of Standard (%)
Near Site Boundary (All Liquid Pathways)			
All Liquid Pathways Except Irrigation	0.05		
Irrigation Pathways	0.10		
Total Liquid Pathways	0.15	100 ^a	0.15%

Note: ^aDOE dose standard: 100 mrem/yr (DOE Order 458.1)

About 66% of the 2016 total dose to the representative person is from consuming meat, milk, and vegetables that have been raised using Savannah River water from RM 118.8. The fish consumption pathway accounted for 23%, and the drinking water pathway accounted for 11%. As Figure 6-4 shows, unidentified beta emitters (23%) and cesium-137 (21%) contributed the most to the liquid dose.

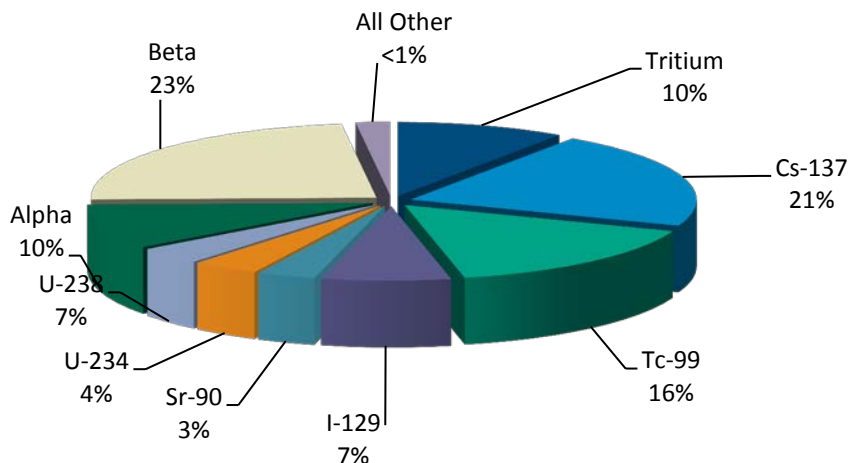


Figure 6-4 Radionuclide Contributions to the 2016 SRS Total Liquid Pathway Dose of 0.15 mrem (0.0015 mSv)

6.4.1.4 Drinking Water Pathway Dose

People living downriver of SRS may receive some dose by drinking water that contains radioactive releases from the Site. Tritium in downriver drinking water represented the highest percentage of the dose (about 46%) received by customers of the three downriver water treatment plants.

In 2016, SRS-only releases were responsible for a maximum potential drinking water dose of 0.012 mrem (0.00012 mSv). This dose is 25% less than the 2015 dose of 0.016 mrem (0.00016 mSv). SRS attributes this drop to the decrease in tritium releases and to the increase in the estimated Savannah River flow rate during 2016. There is not a separate drinking water dose standard, but the EPA Maximum Contamination Levels (MCL), defined in 40 CFR 141 (EPA 2000), assume a potential dose of about 4 mrem/yr for beta and gamma emitters.

6.4.1.5 Collective (Population) Dose

SRS calculates the collective drinking water consumption dose for the separate population groups that are customers of the BJWSA and City of Savannah I&D water treatment plants. Calculations of collective doses from agricultural irrigation assume that 1,000-acre parcels of land are used for each of the major food types grown in the SRS area (vegetables, milk, and meat), with the population within 50 miles of SRS consuming all the food produced on these 1,000-acre parcels.

In 2016, the collective dose from all liquid pathways was 3.5 person-rem (0.035 person-Sv). SRS calculates the collective dose in person-rem as the average dose per typical person multiplied by the number of people exposed. DOE Order 458.1 requires that SRS calculate and report a collective dose, but there is not a separate collective dose standard for comparison.

6.4.2 **Air Pathway**

6.4.2.1 Air Release Source Terms

Chapter 5, *Radiological Environmental Monitoring Program*, documents the 2016 radioactive air release quantities used as the source term in SRS dose calculations. Tritium accounts for a majority of the dose from SRS air releases. As discussed in Chapter 5, SRS tritium releases increased about 14% from 2015 to 2016, which increased the 2016 SRS air pathway doses.

6.4.2.2 Air Concentrations

SRS uses calculated radionuclide concentrations instead of measured concentrations for dose determinations because conventional analytical methods do not detect most of the radionuclides SRS released in the air samples collected at the Site perimeter and offsite locations. However, SRS can routinely measure tritium concentrations at locations along the Site perimeter and compare these results with the calculated concentrations to confirm the dose models. In 2016, this comparison showed that the dose models used at SRS were about 1.5 to 4 times more conservative than the actual measured tritium concentrations.

6.4.2.3 Dose to the Representative Person

The 2016 estimated dose from air releases to the representative person was 0.038 mrem (0.00038 mSv), 0.38% of the EPA 40 Code of Federal Regulations (CFR) 61 air pathway standard of 10 mrem per year. Table 6-4 compares the representative person dose with the EPA standard. The 2016 dose was about 19% more than the 2015 dose of 0.032 mrem (0.00032 mSv). SRS attributes this increase to the 14% increase in tritium releases during 2016 (See Chapter 5, *Radiological Environmental Monitoring Program*.)

Table 6-4 Potential Doses to the Representative Person and to the MEI from SRS Air Releases in 2016 and Comparison to the Applicable Dose Standard

	MAXDOSE-SR	CAP88-PC (EPA NESHAP)
Calculated dose (mrem)	0.038	0.024
Applicable Standard (mrem)	10 ^a	10 ^b
Percent of Standard (%)	0.38	0.24

Notes:

^a DOE: DOE Order 458.1

^b EPA: (NESHAP) 40 CFR 61, Subpart H

As Figure 6-5 shows, tritium releases were nearly 94% of the dose to the representative person. Iodine-129 and cesium-137 were about 2% each. No other individual radionuclide was more than 1% of the representative person dose.

The major ways a representative person received radiation dose from air releases were inhalation (37%), consuming vegetables (36%), and consuming cow milk (24%).

6.4.2.4 Collective (Population) Dose

SRS calculates the air-pathway collective dose for all 781,060 members of the population living within 50 miles of the center of the Site. In 2016, SRS estimated the airborne-pathway collective dose to be 1.4 person-rem (0.014 person-Sv).

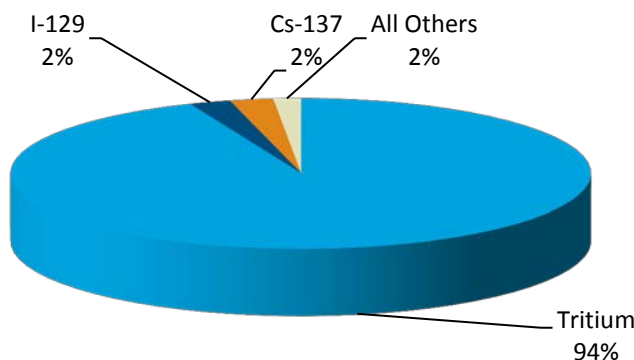


Figure 6-5 Radionuclide Contributions to the 2016 SRS Air Pathway Dose of 0.038 mrem (0.00038 mSv)

6.4.2.5 National Emission Standards for Hazardous Air Pollutants (NESHAP) Compliance

To demonstrate the Site is complying with NESHAP regulations (EPA 2002), SRS calculated maximally exposed individual (MEI) and collective doses using the following three methods:

- 1) The CAP88 PC version 4.0.1.17 computer code
- 2) The 2016 airborne-release source term
- 3) Site-specific input parameters

EPA requires using the MEI concept and not the reference person concept at this time. It specifies most of the input parameters in the CAP88 PC program. The EPA requires specific approval for any changes to these parameters.

For 2016, SRS used CAP88 PC (version 4.0.1.17, dated September 2014) to demonstrate it complied with EPA's 10 mrem/yr (0.1 mSv/yr) public dose standard for airborne emissions from DOE sites. SRS estimated the MEI dose at 0.024 mrem (0.00024 mSv), or 0.24% of the 10-mrem/yr EPA standard, as Table 6-4 shows.

Tritium oxide releases accounted for about 88% of the MEI dose, elemental tritium accounted for 6.5%, and cesium-137 accounted for 3.6%. The 2016 NESHAP compliance dose (MEI dose) was about 10% more than the 2015 dose of 0.022 mrem (0.00022 mSv). Again, SRS attributes this increase to the 14% increase in tritium releases during 2016. (See Chapter 5, *Radiological Environmental Monitoring Program*.)

6.4.3 All-Pathway Doses

6.4.3.1 All-Pathway Representative Person Dose

As stated in DOE Order 458.1, the all-pathway dose standard to a member of the public is 100 mrem/yr. SRS ensures a conservative estimate by combining the representative person airborne all-pathway and liquid all-pathway dose estimates, even though the two estimated doses are for hypothetical individuals living in different geographic locations.

For 2016, the potential representative person all-pathway dose was 0.19 mrem (0.0019 mSv), calculated as 0.15 mrem from liquid pathways plus 0.038 mrem from air pathways. As Table 6-5a shows, the all-pathway representative person dose is 0.19% of the 100 mrem/yr (1 mSv/yr) DOE dose standard. The all-pathway total dose is about 6% more than the 2015 total dose of 0.18 mrem (0.0018 mSv). SRS attributes this small increase to the 14% increase in airborne tritium releases during 2016.

Figure 6-6 shows a 10-year history of SRS's all-pathway (airborne pathways plus liquid pathways) doses to MEI and representative populations.

6.4.3.2 All-Pathway Collective (Population) Dose

DOE Order 458.1 requires that SRS calculate and report a collective dose, but there is not a separate collective dose standard for comparison. For 2016, the total potential collective all-pathway dose was 4.9 person-rem (0.049 person-Sv), calculated as 3.5 person-rem from liquid pathways plus 1.4 person-rem from air pathways. To compare, the annual collective dose from natural sources of radiation that the population within the 50-mile radius surrounding SRS receives is about 243,000 person-rem (781,060 people X 0.311 rem/yr). As Table 6-5b shows, the SRS all-pathway collective dose of 4.9 person-rem is less than 0.01% of the annual collective background dose.

Table 6-5a Potential Dose to the Representative Person from all Standard Pathways in 2016

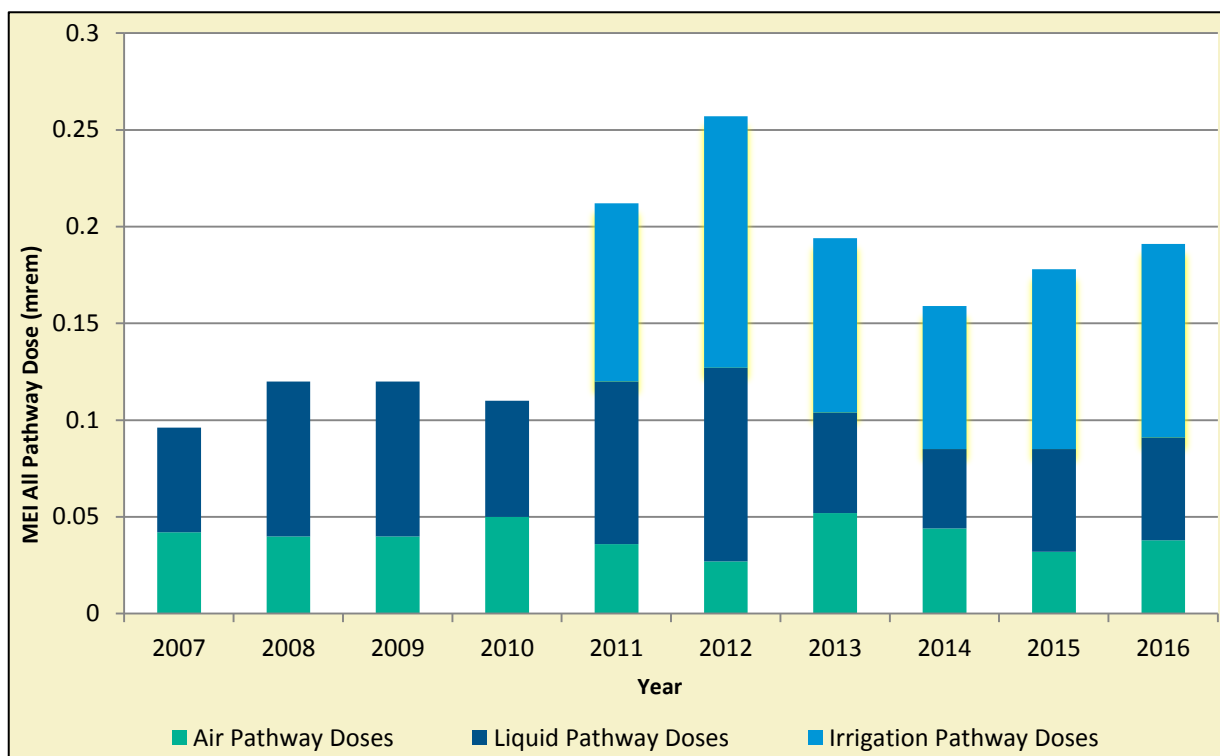
Pathways	Committed Dose (mrem)	Applicable Standard (mrem)	Percent of Standard (%)
Near Site Boundary (All Pathways)			
Total Liquid Pathways	0.15	100 ^a	0.15%
Total Air Pathways	0.038	10 ^{a,b}	0.38%
Total All Pathways	0.19	100 ^a	0.19%

Notes:

^a DOE: DOE Order 458.1^b EPA: (NESHAP) 40 CFR 61, Subpart H**Table 6-5b Potential Collective Dose to the 50-Mile Population Surrounding SRS, Including the People Served by the Downriver Drinking Water Plants (Based on Dose to a Typical Person from all Standard Pathways in 2016)**

Pathways	Collective Dose (person-rem)	Natural Background Dose (person-rem)	Percent of Natural Background (%)
50-mile Population Dose (All Pathways)			
Total Liquid Pathways	3.5	Not Applicable	Not Applicable
Total Air Pathways	1.4	Not Applicable	Not Applicable
Total All Pathways	4.9	243,000 ^a	< 0.01%

Note: ^a Calculated as 781,060 people (surrounding SRS population) times 311 mrem (0.311 rem) per person per year



Notes:

1. Beginning in 2011, the irrigation pathway dose is included in the liquid pathway dose. Previous years do not include the irrigation pathway dose.
2. Beginning in 2012, SRS began using the representative person dose instead of the Maximally Exposed Individual dose.

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

6.5 SPORTSMAN DOSE CALCULATION RESULTS

DOE Order 458.1 specifies radiation dose standards for individual members of the public. The dose standard of 100 mrem/yr includes the dose a person receives from routine DOE operations through all exposure pathways. Additionally, SRS considers and quantifies nontypical exposure pathways that are not included in the standard calculations of the doses to the representative person. This is because they apply to unlikely scenarios such as eating fish caught only from the mouths of SRS streams (“creek-mouth fish”) or to special scenarios such as hunters who volunteer to participate in an onsite hunt.

SRS also considered the following exposure pathways for a hypothetical offsite hunter and offsite fisherman on Creek Plantation, a neighboring, privately owned portion of the Savannah River Swamp:

- Ingesting deer meat or fish harvested on Creek Plantation
- Receiving external exposure to contaminated soil
- Incidentally ingesting contaminated soil
- Incidentally inhaling resuspended contaminated soil

6.5.1 Onsite Hunter Dose

Deer and Hog Consumption Pathway—SRS holds annual hunts for the public to control the Site’s deer and wild hog populations and to reduce animal-vehicle accidents. The estimated dose from consuming

harvested deer or hog meat is determined for every onsite hunter. Table 6-6 presents the maximum potential dose an onsite hunter received in 2016 as 13.5 mrem (0.135mSv), or 13.5% of DOE's 100 mrem/yr dose standard. This dose is for an actual hunter who harvested two deer during the hunts. For the hunter-dose calculation, SRS conservatively assumes that this hunter individually consumed the entire edible portion, about 40 kilogram (kg) (89 lbs).

Turkey Consumption Pathway—SRS hosts a special turkey hunt in April for hunters with mobility impairments. Hunters harvested 25 turkeys in 2016. SRS measured all of the turkeys for radiation. Because none of them measured above the background value, SRS did not assign a dose to these hunters.

Table 6-6 2016 Sportsman Doses Compared to the DOE Dose Standard

	Committed Dose (mrem)	Applicable Standard (mrem) ^a	Percent of Standard (%)
Sportsman Dose			
Onsite Hunter	13.5	100	13.5
Creek-Mouth Fisherman ^b	0.22	100	0.22
Savannah River Swamp Hunter			
Offsite Hog Consumption	2.24	100	9.26
Offsite Deer Consumption	6.36		
Soil Exposure ^c	2.90		
Maximum Offsite Hunter Dose (Deer + Soil Exposure)	9.26		
Savannah River Swamp Fisherman			
Steel Creek Fish Consumption	0.14	100	0.81
Soil Exposure ^d	0.67		
Total Offsite Fisherman Dose (Fish + Soil Exposure)	0.81		

Notes:

^a DOE dose standard; 100 mrem/yr (DOE Order 458.1)

^b In 2016, the maximum dose to a hypothetical fisherman resulted from consuming bass from the mouth of Fourmile Branch

^c Includes the dose from combining external exposure and incidentally ingesting and inhaling the worst-case Savannah River swamp soil

^d Includes the dose from combining external exposure and incidentally ingesting and inhaling Savannah River swamp soil near the mouth of Steel Creek.

6.5.2 Hunter Dose

Deer and Hog Consumption Pathway—The deer and hog consumption pathways considered were for hypothetical offsite individuals whose entire intake of meat (81 kg [179 lbs]) during the year was either deer or hog meat. SRS assumes that these individuals harvest deer or hogs that had lived on SRS during the year but then moved offsite prior to hunting season.

Based on these unlikely assumptions and on the measured average concentration of cesium-137 in all deer

(2.06 pCi/g) and hogs (1.05 pCi/g) harvested from SRS during 2016, the potential maximum doses from this pathway were estimated to be 6.4 mrem (0.064 mSv) for the offsite deer hunter and 2.2 mrem (0.022 mSv) for the offsite hog hunter.

Savannah River Swamp Hunter Soil Exposure Pathway—SRS estimated the potential dose to a recreational hunter exposed to SRS legacy contamination on the privately owned Creek Plantation. The potential dose assumed that this person hunted for 120 hours during the year (8 hours a day for 15 days) at the location of maximum radionuclide contamination. SRS estimated this offsite-hunter soil exposure dose to be 2.9 mrem.

As Table 6-6 shows, the offsite deer consumption pathway dose (6.4 mrem) and the Savannah River Swamp hunter soil exposure pathway dose (2.9 mrem) were conservatively added together to obtain a total maximum offsite hunter dose of about 9.3 mrem (0.093 mSv). This potential dose is 9.3% of the DOE 100 mrem/yr dose standard.

6.5.3 Hypothetical Offsite Fisherman Dose

Creek-Mouth Fish Consumption Pathway—For 2016, SRS analyzed three species of fish (panfish, catfish, and bass) taken from the mouths of four SRS streams. Using these concentrations, SRS estimated the maximum potential dose from fish consumption to be 0.22 mrem (0.0022 mSv) from bass it collected at the mouth of Fourmile Branch. SRS bases this hypothetical dose on the low probability scenario that during 2016, a fisherman consumed 24 kg (53 lb) of bass caught exclusively from the mouth of Fourmile Branch. About 86% of this potential dose was from cesium-137.

Savannah River Swamp Fisherman Soil Exposure Pathway—SRS calculated the potential dose to a recreational fisherman exposed to SRS legacy contamination in Savannah River Swamp soil on the privately owned Creek Plantation using the RESidual RADioactivity (RESRAD) code (Yu et al., 2001). SRS assumes 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, SRS estimated 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 renewed suspension soil to be 0.67 mrem (0.0067 mSv).

As Table 6-6 shows, the maximum Steel Creek fish consumption dose (0.14 mrem) and the Savannah River Swamp fisherman soil exposure dose (0.67 mrem) were added to conservatively obtain a total offsite fisherman dose of 0.81 mrem (0.0081 mSv). This potential dose is 0.81% of the DOE 100 mrem/yr dose standard.

6.5.4 Potential Risk from Consumption of SRS Creek-Mouth Fish

During 1991 and 1992, in response to a U.S. House of Representatives Appropriations Committee request for a plan to evaluate risk to the public from fish collected from the Savannah River, SRS developed a fish monitoring plan in conjunction with EPA, the Georgia Department of Natural Resources, and SCDHEC. This plan includes assessing radiological risk from consuming Savannah River fish and requires that SRS summarize the results in the annual *SRS Environmental Report*. For 2016, SRS estimated the maximum potential lifetime risk of developing fatal and nonfatal cancer from consuming SRS creek-mouth fish to be

1.7E-07. That is, if 10 million people each received a dose of 0.22 mrem, there is a potential for 1.7 extra cancer incidents.

6.6 RELEASE OF MATERIAL CONTAINING RESIDUAL RADIOACTIVITY

DOE Order 458.1 establishes authorized surface contamination limits, which in turn allow unconditional release of personal and real property. This order defines personal property as “property of any kind, except for real property” and defines real property as “land and anything permanently affixed to the land such as buildings, fences and those things attached to the buildings, such as light fixtures, plumbing and heating fixtures, or other such items, that would be personal property if not attached.” SRS handles the unconditional release of real property on an individual basis that requires specific approval from DOE. SRS did not release any real property in 2016, so the following discussion is associated with release of personal property from SRS. DOE Order 458.1 specifies that the Site must prepare and submit an annual summary of cleared property to the DOE-SR Manager.

6.6.1 Property Release Methodology

SRS uses procedures to govern unconditionally releasing equipment. SRS can release the item after it has a radiological survey if it meets specific documented limits. For items meeting unconditional release criteria, SRS generates a form and attaches it electronically to the applicable radiological survey via the Visual Survey Data System (VSDS). In some areas, SRS documents equipment and material release directly on the radiological survey form. SRS subsequently compiled these VSDS and survey forms and coordinated a site-wide review to determine the amount of material and equipment SRS released from its facilities in 2016. These measures ensure that radiological material releases from SRS are consistent with DOE Order 458.1 requirements.

SRS unconditionally released 11,516 items of personal property from radiological areas in 2016. Most of these items did not leave the Site and were reused elsewhere on the Site. However, all of these items required no additional radiological controls post-survey as they met DOE Order 458.1 release criteria (The recently implemented DOE Order 458.1 allows the use of DOE Order 5400.5-derived supplemental limits for unconditionally releasing equipment and materials.)

In 2003, DOE approved a SRS request to use supplemental limits to release material from the Site with no further DOE controls. These supplemental release limits, provided in Table 31 of *Radiological Environmental Dose Assessment Methods and Compliance Dose Results for 2016 Operations at the Savannah River Site* (Jannik, Minter, and Dixon 2017a), are dose-based and are such that if any member of the public received any exposure, it would be less than 1 mrem/yr. The supplemental limits include both surface and volume concentration criteria. The volume criteria allow SRS the option to dispose of potentially volume-contaminated material in Three Rivers Landfill, an onsite sanitary waste facility. In 2016, SRS did not release any material from the Site using the supplemental release limits volume concentration criteria.

6.7 RADIATION DOSE TO AQUATIC AND TERRESTRIAL BIOTA

DOE Order 458.1 requires that SRS conduct Site operations in a manner that protects the local biota from adverse effects due to radiation and radioactive material releases. To demonstrate it is complying with this requirement, SRS uses the approved DOE Standard, DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002).

The biota dose rate limits specified in this standard are the following:

- Aquatic animals: 1.0 rad/day (0.01 gray/day)
- Riparian animals: 0.1 rad/day (0.001 gray/day)
- Terrestrial plants: 1.0 rad/day (0.01 gray/day)
- Terrestrial animals: 0.1 rad/day (0.001 gray/day)

6.7.1 DOE Biota Concentration Guides

SRS evaluates plant and animal doses for water and land systems using the RESRAD Biota model (version 1.5) (SRS EDAM 2012), which directly implements the DOE (2002) guidance. The RESRAD Biota model uses a graded approach consisting of three increasingly more detailed steps of analysis:

- Level 1 Screening—uses maximum measured concentrations and conservative default model input parameters
- Level 2 Screening—uses average concentrations or site-specific input parameters, as appropriate
- Level 3 Analysis—uses site-specific biota parameters or measured concentrations in the actual biota living at the assessed location

For water systems (animals who live in the water or along riverbanks), the RESRAD Biota model performs a combined water-plus-sediment evaluation. SRS performed initial (Level 1) screenings in 2016 using maximum radionuclide concentration data from SRS's 14 onsite stream and sediment sampling locations. A sum of the fractions less than 1.0 indicates the sampling site has passed its initial pathway screening, which means that the sampling site did not exceed its biota dose rate limits, and SRS does not have to assess the location further. All but one SRS aquatic system location passed the initial screening and did not require further assessment. The Z-Area Basin sampling location failed the Level 1 screening with a sum of the fractions of 1.05, requiring the performance of a Level 2 screening. The Site performed a Level 2 screening at this location using average concentrations, and it passed. Therefore, SRS did not have to assess this location further.

To evaluate land-based systems, SRS performed initial screenings using concentration data from the five onsite radiological soil sampling locations. Typically, SRS collects and analyzes only one soil sample per year from each location. For 2016, all land-based locations passed their initial pathway screenings.

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The purpose of the Savannah River Site's (SRS's) groundwater management program is to protect, monitor, remediate, and use groundwater. This program does the following:

- Ensures future groundwater contamination does not occur
- Monitors groundwater to identify areas of contamination
- Remediates groundwater contamination as needed
- Conserves groundwater

2016 Highlights

Drinking Water Standards—The data show no exceedances of drinking water standards (measured by maximum contaminant limit [MCLs] or regional screening levels [RSLs]) in SRS boundary wells near A/M Area.

Groundwater Contaminant Removal—SRS removed 11,300 pounds (lbs) of volatile organic compounds (VOCs) from groundwater and the vadose zone and prevented 133.2 curies of tritium from reaching SRS streams.

Offsite Groundwater Monitoring (Georgia)—For more than 15 years, detections of tritium in Georgia groundwater monitoring wells have been well below the MCL for tritium (20 pCi/mL). This data supports the conclusions drawn from a U.S. Geological Survey (USGS) that indicate there is no mechanism by which groundwater could flow under the Savannah River and contaminate Georgia wells (Cherry 2006).

7.1 INTRODUCTION

Some of SRS's past operations have released chemicals and radionuclides into the soil and contaminated the groundwater around hazardous waste management facilities and waste disposal sites. Because of these past releases, SRS operates extensive groundwater monitoring and groundwater remediation programs.

The SRS groundwater monitoring program requires sampling of wells regularly to monitor for groundwater contaminants. Wells are monitored to meet sampling requirements in the [Federal Facility Agreement \(FFA\) for the Savannah River Site](#) (FFA 1993)-approved monitoring plans and Resource Conservation and Recovery Act (RCRA) permits. SRS uses South Carolina Department of Health and Environmental Control (SCDHEC)-certified laboratories to analyze groundwater samples.

The monitoring data show that the majority of contaminated groundwater is in the central area of SRS. Additionally, the contaminated groundwater does not extend beyond the SRS boundary. Groundwater contamination at SRS is primarily limited to the Upper Three Runs/Steep Pond Aquifers and the Gordon/Lost Lake Aquifers (Figure 7-1). SRS submits summaries of groundwater data to regulatory agencies, and, if necessary, remediates or removes the contamination. A list of documents

Chapter 7—Key Terms

Aquifer is an underground water supply found in porous rock, sand, gravel, etc.

Attenuation is a reduction of groundwater contaminants over time due to naturally occurring physical, chemical, and biological processes.

Confining Unit is the opposite of an aquifer. It is a layer of rock or sand that limits groundwater movement in and out of an aquifer.

Contaminants of Concern are contaminants found at the unit that have undergone detailed analysis and have been found to present a potential threat to human health and the environment.

Groundwater is water found underground in cracks and spaces in soil, sand, and rocks.

Maximum Contaminant Level (MCL) is the highest level of a contaminant allowed in drinking water.

Plume is a volume of contaminated water originating at a waste source (for example, a hazardous waste disposal site). It extends downward and outward from the waste source.

Recharge occurs when water from the surface travels down into the subsurface, replenishing the groundwater.

Regional Screening Level (RSL) is the risk-based concentration derived from standardized equations combining exposure assumptions with toxicity data.

Remediation cleans up sites contaminated with waste due to historical activities.

Surface water is water found above ground (for example, streams, lakes, wetlands, reservoirs, and oceans).

Waste Unit refers to a particular area that is, or may be, posing a threat to human health or the environment. They range in size from a few square feet to tens of acres and include basins, pits, piles, burial grounds, landfills, tank farms, disposal facilities, process facilities, and contaminated groundwater.

that SRS submits to the regulatory agencies reporting groundwater monitoring data is in Appendix E.

SRS uses several technologies to remediate groundwater that exceeds the MCLs or the RSLs. Remediation includes closing waste units to reduce the potential for contaminants to reach groundwater, actively treating contaminated water, and employing passive and natural (attenuation) remedies. U.S. Department of Energy (DOE) and the regulatory agencies must agree on the appropriate final disposition of the waste units.

The major groundwater remediation activities at SRS focus on VOCs and tritium. VOCs in groundwater, mainly trichloroethylene (TCE) and tetrachloroethylene (PCE), resulted from their use as degreasing agents in industrial work at SRS. Tritium in groundwater is a byproduct of the nuclear materials production process at SRS. Examples of SRS corrective measures include Monitored Natural Attenuation and phytoremediation (using trees and plants to remove or break down contaminants). These practices are removing VOCs from the groundwater and effectively reducing tritium releases into SRS streams and the Savannah River.

7.2 GROUNDWATER AT SRS

The groundwater flow system at SRS consists of the following four major aquifers separated by confining units:

- Upper Three Runs/Steed Pond
- Gordon/Lost Lake
- Crouch Branch
- McQueen Branch

Groundwater flow in recharge areas generally migrates downward and laterally. It eventually flows into the Savannah River and its tributaries or migrates into the deeper regional flow system. Figure 7-1 presents a three-dimensional block diagram of these units at SRS and the generalized groundwater flow patterns within those units. The movement of water from the ground's surface into the aquifers can carry contamination along with it, resulting in underground plumes of contaminated water (Figure 7-2).

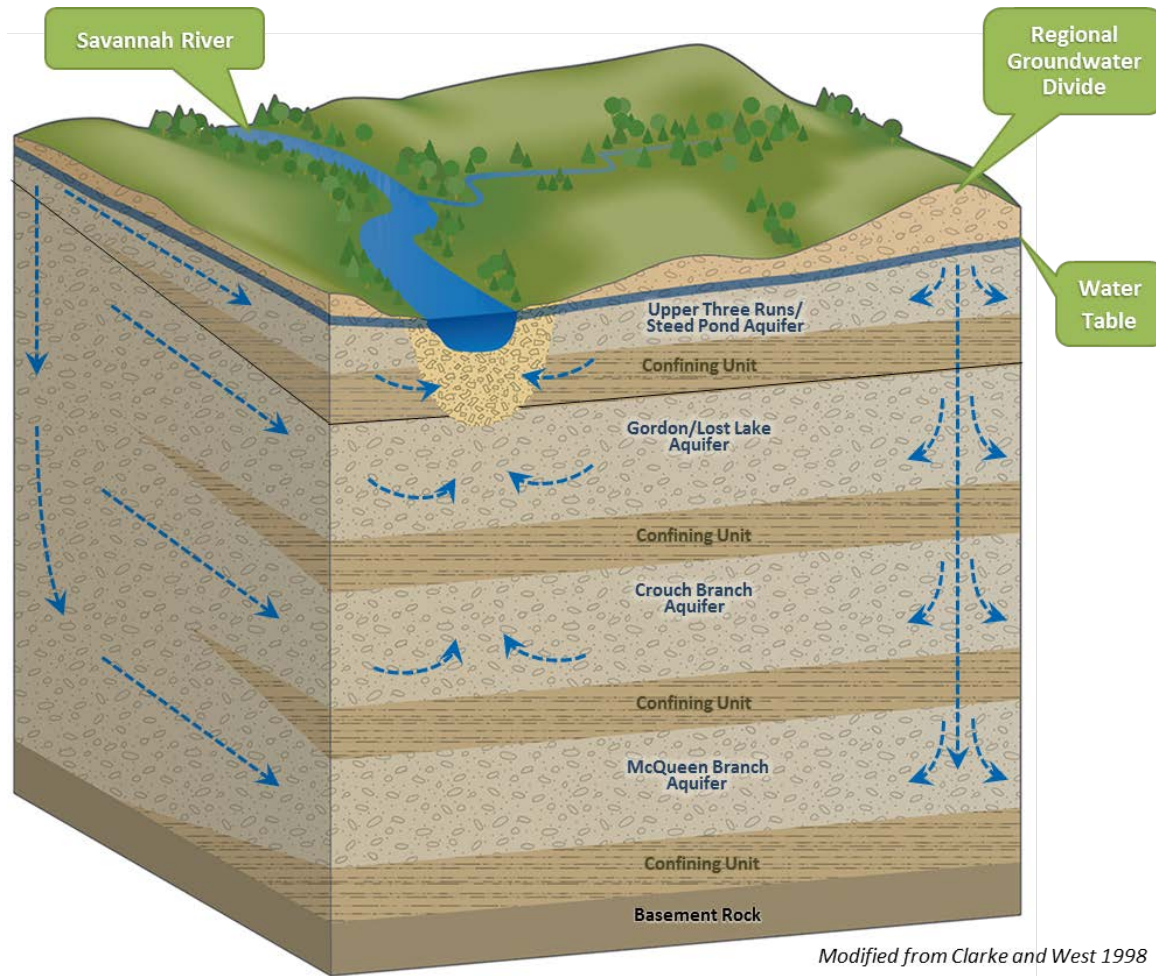


Figure 7-1 Groundwater at SRS

7.3 GROUNDWATER PROTECTION PROGRAM AT SRS

SRS has designed and implemented a groundwater protection program to prevent any new releases to groundwater, and to remediate contaminated groundwater to meet federal and state laws and regulations, DOE Orders, and SRS policies and procedures. It contains the following elements:

- Protecting SRS groundwater
- Monitoring SRS groundwater
- Remediating SRS groundwater
- Conserving SRS groundwater

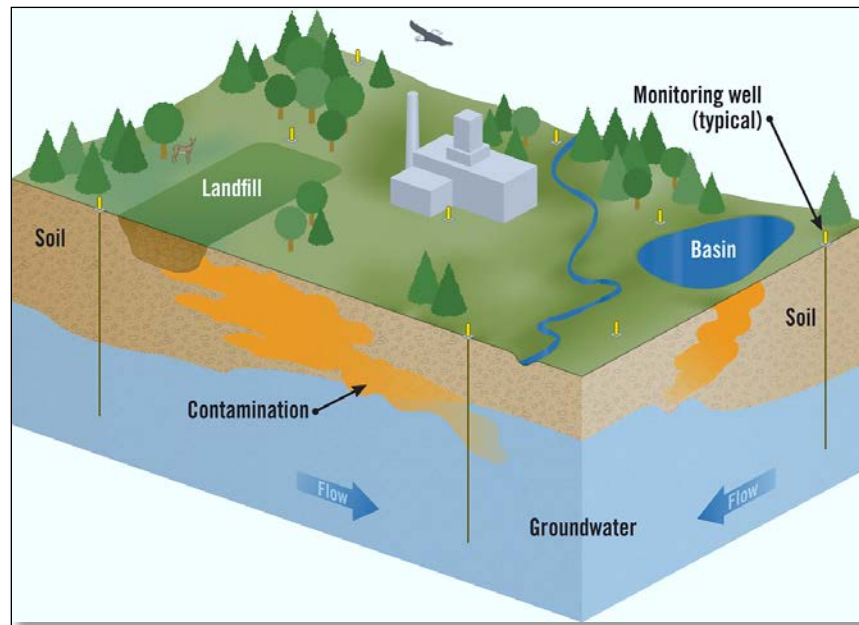


Figure 7-2 How Contamination Gets to Soil and Groundwater

7.3.1 Protecting SRS Groundwater

SRS groundwater management focuses on preventing and monitoring groundwater contamination, protecting the public and environment from contamination, and preserving groundwater quality for future use. Groundwater protection is performed through the following:

- Preventing or controlling groundwater contamination sources from construction sites, hazardous waste management facilities, and waste units
- Monitoring groundwater and surface water to detect contaminants
- Reducing contaminants via a groundwater cleanup program

7.3.2 Monitoring SRS Groundwater

The purpose of monitoring groundwater is to observe and evaluate changes in the groundwater quality over time and to establish, as accurately as possible, the baseline quality of the groundwater occurring naturally in the aquifers. The SRS groundwater monitoring program includes two primary components: groundwater contaminant source monitoring and groundwater surveillance monitoring. SRS evaluates groundwater-monitoring data frequently to identify whether new groundwater contamination exists or if it needs to modify current monitoring programs.

SRS uses groundwater-monitoring data to determine the effects of Site operations on groundwater quality. The program supports the following critical activities:

- Complying with environmental regulations and DOE directives
- Evaluating the current status of groundwater plumes
- Evaluating new activities planned near or within the groundwater plume footprint
- Enhancing groundwater remediation through basic and applied research projects

Monitoring the groundwater around SRS facilities, waste disposal sites, and associated streams is the best way to detect and track contaminant migration. Through careful monitoring and analysis, SRS implements appropriate remedial or corrective actions. Figure 7-3 shows the groundwater plumes associated with SRS.

7.3.2.1 Groundwater Surveillance Monitoring

Surveillance monitoring at SRS focuses on collecting and analyzing data to characterize the groundwater flow and the presence or absence of contaminants. Characterization at SRS includes the following activities:

- Collecting soil and groundwater samples to determine the extent of contamination
- Obtaining geologic soil cores or seismic profiles to better determine underground structural features, as warranted
- Installing wells to periodically collect water-level measurements and groundwater samples
- Developing maps to help define groundwater flow
- Performing calculations based on water elevation data in order to estimate groundwater velocities
- Analyzing regional groundwater to provide a comprehensive understanding of SRS groundwater movement, and specifically contaminant movement, near facilities, individual waste units, and at the Site boundary
- Characterizing regional surface water flow to assess contaminant risk to perennial streams, which are the receptors of groundwater flow



**Sampling a Monitoring Well (above)
and Equipment (right)**

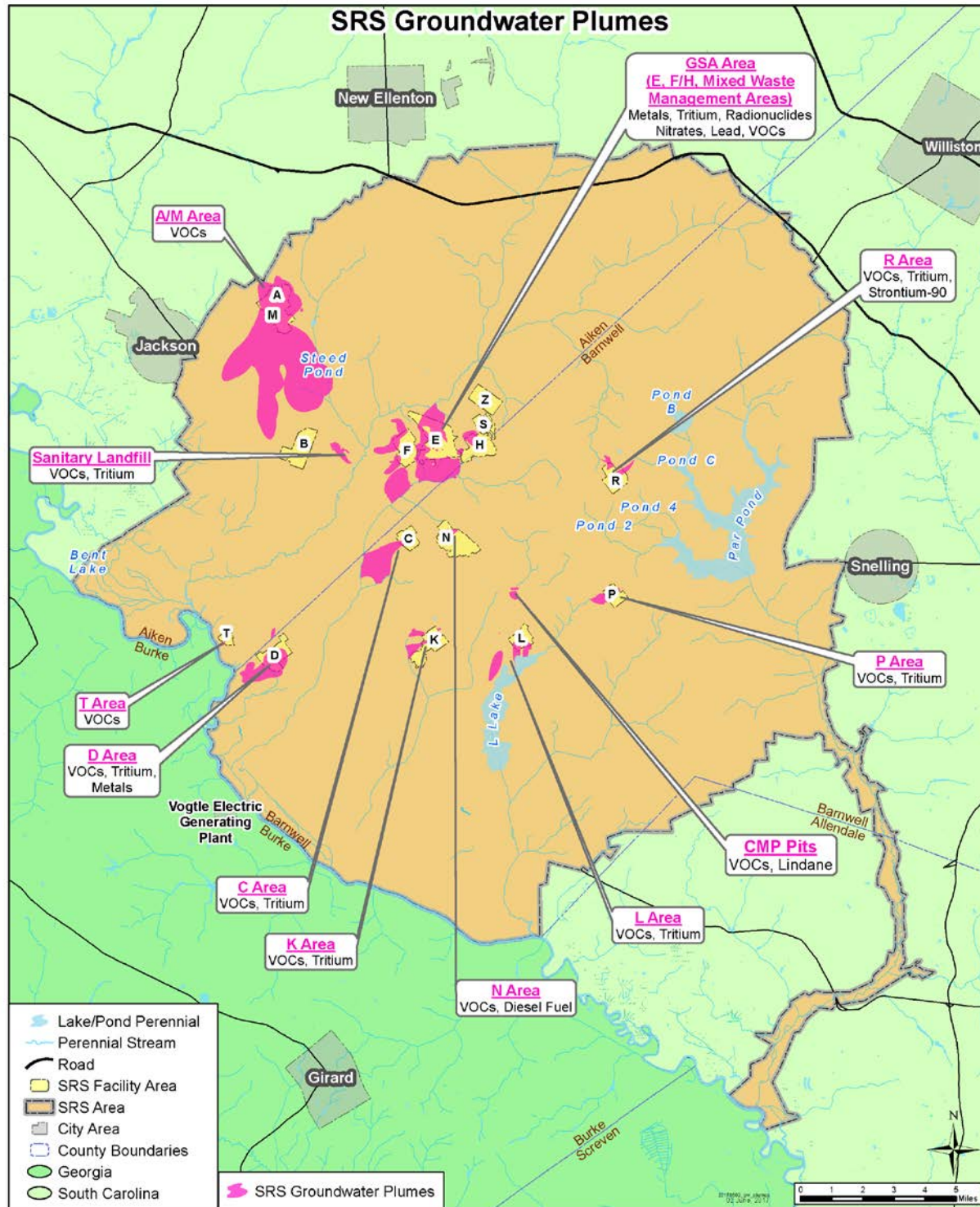


Figure 7-3 Groundwater Plumes at SRS

7.3.2.2 2016 Groundwater Data Summary

SRS uses more than 150 wells to monitor a significant plume beneath A/M Areas. Some of these monitoring wells lie within a half-mile of the northwestern boundary of SRS. The direction of groundwater flow in the area parallels the Site boundary; however, groundwater flow direction can fluctuate. Because of this, SRS pays particular attention to the groundwater results from these wells located along the Site boundary, as well as those between the A/M Areas and the nearest population center, Jackson, South Carolina (Figure 7-4). The data show no exceedances of drinking water standards (MCLs or RSLs) in SRS boundary wells near A/M Area. In the majority of these SRS boundary wells, no detectable contamination exists.

Although most of SRS-contaminated groundwater plumes do not approach the Site boundary, the potential to affect Site streams does exist when contaminated groundwater flows into nearby streams. SRS monitors and evaluates groundwater contamination that flows into Site streams and remediates as appropriate. In conjunction with stream monitoring, as discussed in Chapter 5, *Radiological Environmental Monitoring Program*, Section 5.4.3, *SRS Stream Sampling and Monitoring*, SRS conducts extensive monitoring near SRS waste units and operating facilities, regardless of their proximity to the boundary. [Savannah River Site Groundwater Management Strategy and Implementation Plan](#) (SRNS 2011) and the *Environmental Monitoring Program Management Plan*, SRS Manual 3Q1, Procedure 101, Revision 8 (SRS EM Plan 2016) contain details concerning groundwater monitoring and conditions at individual sites.

Table 7-1 identifies the typical contaminants of concern (COCs) found in SRS groundwater and their significance. These COCs are a result of SRS operations that released chemicals and radionuclides into the soil and groundwater around hazardous waste management facilities and waste disposal sites. Table 7-2 presents a general summary of the most common contaminants found in groundwater at SRS facility areas, based on 2016 monitoring data, and compares the maximum concentrations to the appropriate drinking water standards. Table 7-2 shows the major COCs in the groundwater include common degreasers (TCE and PCE) and radionuclides (tritium, gross alpha, and nonvolatile beta emitters).

Since the early 1990s, SRS has directed considerable effort toward assessing the likelihood of flow beneath the Savannah River from South Carolina to Georgia. A groundwater model that the U.S. Geological Survey (USGS) developed indicates there is no mechanism by which groundwater could flow under the Savannah River and contaminate Georgia wells (Cherry 2006). SRS continues to monitor for tritium in groundwater wells in Georgia (Figure 7-5) by collecting samples annually during the second half of the year. Detections of tritium in groundwater in these Georgia off-site wells have been below 1.5 pCi/mL since 1999 (Figure 7-6). The MCL, or drinking water standard, for tritium is 20 pCi/mL. The results are consistent with aquifer recharge from rainfall in the Central Savannah River Area. The overall groundwater data trend continues to show a gradual decline in the levels of tritium in the Georgia wells.

As a result of optimizing groundwater based on historical data, SRS reduced its off-site groundwater sampling program from 44 wells to 10 representative wells in Georgia during 2016. The 10 wells sampled were BLTW 1, GSTW1, MHTW 1, MPTW1, MPTW4, TR92 1A, TR92 2A, TR92 4A2, TR92 5A, and TR92 6A2. All samples collected in 2016 had no detectable concentrations of tritium.

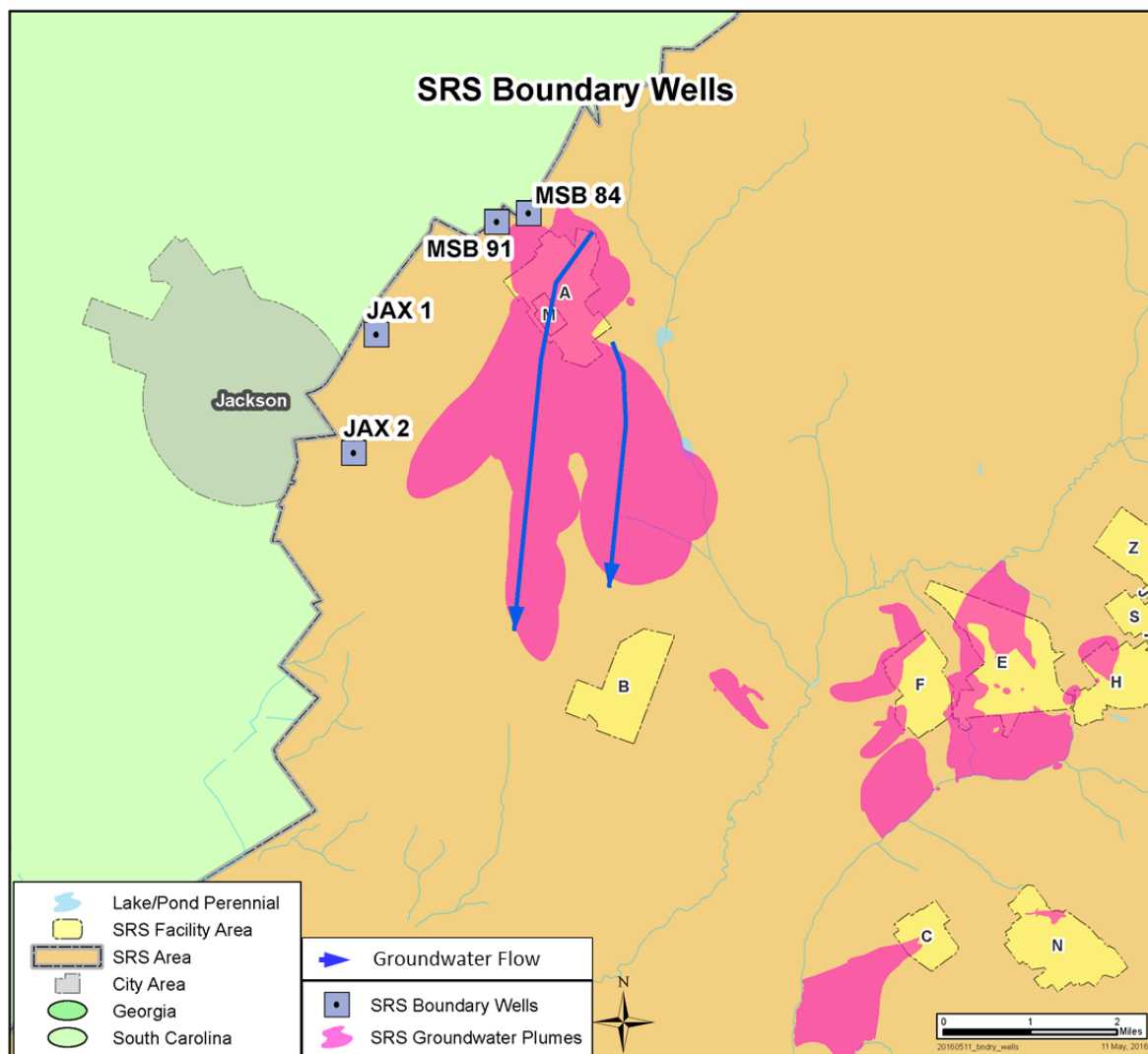


Figure 7-4 Location of Site Boundary Wells at SRS—Between A/M Areas and Jackson, South Carolina

Table 7-1 Typical Contaminants of Concern at SRS

Contaminants	Sources	Limits, Exposure Pathways, and Health Effects
Gross Alpha	Alpha radiation emits positively charged particles from the radioactive decay of certain elements including uranium, thorium, and radium. Alpha radiation in drinking water can be in the form of dissolved minerals or a gas (radon).	MCL is 15 pCi/L. An alpha particle cannot penetrate a piece of paper or human skin. It causes increased risk of cancer through ingestion or inhalation.
Nonvolatile Beta	Beta decay commonly occurs among neutron-rich fission byproducts produced in nuclear reactors.	MCL is 4 mrem/yr. It causes increased risk of cancer through ingestion, inhalation, or dermal exposure.
Tritium	Radioactive isotope of hydrogen with a half-life of 12.3 years. It emits a very weak beta particle and behaves like water.	MCL is 20 pCi/mL. It primarily enters the body when people swallow tritiated water. It causes increased risk of cancer through ingestion, inhalation, or dermal exposure.
TCE/PCE	VOCs used primarily to remove grease from fabricated metal parts.	MCL is 5 µg/L. It causes increased risk of cancer through ingestion, inhalation, or dermal exposure.
Vinyl Chloride	VOC formed as a degradation product of TCE/PCE.	MCL is 2 µg/L. It causes increased risk of cancer through ingestion, inhalation, or dermal exposure.
1,4-Dioxane	Synthetic industrial chemical used as a stabilizer for VOCs to reduce degradation.	RSL for tap water is 0.46 µg/L. It causes increased risk of cancer through ingestion, inhalation, or dermal exposure.

Table 7-2 Summary of the Maximum Contaminant Concentrations for Major Areas within SRS

Location	Major Contaminant	Units	2016 Max Concentration	Well	MCL/ RSL	Likely Stream Endpoints
A/M Area	Tetrachloroethylene	µg/L	74,000	MSB002BR	5	Tims Branch/Upper Three Runs in Swamp in West
	Trichloroethylene	µg/L	22,000	MSB107B	5	
	1,4-Dioxane	µg/L	260	ARP 1A	6.1 ^a	
C Area	Tetrachloroethylene	µg/L	8.15	CRP 5C	5	Fourmile Branch and Castor Creek
	Trichloroethylene	µg/L	1,640	CRP 20CU	5	
	Tritium	pCi/mL	1,290	CSB020C	20	
CMP Pits (G Area)	Tetrachloroethylene	µg/L	686	CMP 35D	5	Pen Branch
	Trichloroethylene	µg/L	366	CMP 35D	5	
	1,4-Dioxane	µg/L	110	CMP 11D	0.46	
	Lindane	µg/L	5.12	CMP 35D	0.2	
D Area	Tetrachloroethylene	µg/L	13	DCB 45C	5	Savannah River Swamp
	Trichloroethylene	µg/L	180	DCB 62	5	
	Vinyl Chloride	µg/L	21	DOB 15	2	
	Tritium	pCi/mL	277	DCB 26AR	20	
E-Area MWMF	Trichloroethylene	µg/L	270	SWP 1C	5	Upper Three Runs/Crouch Branch in North; Fourmile Branch in South
	1,4-Dioxane	µg/L	840	BSW 6C3	6.1 ^a	
	Tritium	pCi/mL	15,100	BSW 8C1	20	
	Gross Alpha	pCi/L	33.8	BSW 3D2	15	
	Nonvolatile Beta	pCi/L	47.1	HSP 097A	50 ^b	
F Area	Trichloroethylene	µg/L	28.4	FBP 43DL	5	Fourmile Branch
	Tritium	pCi/mL	81.8	FSL 5D	20	

Location	Major Contaminant	Units	2016 Max Concentration	Well	MCL/ RSL	Likely Stream Endpoints
	Gross Alpha	pCi/L	1,240	FGW 5C	15	
	Nonvolatile Beta	pCi/L	874	FGW 5C	50 ^b	
F-Area HWMF	Trichloroethylene	µg/L	17.5	FSB 78C	5	Fourmile Branch
	Tritium	pCi/mL	1,790	FSB 94C	20	
	Gross Alpha	pCi/L	389	FSB 95DR	15	
	Nonvolatile Beta	pCi/L	1,030	FSB 95DR	50 ^b	
F-Area Tank Farm	Tritium	pCi/mL	42.8	FTF 30D	20	Fourmile Branch/Upper Three Runs
	Nonvolatile Beta	pCi/L	624	FTF 28	50 ^b	
	Manganese	µg/L	187	FTF 9R	430	
H Area	Trichloroethylene	µg/L	6.28	HGW 2D	5	Upper Three Runs/Crouch Branch in North; Fourmile Branch in South
	Gross Alpha	pCi/L	14.8	HAA 15A	15	
	Nonvolatile Beta	pCi/L	44.5	HAA 12A	50 ^b	
	Tritium	pCi/mL	32.5	HGW 2D	20	
H-Area HWMF	Trichloroethylene	µg/L	97.9	HSB 120C	5	Fourmile Branch
	Tritium	pCi/mL	1,640	HSB 113DR	20	
	Gross Alpha	pCi/L	49.6	HSB 102D	15	
	Nonvolatile Beta	pCi/L	689	HSB 102D	50 ^b	
H-Area Tank Farm	Tritium	pCi/mL	60.8	HAA 12C	20	Fourmile Branch/Upper Three Runs
	Nonvolatile Beta	pCi/L	223	HAA 8D	50 ^b	
	Manganese	µg/L	358	HAA 10D	430	
K Area	Tetrachloroethylene	µg/L	7.1	KDB 1	5	Indian Grave Branch
	Trichloroethylene	µg/L	3.2	KRP 9	5	
	Tritium	pCi/mL	5,240	KRB 19D	20	
L Area	Tetrachloroethylene	µg/L	56.2	LSW 25DL	5	L Lake
	Trichloroethylene	µg/L	6.6	LAC 8DL	5	
	Tritium	pCi/mL	643	LSW 25DL	20	
P Area	Trichloroethylene	µg/L	7,710	PGW025B	5	Steel Creek
	Tritium	pCi/mL	13,400	PSB002C	20	
R Area	Trichloroethylene	µg/L	14.6	RAG008B	5	Mill Creek in Northwest; Tributaries of PAR Pond
	Tritium	pCi/mL	524	RPS004C	20	
	Strontium-90 ^c	pCi/L	111	RSE 10	8	
Sanitary Landfill	1,4-Dioxane	µg/L	189	LFW 62C	6.1 ^a	Upper Three Runs
	Trichloroethylene	µg/L	2.2	LFW 62C	5	
	Mercury	µg/L	4.6	LFW 48C	2	
TNX	Trichloroethylene	µg/L	113	TBG 3	5	Savannah River Swamp
Z Area	Technetium-99	pCi/L	149	ZBG 2	50 ^b	Upper Three Runs
	Nonvolatile Beta	pCi/L	72.9	ZBG 2	50 ^b	

Notes: MWMF is the Mixed Waste Management Facility; HWMF is the Hazardous Waste Management Facility; TNX is the 678-T facilities; CMP is the Chemicals, Metals, and Pesticides Pits.

^a The 1,4-Dioxane standard is a RCRA Permitted Groundwater Protection Standard (GWPS).

^b The MCL for nonvolatile beta activity (pCi/L or pCi/mL) equivalent to 4 mrem/yr varies according to which specific beta emitters are present in the sample. At SRS this value equates to 50 pCi/L.

^c At R Area, strontium-90 is sampled every five years per agreement with state and federal regulators. It was last sampled in 2015.

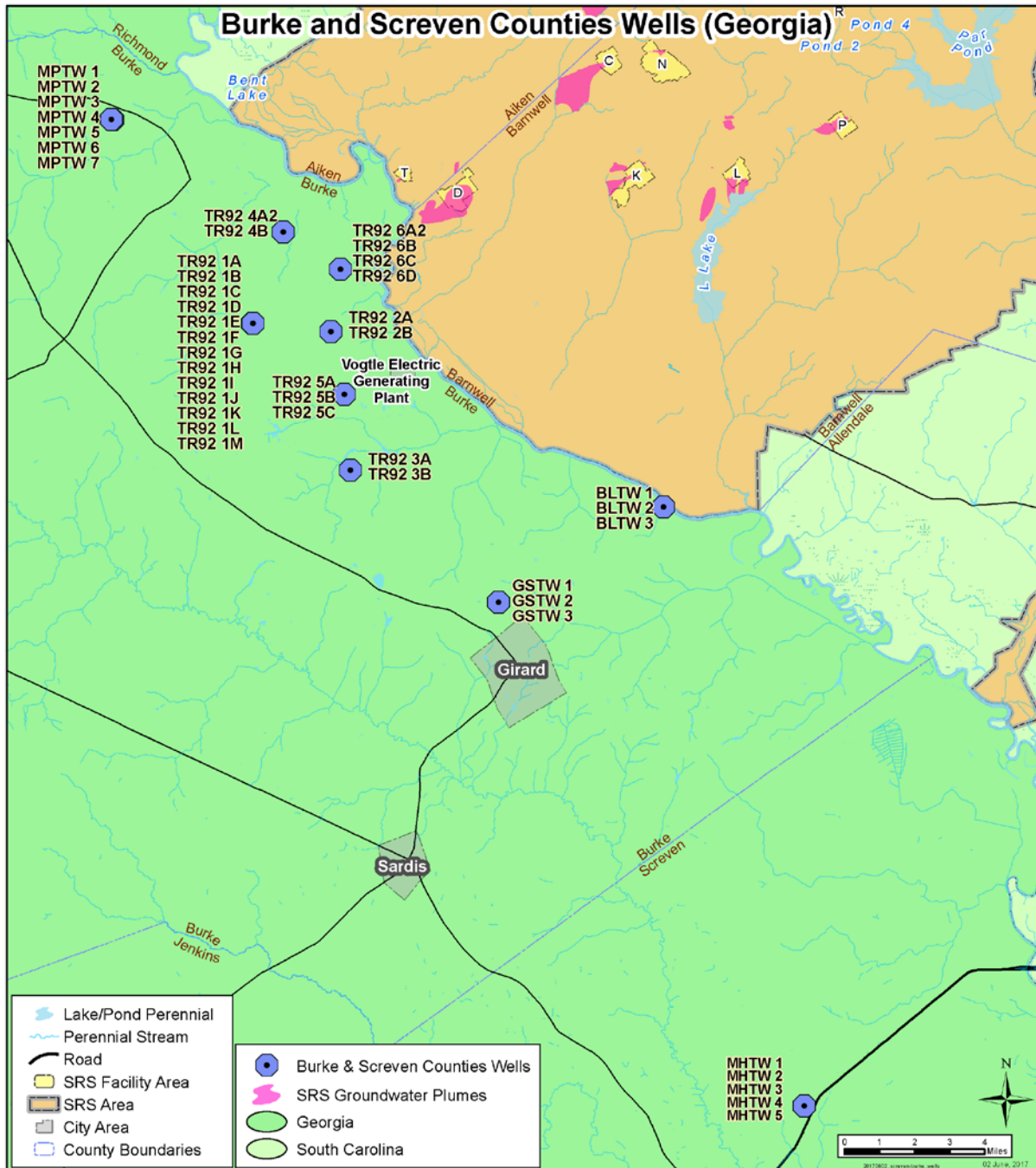


Figure 7-5 Location of Monitoring Wells Sampled for Tritium in Burke and Screven Counties, Georgia

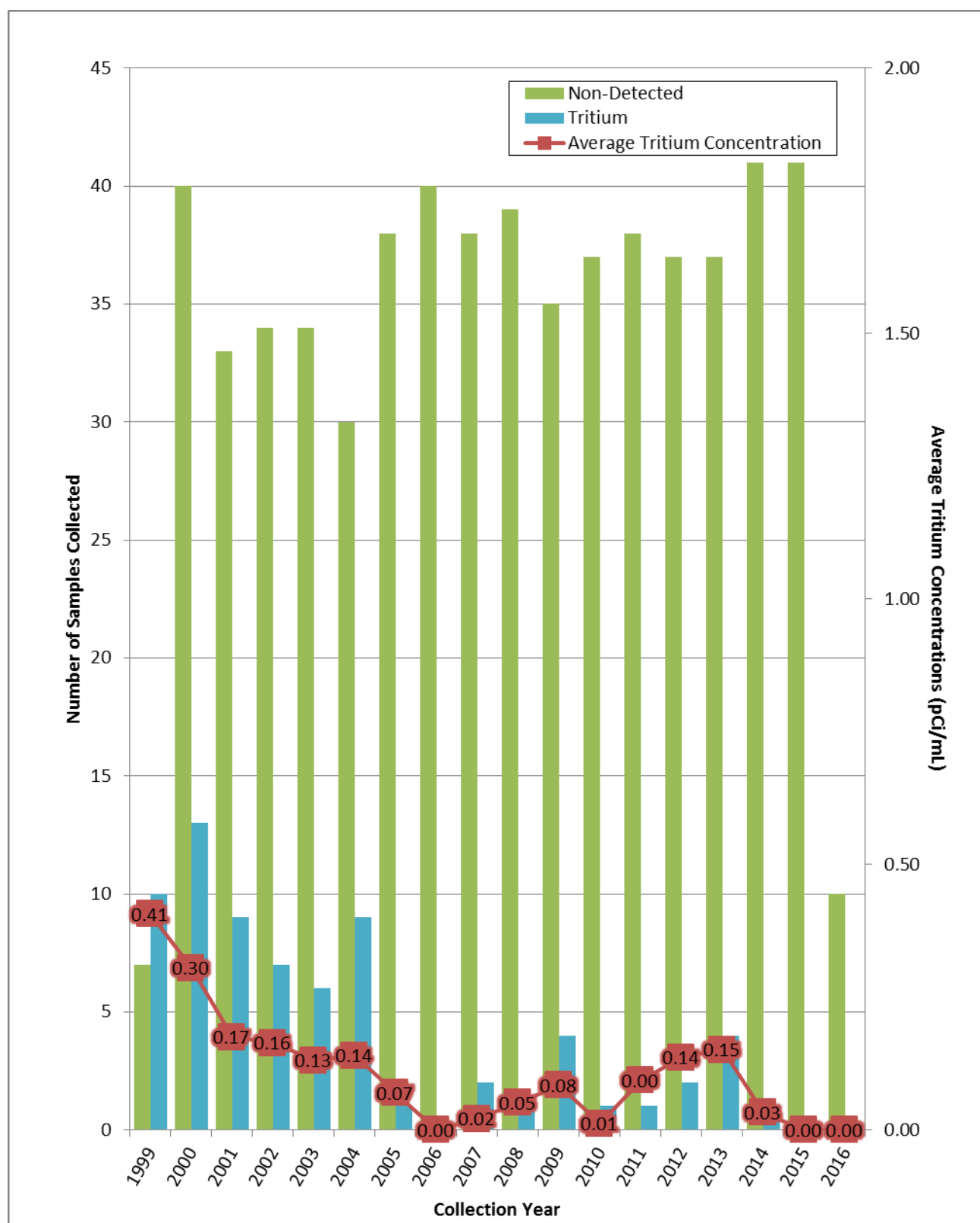


Figure 7-6 Tritium Concentration in Wells Sampled in Burke and Screven Counties, Georgia

7.3.3 Remediating SRS Groundwater

SRS's environmental remediation program has been in place for more than 20 years. The [Federal Facility Agreement \(FFA\) for the Savannah River Site](#) (FFA 1993) specifies that RCRA and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulate remediating and monitoring contaminated groundwater. Remediation focuses on removing mass, reducing contaminant levels, and reducing the exposure to humans and the environment of the contaminants that exceed either the MCLs or RSLs that Table 7-2 identifies.

For each remediation project, SRS determines the degree and extent the groundwater is contaminated. After completing this evaluation, SRS and the regulatory agencies decide upon a strategy for remediating the groundwater.

SRS often applies remedial actions to the groundwater contamination source. For instance, SRS widely uses soil vapor extraction, a technology that pulls contaminated soil vapor from the vadose zone to remove VOCs from the unsaturated (vadose) zone above the water table. This technology minimizes the amount of VOCs that will reach the water table.

SRS implements several groundwater remedial technologies. These technologies manage the rate of contaminant movement and reduce the risk of contaminant exposure to human health and ecological receptors. Thirty-seven remediation systems are currently operating. The Site is no longer using 18 groundwater treatment systems. In 2016, SRS removed 11,300 lbs. of VOCs from the groundwater and the vadose zone and prevented 133.2 curies of tritium from reaching SRS streams (SRNS 2017b). SRS has worked for more than 20 years to reduce the tritium flux to Fourmile Branch. Since 2000, SRS has reduced the tritium flux to Fourmile Branch by almost 70% using groundwater remedial technologies (subsurface barriers and water capture with irrigation). The Mixed Waste Management Facility (MWMF) Phytoremediation Project has the largest reductions.

In October, SRS notified SCDHEC that the MWMF Phytoremediation Project had been down for more than 72 hours due to mechanical problems with the irrigation system as a result of Hurricane Matthew, which made landfall in South Carolina on October 8. At the MWMF Phytoremediation site, more than 5 inches of rain fell, which caused silt and sediment to enter the irrigation pump intake and clog the water filtration system. The irrigation system was offline while personnel cleaned and repaired the filter system. The phytoremediation system returned to normal operation on November 14. No significant impacts were realized.

Overall, the size, shape, and volume of most SRS groundwater plumes are shrinking because the majority of the contaminant sources have remediation systems in place. The [Soil and Groundwater Closure Projects Technology Descriptions](#) (WSRC 2007) explains SRS remediation systems.

7.3.4 Conserving SRS Groundwater

As in the past, SRS continues to report its drinking and process water use to SCDHEC. In 2016, SRS used 2.82 million gallons of water per day. Information on SRS water conservation is in Chapter 2, *Environmental Management System*.

SRS manages its own drinking and process water supply from groundwater located beneath SRS. Approximately 40 production wells in widely scattered locations across the Site supply SRS domestic and

process water systems. Eight of these wells are domestic water systems that supply drinking water. The other 32 wells provide water for all SRS facility operations. The [SRS Environmental Report for 2016](#) webpage contains a map of SRS domestic water systems under the *Environmental Maps* heading.

The A-Area domestic water system now supplies treated water to most Site areas. The system comprises a treatment plant, distribution piping, elevated storage tanks, and a well network. The wells range in capacity from 200 to 1,500 gallons per minute. Remote facilities, such as field laboratories, barricades, and pump houses, use small drinking water systems and bottled water. SRS domestic water systems meet state and federal drinking water quality standards. SCDHEC samples the systems quarterly for chemical analyses. Monitoring the A-Area water system for bacteria occurs monthly. SCDHEC performs sanitary surveys every two years on the A-Area system and inspects the smaller systems every three years. All 2016 water samples complied with SCDHEC and U.S. Environmental Protection Agency (EPA) water quality standards. Information on compliance activities associated with the SRS drinking water system is in Chapter 3, *Compliance Summary*, Section 3.3.7.2, *Safe Drinking Water Act (SDWA)*.

The process water systems are located in A, F, H, and S Areas. These systems meet SRS 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. Process water wells ranging in capacity from 100 to 1,500 gallons per minute supply water to these systems. In K Area, L Area, and Z Area, the domestic water system supplies the process water system. At some locations, the process water wells pump to ground-level storage tanks, where SRS implements corrosion control measures. At other locations, the wells directly pressurize the process water distribution piping system without supplemental treatment.

The Savannah River Site (SRS) Quality Assurance (QA)/Quality Control (QC) program objectives ensure SRS products and services meet or exceed customers' requirements and expectations. SRS QA/QC objectives associated with the Environmental Monitoring Program ensure the environmental data the program collects accurately represent SRS discharges and the conditions of the surrounding environment. The Environmental Monitoring Program has multiple QA requirements for collecting samples, analyses and reporting, data management, and records management. It is important to confirm the accuracy of sample results so SRS can confidently assess the impacts Site activities may have on human health and the environment.

2016 Highlights

Analytical Laboratory Quality Assurance—SRS uses South Carolina Department of Health and Environmental Control (SCDHEC)-certified laboratories to analyze environmental monitoring samples that are reported to SCDHEC.

The DOE Consolidated Audit Program (DOECAP) audited three SRS subcontracted laboratories and six treatment, storage, and disposal facilities (TSDFs). The audits determined that each facility provided services that were of sufficient quality to warrant DOE continuing to use them.

Quality Control Activities—QC samples identified no defects affecting the analytical results of the surveillance and monitoring programs. Onsite and subcontracted laboratories reported acceptable proficiency and maintained SCDHEC certification for all analyses.

8.1 INTRODUCTION

SRS implements and conducts its QA program to comply with the following regulations: 1) U.S. Department of Energy (DOE) Order 414.1D, *Quality Assurance*, 2) American Society of Mechanical Engineers (ASME) Nuclear Quality Assurance (NQA) standards NQA-1-2008 with the NQA-1a-2009 Addenda, *QA Requirements for Nuclear Facility Applications*, and 3) 10 CFR 830, *Nuclear Safety Management*. In addition, specific programs may have other QA requirements from outside organizations. For example, under the tank closure program and area closure projects, the U.S. Environmental Protection Agency (EPA) and the State of South Carolina require DOE to develop and follow a project-specific sampling and analysis plan and a QA program plan. DOE has QA programs to verify the integrity of analyses from onsite and subcontracted offsite environmental laboratories, and to ensure it is complying with the quality-control program requirements.

The SRS Environmental Monitoring Program uses and disseminates high-quality data to further environmental stewardship and support other site missions. The environmental monitoring QA/QC program is designed to improve the methods and techniques used to both collect and analyze the environmental data and to prevent errors in generating the data. The QA/QC program includes continuous assessments, precision checks, and accuracy checks, as Figure 8-1 shows. The results of activities in one area provide input to assessments or checks conducted in the other two areas in an ongoing process. The result is high-quality data. By combining continuous assessment of field, laboratory, and data management

Chapter 8—Key Terms

Quality assurance is an integrated system of management activities involving planning, implementing, documenting, assessing, reporting, and improving quality to ensure quality in the processes by which products are developed. The goal of QA is to improve processes so that defects do not arise when the product is produced. It is proactive.

Quality control is a set of activities to ensure quality in products by identifying defects in the actual products. The goal of QC is to identify and correct defects in the finished product before it is made available to the customer. QC is a reactive process.

In summary, quality assurance makes sure you are doing the right things, the right way; quality control makes sure the results of what you have done are what you expected.

performance with checks for accuracy and precision, SRS ensures that all monitoring and surveillance data accurately represent conditions at SRS. The glossary contains definitions for each term Figure 8-1 presents.

Some elements of the QA/QC program are inherent within environmental monitoring standard procedures and practices. SRS personnel evaluate these elements as part of the continuous assessment process. The DOEAP focuses on assessing specific QA/QC program elements. Figure 8-1 shows the QA/QC elements discussed in this chapter in bold text.

8.2 BACKGROUND

DOE Order 414.1D, *Quality Assurance*, requires an integrated system of management activities to ensure that the results of the Environmental Monitoring Program meet the requirements of federal and state regulations and DOE Order 458.1, *Radiation Protection of the Public and the Environment*. SRS uses field and laboratory procedures to guide activities such as collecting samples, analyzing samples, evaluating data, and reporting results. SRS uses integrated testing to ensure the integrity of analyses SRS and offsite laboratories perform. In addition, SRS uses QA and QC procedures to verify and control environmental monitoring activities. Together, these quality measures ensure the resulting data provide a representative evaluation of SRS operational impacts on the health and safety of the public, workers, and the environment.

8.3 QUALITY ASSURANCE PROGRAM SUMMARY

The SRS environmental monitoring QA/QC program focuses on minimizing errors through ongoing assessment and control of the program components. The QA and QC activities are interdependent.

For example, QC identifies an ongoing problem with the quality of the product and alerts QA personnel that there is a problem in the process. QA determines the root cause and extent of the problem and changes the process to eliminate the problem, prevent reoccurrences, and improve product quality.

QA focuses on the processes implemented to produce the data presented in this report. In 2016, QA efforts associated with the Environmental Monitoring Program that led to program improvements were as follows:

- Implemented monitoring program changes
- Performed DOEAP audits of laboratories SRS used and audits of commercial treatment, storage, and disposal facilities (TSDFs) SRS waste generators used

QC activities are the tests and checks that ensure SRS is complying with defined standards. In 2016, the QC activities associated with the environmental monitoring program included the following:

- Participated in the Mixed Analyte Performance Evaluation Program (MAPEP) by laboratories that perform analytical measurements on SRS samples
- Participated in proficiency testing for laboratories performing National Pollutant Discharge Elimination System (NPDES) and drinking water analyses
- Collected and analyzed QC samples (duplicates and blind samples) associated with field sampling

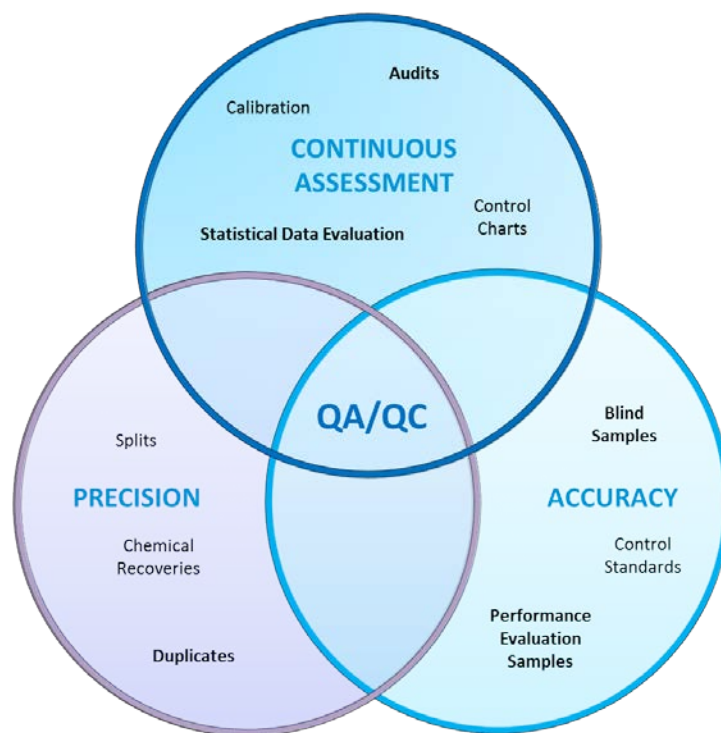


Figure 8-1 Interrelationship between QA/QC Activities

8.4 ENVIRONMENTAL MONITORING PROGRAM QA ACTIVITIES

SRS continuously assesses the Environmental Monitoring Program to identify and implement continuous improvement and minimize the potential for errors. During 2016, SRS implemented the following improvements:

- **Air Effluent**—Increased the accuracy of sample results by compositing two airborne effluent samples. The compositing reduced the minimum detectable concentrations (MDCs) in airborne effluent samples. SRS initiated this approach at two sources to evaluate for potential expansion to other air effluent sources within the program. Results support expanding this method within the Air Effluent Program.
- **Wildlife Monitoring**—Increased the accuracy of field measurements by upgrading the existing monitoring system. The new system yielded a lower MDC and improved correlating field measurements and laboratory data. *Improvements to the Hunter Dose Tracking System* (Aucott et al. 2017) documents the improvements made to the system.

- Liquid Surveillance—Updated flow equations for all liquid surveillance locations. This update maintains the accuracy for calibration parameters used for estimating flow volumes from wireless ultrasonic readings.
- Savannah River Surveillance—Improved representativeness of sampling by relocating a sample location so that it is more indicative of river flow during low river levels.
- Sediment Surveillance—Implemented composite sampling. The result was a more representative sample than the previous grab-sample method.
- Reporting Improvements—Improved the method of reporting in both the *Annual Site Environmental Report* to improve readability for the lay reader and the *Monthly Radioactive Releases Report* to incorporate new information from a subtier document.



Technician collecting sediment samples using composite method

Other quality improvements included the following:

- Rainwater Surveillance Program—SRS discontinued collecting rain ion column samples in the field. The basis for this decision was that data trend analyses showed decreasing levels of radionuclides in deposition samples over the past 10 years. Also, a lower-cost alternative for deposition monitoring is available, if needed, and this data is not used in the dose modeling.
- Groundwater Monitoring Program—SRS optimized the groundwater monitoring for Georgia wells. Data trend analyses of 15 years of data from 44 wells showed no results above the maximum concentration level for tritium (20 pCi/mL).
- Environmental Monitoring Program—SRS began a notification process reminding sample collection personnel to order sampling materials that have a short shelf-life. A shortage of silica gel onsite, a backorder with the subcontracted supplier, and a possible delay in sampling, led to setting up a system to ensure the needed materials are always on hand to support the Environmental Monitoring Program sampling schedule.

8.4.1 Department of Energy Consolidated Audit Program (DOECAP)

The DOECAP is a comprehensive audit program of contract and subcontracted laboratories that provide analytical services to DOE Operations and Field Offices. The DOECAP performs consolidated audits to reduce the number of audits DOE field sites conduct independently and to standardize audit methodologies, processes, and procedures. DOECAP audits commercial environmental analytical laboratories and commercial TSDFs that DOE facilities use.

8.4.1.1 DOECAP Laboratory Audits

DOECAP audits annually each subcontracted laboratory SRS uses to ensure the laboratories demonstrate technical capability and proficiency and comply with DOE QA requirements. The audit evaluates how well the laboratories document incoming samples, calibrate instruments, adhere to analytical procedures, verify data, issue data reports, manage records, perform nonconformance and corrective actions, perform preventative maintenance, and dispose of samples. Within these topics, auditors evaluate the use of control charts, control standards, chemical recoveries, performance evaluation samples, and laboratory procedures.

In 2016, DOECAP audited three SRS subcontracted laboratories that analyze the environmental samples documented in this annual report. The audits determined there was nothing of sufficient magnitude that would make the audited facilities unacceptable to provide service to DOE or SRS. Table 8-1 summarizes the number of Priority I and II findings and the status of their resolution. In 2016, there were 2 Priority I and 32 Priority II findings. None of the findings affected either SRS samples or analyses SRS requested in 2016. To close the open item, the audit team verified that the laboratory implemented corrective actions that were satisfactory. Any corrective actions that did not satisfy the requirement remain open until the 2017 audit.

Priority Definitions

A Priority I finding documents a deficiency that is of sufficient magnitude to potentially render the audited facility unacceptable to provide the affected service to DOE.

A Priority II finding documents a deficiency that is not of sufficient magnitude to render the audited facility unacceptable to provide services to DOE. Each affected laboratory submits corrective action responses to DOECAP that auditors review and approve prior to the next year's audit.

8.4.1.2 DOECAP TSDF Audits

DOECAP performs annual audits of the commercial TSDFs SRS uses to treat and dispose of hazardous waste. These reviews ensure that TSDFs are meeting contract requirements and are complying with applicable local, state, and federal regulations. DOECAP uses functional area checklists to conduct the following audits: QA, analytical data quality, environmental compliance, waste operations, safety and industrial hygiene, and transportation.

In 2016, DOECAP audited six TSDFs that SRS waste generators used. A review of the final reports from each audit indicated there were no significant findings that would cause SRS waste generators to discontinue using the TSDFs.

Table 8-1 summarizes the one Priority I finding and 30 Priority II findings. The Priority I finding was a previous Priority II finding that was elevated to Priority I due to the TSDF not implementing sufficient corrective actions in a timely manner. The reason it was elevated to a Priority I finding was that some individual sites do not have an approved QA plan and have a less-than-robust comprehensive QA program. The Priority I finding is for the QA program for one contractor at multiple facilities. The facilities' corporate offices issued policies and procedures that the vendor has not fully implemented at all of its sites. DOECAP noted the issue several years ago. DOECAP management has been working with the vendor to implement

company-wide policies and procedures to use at all of its offices and sites. SRS DOEAP subject-matter experts will track the corrective actions from implementation through closure.

Four out of the 30 Priority II findings remain open while the vendors implement corrective actions. The remaining open Priority II findings are programmatic in nature and do not impact the quality of services the vendor is providing SRS. Auditors will address these open findings during the 2017 audits.

Table 8-1 2016 DOEAP Audits for SRS Subcontracts

Program Audit Types	Number of Audits Conducted in 2016	2016 Priority I Findings	2016 Priority II Findings	Closed 2015 Priority I Findings	Closed 2015 Priority II Findings	Open 2015 Priority I Findings	Open 2015 Priority II Findings
Laboratory	3	2	32	0	42	0	5
TSDF	6	1	30	0	26	0	4

8.5 ENVIRONMENTAL MONITORING PROGRAM QC ACTIVITIES

An important part of the SRS Environmental Monitoring Program QC activities is to ensure collecting and analyzing samples are performed to the highest standard and are free of errors. The Site collects quality control samples and analyzes them to identify any collection and analysis errors. All laboratories analyzing samples for the SRS Environmental Monitoring Program must participate in QC programs that either SCDHEC or DOE direct.

8.5.1 QC Sampling

SRS personnel collect and transport several types of QC samples, including blinds, field duplicates, trip blanks, and field blanks throughout the year to determine the source of any measurement error.

SRS personnel routinely analyze blind samples (a sample with a composition known to the submitter, but not to the analyst) of field measurements of pH to assess the quality and reliability of field data measurements. For 2016, all 24 blind sample analyses were within the acceptable limit of less than a 0.4 pH unit difference between the original and blind samples. Analysis of blind samples tests the analyst's proficiency in performing the specified analysis.

During intralaboratory checks performed for the NPDES industrial wastewater program, SRS personnel collect blind and duplicate field samples for at least 10% of each outfall's required frequency. For example, if an outfall has a monthly sampling requirement, then SRS collects two blinds and two duplicates during the year. SRS onsite and subcontracted laboratories also analyze duplicate samples for the water quality (nonradiological) program. Each month, SRS collects duplicate samples at one river and one stream location to verify analytical results.

The relative percent difference (RPD) between each sample and its blind or duplicate (comparing only when both values are at least five times above the detection limit) should be 20% or less. Table 8-2 summarizes the results of blind and duplicate sample analyses associated with the NPDES industrial wastewater program and the water quality program. This table addresses analyses both SRS and offsite subcontracted laboratories conduct. The duplicate samples test the samplers' proficiency in collecting the samples. All of the blind samples, 98% of the NPDES duplicate samples, and 97% of the water quality duplicate samples met the acceptable difference limit. The two NPDES duplicate samples with a difference greater than 20% represent one analyte. Reasons for duplicate results differing for both NPDES and water quality include analytical uncertainties associated with the measurements, such as the precision of the analytical instruments and detection limits of the analytical instruments.

Table 8-2 Summary of Laboratory Blind and Duplicate Sample Analyses

Program and Sample Type	Number of Samples Analyzed	Number of Samples within Acceptable Limits (RPD between results < 20%)	Number of Samples Outside Acceptable Limits (RPD between results \geq 20%)
NPDES Blind	102	102	0
NPDES Duplicate	113	111	2
Water Quality River/Stream Duplicate	648	626	22

Though results indicate there were some differences between duplicates, they did not impact conclusions made with the data. The results indicate that in 2016 there were no consistent problems with either sample collection or laboratory analysis techniques.

Table 8-3 summarizes the results of field and trip blank analyses associated with the NPDES program. Field blanks determine whether the field sampling and sample processing environments have contaminated the sample. A trip blank documents contamination associated with shipping and field-handling procedures. The analytical results indicate neither sampling nor shipping contributed to contaminants being found in the actual samples as discussed in Chapter 4, *Nonradiological Environmental Monitoring Program*.

Table 8-3 Summary of Trip and Field Blank Sample Analyses

Program and Sample Type	Number of Samples Analyzed	Number of Samples with Results Below Detection Limits
NPDES Trip Blank	52	52
NPDES Field Blank	12	12

8.5.2 Laboratory Proficiency Testing

8.5.2.1 Nonradiological Methods Proficiency Testing

SRS laboratories performing NPDES and drinking water analyses maintained state certification for all analyses after achieving acceptable results in SCDHEC-required proficiency testing. Proficiency testing is also known as comparative testing and evaluates a laboratory's performance against pre-established criteria by testing the same samples at other laboratories and comparing the results. South Carolina state regulation 61-81, *State Environmental Laboratory Certification Program*, requires the testing. All laboratories used proficiency-tested providers that SCDHEC approved.

During 2016, onsite and subcontracted laboratories participated in water pollution and water supply performance evaluation studies, and each reported proficiency greater than 99% for the parameters tested for NPDES and drinking water laboratories. Therefore, both onsite and subcontracted laboratories maintained SCDHEC certification for all analyses at SRS.

The laboratories develop corrective actions for the failed analyses that they document and submit to SCDHEC, along with passing proficiency testing results for those analyses. The objective of the corrective actions is to prevent a reoccurrence of failed analyses. These corrective actions may include modifying sample preparation or analysis procedures. The underlying reasons for the unacceptable measurements did not affect the analyses provided to SRS in support of the NPDES and drinking water monitoring programs.

8.5.2.2 Radiological Methods Proficiency Testing

All laboratories with licenses to handle radioactive materials that perform environmental analytical measurements to support DOE Environmental Management activities are required to participate in the Mixed Analyte Performance Evaluation Program (MAPEP), a laboratory comparison program that tracks performance accuracy and tests the quality of environmental data reported to DOE. One SRS laboratory continues to participate in MAPEP, analyzing MAPEP performance evaluation samples including water, soil, air filter, and vegetation matrices, all with environmentally important stable inorganic, organic, and radioactive constituents.

MAPEP offered two separate studies in 2016: 1) an oily tar sample in the MAPEP Session 34, and 2) a large soil sample in MAPEP Session 35. The SRS Environmental Laboratory participated in the two studies, receiving 97.4% acceptable results in MAPEP 34 and 93.7% in MAPEP 35. All unacceptable measurements were related to minor errors in offline chemist spreadsheet calculations used to meet MAPEP nonroutine reporting requirements for gamma isotopes (for example, cobalt-60, cesium-137), not method quality. MAPEP results for SRS subcontracted laboratories were also satisfactory, with an average percent of passing parameters of 99% for water matrix and 97% for soil matrix. The laboratories developed corrective actions for the failed analyses to prevent a reoccurrence. These corrective actions included modifying procedures for preparing and analyzing samples. The underlying reasons for the unacceptable measurements did not affect the analyses provided to SRS in support of the Environmental Monitoring Program.

8.6 RECORDS MANAGEMENT

Environmental Monitoring Program documentation is an important part of the SRS environmental program. The Annual Environmental Report is the public record of the SRS Environmental Monitoring Program's performance. SRS compiles it every year following DOE Order 231.1B, *Environment, Safety, and Health Reporting*.

In addition to the Annual Environmental Report, the Site generates various records and reports to document SRS nonradiological and radiological environmental programs, groundwater management, and how the Site complies with applicable regulations. In addition, records and reports notify the proper officials of unusual or unforeseen occurrences and maintain an accurate and continuous record of the effects of SRS operations on the environment. This documentation also communicates results of the Environmental Monitoring Program and groundwater management and compliance programs to government agencies and the general public. SRS maintains the documents and records generated as part of the SRS Environmental Monitoring Program in accordance with SRS records management procedures.

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FY 2016 EMS Goals and Objectives

FY16 EMS Goals and Objectives

Clean Energy Initiatives

Sustainability Goals

Environmental Protection

Requirement | Leadership in sound environmental stewardship at SRS through innovative programs and projects.

Strategy | Continuous improvement in the reduction of the environmental impacts of SRS operations.

Goal	Environmental Aspect	Strategies	Implementation	Status
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Greenhouse Gas Reduction	Greenhouse Gas Emissions	Operate 4 biomass plants Travel reductions and use of internet conference resources	Site Sustainability Plan	Exceeding Goal. SRS has achieved this reduction primarily due to the Biomass Cogeneration Facility.
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Sustainable Buildings	Greenhouse Gas Emissions	Cool roof technology Preventative maintenance and energy efficient repairs Work to reduce peak Electric air requirements	Site Sustainability Plan	Partially Meeting Goal. Cool roof are being installed and energy efficient maintenance continues. EISA building evaluations are being performed, but more need to be completed.
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Fleet Management	Renewable Energy	Continue to obtain alternate fuel vehicles for SRS fleet	Site Sustainability Plan	Goal Exceeded. SRS continues to be a leader in the use of E85 fuels.
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Water Use Efficiency and Management	Energy Efficiency	Reduce water usage through low flow device installation	Site Sustainability Plan	Goal Met. SRS has realized a 20.3% decrease in potable water intensity (FY2016 versus FY2007).
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Pollution Prevention and Waste Reduction	Pollution Prevention	Diversion of at least 50% of routine sanitary waste to recycle	Site Sustainability Plan	Goal Met. SRS diverted 50% (695 metric tons) of nonhazardous solid waste for recycling.
		Conduct a One Simple Act of Green IDEAS campaign	3Q Procedure 13.5	Goal Met. Campaign continues through the IDEAS program during February. Winner was diesel filter cleaning.
		Monthly One Simple Act of Green communication	3Q Procedure 13.5	Partially Meeting Goal. Some communications did not carry the OSAG label.

Sustainable Acquisition	Procurement of Environmentally Preferred Goods And Services	Include EPP clause in 95% of applicable new solicitations	Site Sustainability Plan	Goal Met. 100% of solicitations contained the EPP clause.
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Electronic Stewardship and Data Centers	Energy Efficiency	SRS will continue leasing and purchasing eligible PCs, laptops and Monitors which meet EPEAT standards	Site Sustainability Plan	Goal Exceeded. 99% of eligible products purchased met the EPEAT standards.
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Renewable Energy	Biomass power	7.5% of electricity consumed Will be from renewable resources	Site Sustainability Plan	Goal Exceeded. 48% of electricity consumed at SRS is biomass produced.
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All Releases Remain Within Regulatory Limits	Maintain Regulatory Compliance	Conduct "Pre 3560" inspection to identify issues at outfalls	3Q Procedure 2.16 (Rob Backer)	Goal Met. Inspections were conducted during the year.
		Conduct "Pre CEI" inspection to identify potential RCRA issues	3Q Procedure 6.9 & 6.21 (Hal Morris)	Goal Met. Inspections were conducted during the year.
		Communicate on significant site environmental issues through the SEMC	SRS Environmental Policy	Goal Met. SEMC meets monthly and works to solve common issues such as chemical waste disposal.

Ensure Facility Activities Meet Regulatory Expectations	Continuous Improvement	Conduct routine and thorough Assessments of activities to identify environmental improvements	Self Assessment Program	Goal Met. Assessments were planned, scheduled and conducted in accordance with procedures and requirements.
		Conduct Quarterly ECA Meetings	3Q Procedure 13.5 (Jeff Ward)	Partially Meeting Goal. Quarterly meetings have been replaced with focused sessions to address specific issues.

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Appendix Table B-1 SRS Nonradiological Media and Sampling Frequencies

Media		Sampling Frequency		
		Monthly	Quarterly	Annually
Surface Water^a	Water quality downstream of NPDES outfalls (stream and river)	✓	✓	
Sediment	Surveillance for existence and possible buildup of the inorganic contaminants			✓
Fish	Bioaccumulation of nonradiological contaminants in fish			✓
Drinking Water	Safe Drinking Water Act compliance	✓	✓	✓

Note:

^a All water quality parameters for surface water are sampled monthly except pesticides. Pesticides are sampled quarterly.

Appendix Table B-2 SRS Radiological Media and Sampling Frequencies

Media		Sampling Frequency				
		Weekly	Bi-Weekly	Monthly	Quarterly	Annually
Air	Airborne particulate matter		✓			
	Gaseous state of radioiodine		✓			
	Tritiated water vapor		✓			
	Tritium in rainwater			✓		
Soil	Radionuclide deposition into soils					✓
Food Products	Radionuclides uptake in the food chain					✓
Vegetation	Radionuclide uptake in plants					✓
TLDs	Ambient gamma radiation monitoring				✓	
Water	Onsite drinking water				✓	✓
	Offsite drinking water			✓		
	Onsite surface water (Streams and basins)	✓	✓	✓		✓
	Savannah River	✓				✓
Sediment	Radionuclides in streambeds, the Savannah River bed, and SRS basins bed					✓
Fish and Shellfish	Radionuclides in freshwater fish, saltwater fish and shellfish					✓
Wildlife	Radionuclides in onsite deer, feral hogs, turkey, and coyotes during SRS-sponsored hunts					✓

Appendix Table C-1 River and Stream Water Quality Summary Results

Analytes that were not detected during 2016 are not included in the table. Bolded concentration results were reported as detected. Concentrations not bolded indicate the result was less than the sample quantitation limit.

Location	Detected Analytes	# of Detected Results	Units	Mean	Min Value	Max Value
FMC-2	Aluminum	12	µg/L	189.6	46.8	753.0
	Beryllium	3	µg/L	0.229	< 0.100	1.570
	Cadmium	2	µg/L	0.886	< 0.500	5.120
	Chromium	1	µg/L	2.12	< 2.00	3.47
	Copper	4	µg/L	3.16	< 2.00	10.20
	Iron	12	µg/L	2,907	578	6,970
	Manganese	12	µg/L	186.67	25.00	460.0
	Mercury	4	µg/L	0.0231	< 0.0200	0.0365
	Nickel	2	µg/L	3.20	< 3.00	4.78
	Nitrate-Nitrogen	12	mg/L	0.1638	0.200	0.6540
	Nitrite-Nitrogen	4	mg/L	0.0061	< 0.0034	0.0300
	Total Organic Carbon	12	mg/L	7.3	4.1	12.0
	Phosphorus	12	mg/L	0.077	0.012	0.170
	Total Suspended Solids	12	mg/L	9	1	32
	Zinc	11	µg/L	16.28	< 2.00	32.90
FM-2B	Aluminum	7	µg/L	96.2	< 40.0	245.0
	Beryllium	3	µg/L	0.218	< 0.100	1.020
	Cadmium	4	µg/L	0.919	< 0.500	3.140
	Chromium	1	µg/L	2.06	< 2.00	2.68
	Copper	2	µg/L	2.17	< 2.00	3.26
	Iron	12	µg/L	2,274	530	8,990
	Lead	1	µg/L	10.2	< 10.0	11.8
	Manganese	12	µg/L	198.05	15.50	790.00
	Nickel	1	µg/L	3.14	< 3.00	4.64
	Nitrate-Nitrogen	12	mg/L	0.1241	0.0567	0.2400
	Nitrite-Nitrogen	1	mg/L	0.0034	< 0.0027	0.0044
	Total Organic Carbon	12	mg/L	6.2	3.6	8.3
	Phosphorus	12	mg/L	0.067	0.032	0.130
	Total Suspended Solids	9	mg/L	6	< 1	28
	Zinc	11	µg/L	12.74	< 2.00	29.10
	2,4,5-TP (Silvex)	1	µg/L	0.17	< 0.01	0.66

Location	Detected Analytes	# of Detected Results	Units	Mean	Min Value	Max Value
FM-6	Aluminum	10	µg/L	113.0	< 40.0	366.0
	Beryllium	1	µg/L	0.101	< 0.100	0.108
	Copper	2	µg/L	2.17	< 2.00	3.13
	Iron	12	µg/L	925	628	1,140
	Manganese	12	µg/L	49.55	28.50	87.90
	Nickel	1	µg/L	3.22	< 3.00	5.60
	Nitrate-Nitrogen	12	mg/L	0.4229	0.1400	0.9300
	Nitrite-Nitrogen	1	mg/L	0.0033	< 0.0027	0.0038
	Total Organic Carbon	12	mg/L	4.6	3.3	7.2
	Phosphorus	12	mg/L	0.103	0.053	0.210
	Total Suspended Solids	11	mg/L	4	< 1	8
	Zinc	11	µg/L	9.28	< 2.00	22.30
	L3R-2	9	µg/L	149.6	< 40.0	562.0
L3R-2	Aluminum	9	µg/L	149.6	< 40.0	562.0
	Iron	12	µg/L	531	367	705
	Manganese	12	µg/L	64.88	27.80	110.00
	Nitrate-Nitrogen	11	mg/L	0.0560	< 0.0013	0.1100
	Total Organic Carbon	12	mg/L	4.9	2.9	9.2
	Phosphorus	12	mg/L	0.054	0.020	0.140
	Total Suspended Solids	10	mg/L	4	< 1	11
	Zinc	11	µg/L	8.83	< 2.00	18.40
	PB-3	12	µg/L	285.1	64.1	1,280.0
	Aluminum	12	µg/L	285.1	64.1	1,280.0
	Copper	1	µg/L	2.07	< 2.00	2.80
	Iron	12	µg/L	819	564	1,020
	Manganese	12	µg/L	52.37	20.70	68.90
PB-3	Nitrate-Nitrogen	12	mg/L	0.1401	0.0570	0.2520
	Nitrite-Nitrogen	1	mg/L	0.0034	< 0.0027	0.0045
	Total Organic Carbon	12	mg/L	6.0	3.4	9.3
	Phosphorus	12	mg/L	0.064	0.023	0.180
	Total Suspended Solids	12	mg/L	6	3	10
	Zinc	11	µg/L	12.17	< 2.00	45.60
	RM-118.8	12	µg/L	363.8	97.2	1,140.0
	Aluminum	12	µg/L	363.8	97.2	1,140.0
	Beryllium	4	µg/L	0.406	< 0.100	1.150
	Cadmium	6	µg/L	1.769	< 0.500	4.130
	Chromium	5	µg/L	2.21	< 2.00	2.87
	Copper	5	µg/L	2.27	< 2.00	3.56
	Iron	12	µg/L	726	420	1,210
RM-118.8	Manganese	12	µg/L	73.41	20.70	110.00
	Nickel	3	µg/L	3.28	< 3.00	4.89
	Nitrate-Nitrogen	12	mg/L	0.3179	0.1980	1.1000
	Nitrite-Nitrogen	2	mg/L	0.0038	< 0.0027	0.0083

Location	Detected Analytes	# of Detected Results	Units	Mean	Min Value	Max Value
	Total Organic Carbon	12	mg/L	4.4	3.1	7.3
	Phosphorus	12	mg/L	0.150	0.041	0.420
	Total Suspended Solids	12	mg/L	8	3	14
	Zinc	11	µg/L	7.34	< 2.00	12.50
RM-129.1	Aluminum	10	µg/L	325.8	< 40.0	1,570.0
	Beryllium	2	µg/L	0.271	< 0.100	1.930
	Cadmium	3	µg/L	1.089	< 0.500	6.970
	Chromium	1	µg/L	2.22	< 2.00	4.65
	Copper	3	µg/L	2.13	< 2.00	2.92
	Iron	12	µg/L	874	432	1,580
	Manganese	12	µg/L	83.58	29.70	233.00
	Nickel	2	µg/L	3.24	< 3.00	5.55
	Nitrate-Nitrogen	12	mg/L	0.2556	0.0619	0.9300
	Nitrite-Nitrogen	1	mg/L	0.0038	< 0.0027	0.0093
	Total Organic Carbon	12	mg/L	5.2	3.4	7.5
	Phosphorus	12	mg/L	0.116	0.045	0.220
	Total Suspended Solids	12	mg/L	6	1	13
	Zinc	11	µg/L	7.53	< 2.00	16.10
RM-141.5	Aluminum	10	µg/L	240.1	< 40.0	897.0
	Beryllium	4	µg/L	0.345	< 0.100	1.390
	Cadmium	4	µg/L	1.388	< 0.500	5.790
	Chromium	2	µg/L	2.17	< 2.00	3.04
	Copper	3	µg/L	2.43	< 2.00	4.54
	Iron	12	µg/L	625	294	1,080
	Manganese	12	µg/L	68.73	14.70	96.00
	Nickel	3	µg/L	3.56	< 3.00	6.47
	Nitrate-Nitrogen	12	mg/L	0.2498	0.1200	0.5200
	Nitrite-Nitrogen	2	mg/L	0.0040	< 0.0027	0.0107
	Thallium	1	µg/L	15.1	< 15.0	16.0
	Total Organic Carbon	12	mg/L	4.4	2.8	7.0
	Phosphorus	12	mg/L	0.134	0.027	0.210
	Total Suspended Solids	11	mg/L	6	< 1	11
	Zinc	11	µg/L	9.40	< 2.00	24.10
RM-150.4	Aluminum	10	µg/L	308.0	< 40.0	1,580.0
	Cadmium	1	µg/L	0.529	< 0.500	0.853
	Copper	3	µg/L	2.33	< 2.00	4.56
	Iron	12	µg/L	532	260	1,180
	Manganese	12	µg/L	65.78	44.90	88.40
	Nickel	1	µg/L	3.08	< 3.00	3.93
	Nitrate-Nitrogen	12	mg/L	0.2415	0.1100	0.3800
	Nitrite-Nitrogen	4	mg/L	0.0054	< 0.0028	0.0200

Location	Detected Analytes	# of Detected Results	Units	Mean	Min Value	Max Value
	Total Organic Carbon	12	mg/L	4.1	3.0	6.3
	Phosphorus	12	mg/L	0.138	0.064	0.210
	Total Suspended Solids	10	mg/L	5	< 1	10
	Zinc	11	µg/L	7.16	< 2.00	14.90
RM-160	Aluminum	9	µg/L	309.2	< 40.0	1,690.0
	Beryllium	2	µg/L	0.211	< 0.100	1.420
	Cadmium	1	µg/L	0.859	< 0.500	4.810
	Chromium	1	µg/L	2.09	< 2.00	3.07
	Copper	6	µg/L	2.39	< 2.00	3.32
	Iron	12	µg/L	542	202	1,910
	Manganese	12	µg/L	79.71	52.20	218.00
	Nickel	2	µg/L	3.14	< 3.00	4.45
	Nitrate-Nitrogen	12	mg/L	0.2359	0.1530	0.5600
	Nitrite-Nitrogen	5	mg/L	0.0071	< 0.0032	0.0210
	Total Organic Carbon	12	mg/L	4.5	3.3	9.0
	Phosphorus	12	mg/L	0.187	0.082	0.280
	Total Suspended Solids	11	mg/L	5	< 1	9
	Zinc	11	µg/L	8.43	< 2.00	17.00
SC-4	Aluminum	9	µg/L	135.1	< 40.0	467.0
	Iron	12	µg/L	494	244	1,300
	Manganese	12	µg/L	47.43	19.70	169.00
	Mercury	1	µg/L	0.0200	< 0.0200	0.0201
	Nitrate-Nitrogen	12	mg/L	0.0831	0.0380	0.1200
	Thallium	1	µg/L	15.1	< 15.0	15.7
	Total Organic Carbon	12	mg/L	4.6	3.3	6.1
	Phosphorus	12	mg/L	0.060	0.014	0.170
	Total Suspended Solids	11	mg/L	7	< 1	37
	Zinc	11	µg/L	6.87	< 2.00	15.00
TB-5	Aluminum	9	µg/L	103.2	< 40.0	234.0
	Cadmium	1	µg/L	0.525	< 0.500	0.795
	Copper	1	µg/L	2.09	< 2.00	3.06
	Iron	12	µg/L	3,376	1,410	7,090
	Manganese	12	µg/L	183.98	57.30	659.00
	Mercury	1	µg/L	0.0210	< 0.0200	0.0314
	Nickel	9	µg/L	5.69	< 3.00	11.60
	Nitrate-Nitrogen	9	mg/L	0.0377	< 0.0013	0.0918
	Total Organic Carbon	12	mg/L	5.2	2.9	6.8
	Phosphorus	12	mg/L	0.069	0.024	0.170
	Total Suspended Solids	11	mg/L	11	< 1	31
	Zinc	11	µg/L	5.91	< 2.00	11.70
TC-1	Aluminum	7	µg/L	81.8	< 40.0	182.0

Location	Detected Analytes	# of Detected Results	Units	Mean	Min Value	Max Value
	Iron	12	µg/L	494	260	842
	Manganese	12	µg/L	21.56	8.77	55.90
	Nitrate-Nitrogen	12	mg/L	0.0804	0.0200	0.3400
	Total Organic Carbon	12	mg/L	4.7	3.3	6.4
	Phosphorus	12	mg/L	0.099	0.038	0.200
	Total Suspended Solids	11	mg/L	6	< 1	14
	Zinc	10	µg/L	8.82	< 2.00	25.80
U3R-1A	Aluminum	5	µg/L	62.0	< 40.0	159.0
	Beryllium	1	µg/L	0.102	< 0.100	0.121
	Chromium	1	µg/L	2.55	< 2.00	8.63
	Iron	12	µg/L	340	228	429
	Manganese	12	µg/L	8.81	7.53	13.30
	Nitrate-Nitrogen	9	mg/L	0.1222	< 0.0013	0.3740
	Nitrite-Nitrogen	1	mg/L	0.0033	< 0.0027	< 0.0034
	Total Organic Carbon	12	mg/L	2.2	1.5	3.8
	Phosphorus	12	mg/L	0.035	0.013	0.110
	Total Suspended Solids	11	mg/L	3	< 1	5
	Zinc	11	µg/L	5.54	< 2.00	11.60
U3R-4	Aluminum	12	µg/L	152.8	41.9	267.0
	Beryllium	1	µg/L	0.102	< 0.100	0.128
	Cadmium	1	µg/L	0.506	< 0.500	0.567
	Iron	12	µg/L	621	401	965
	Manganese	12	µg/L	28.29	14.10	87.20
	Nickel	1	µg/L	3.15	< 3.00	4.75
	Nitrate-Nitrogen	12	mg/L	0.0953	0.0430	0.1780
	Nitrite-Nitrogen	2	mg/L	0.0034	< 0.0027	0.0046
	Thallium	1	µg/L	15.1	< 15.0	16.6
	Total Organic Carbon	12	mg/L	5.2	2.2	17.0
	Phosphorus	11	mg/L	0.0627	< 0.0016	0.1500
	Total Suspended Solids	11	mg/L	6	< 1	16
	Zinc	11	µg/L	11.06	< 2.00	39.40

**Appendix Table C-2 Summary of Detected Metal Results for Sediments Collected
from the Savannah River, SRS Streams, and Stormwater Basins**

Bolded concentration results were reported as detected. Concentrations not bolded indicate the result was less than the sample quantitation limit. The control location for the river sediment samples is River Mile 160 (RM-160.0_SED).

River Sediment Results			
Analyte	Control Conc. (mg/kg)	Location of Maximum Result	Maximum Conc. (mg/kg)
Aluminum	3.70E+03	RM-157.2_SED	2.20E+04
Arsenic	1.90E+00	RM-157.2_SED	3.70E+00
Barium	7.30E+01	RM-157.2_SED	1.40E+02
Chromium	1.30E+01	RM-157.2_SED	2.60E+01
Copper	2.50E+00	RM-157.2_SED	1.50E+01
Cyanide	1.50E+00	RM-160.0_SED	1.50E+00
Iron	5.70E+03	RM-157.2_SED	2.60E+04
Lead	3.50E+00	RM-157.2_SED	1.50E+01
Magnesium	4.60E+02	SC LANDING (RM-141)	2.20E+03
Manganese	1.80E+03	RM-160.0_SED	1.80E+03
Nickel	2.80E+00	RM-157.2_SED	1.10E+01
Uranium	3.10E+01	RM-150.4(Vogtle Discharge)	4.20E+01
Zinc	1.20E+01	RM-157.2_SED	5.90E+01

Note: Cadmium, mercury, selenium, and silver were non-detects.

The control location for the stream and stormwater basin sediment samples is Upper Three Runs U3R-1A (U3R-1A_SED).

Stream and Stormwater Basin Sediment Results			
Analyte	Control Conc. (mg/kg)	Location of Maximum Result	Maximum Conc. (mg/kg)
Aluminum	9.30E+03	E-003_SED	2.70E+04
Arsenic	3.60E+00	E-002_SED	4.80E+00
Barium	8.90E+01	U3R-ROAD-C	9.10E+01
Chromium	1.40E+01	E-001_SED	3.30E+01
Copper	8.40E+00	E-001_SED and E-003_SED	1.30E+01
Cyanide	2.60E+00	FMC-ROAD-A	1.29E+02
Iron	7.60E+03	E-003_SED	2.70E+04
Lead	1.70E+01	U3R-1A_SED	1.70E+01
Magnesium	1.20E+03	E-003_SED	1.40E+03
Manganese	2.80E+01	PB-ROAD-A	2.90E+02
Mercury	4.10E-01	L3R-1A_SED	6.32E+01
Nickel	9.50E+00	E-003_SED	8.30E+00
Selenium	4.70E+00	L3R-2_SED	1.16E+00
Silver	2.40E+00	L3R-1A_SED	1.60E-01
Zinc	1.70E+01	E-001_SED	1.30E+02

Note: Cadmium and uranium were non-detects.

Appendix Table C-3 Summary of Detected Metal Results for Freshwater Fish¹ Tissue Collected from the Savannah River

Analyte	Number of Detected Values (above the MDC)	Number of Estimated Values (above the MDC, below the SQL)	Maximum Concentration (ug/g)	SQL (ug/g)	MDC (ug/g)	Fish Type with Maximum Concentration	Location of Maximum Concentration
Mercury	126	58	1.44	0.2	0.02	Bass	Augusta Lock and Dam
Cadmium	8	8	0.163	0.808	0.081	Panfish	Steel Creek Mouth
Chromium	97	97	0.272	0.753	0.075	Bass	Augusta Lock and Dam
Copper	117	117	0.798	1.70	0.170	Bass	Steel Creek Mouth
Manganese	108	105	3.05	0.644	0.064	Panfish	Fourmile Creek Mouth
Nickel	11	11	0.655	1.62	0.162	Panfish	Steel Creek Mouth
Zinc	126	0	12.6	1.62	0.162	Catfish	Augusta Lock and Dam

Note: 126 freshwater tissue samples were collected and analyzed for metals and mercury.

Appendix Table C-4 Summary of Detected Metal Results for Saltwater Fish¹ Tissue Collected from the Savannah River between River Miles 0–8, Near Savannah, GA

Analyte	Number of Detected Values (above the MDC)	Number of Estimated Values (above the MDC, below the SQL)	Maximum Concentration (ug/g)	SQL (ug/g)	MDC (ug/g)	Fish Type with Maximum Concentration
Mercury	15	15	0.148	0.20	0.02	Sea Trout/Flounder
Arsenic	4	4	1.49	10.8	1.08	Red Drum
Cadmium^a	1	1	0.189	1.02	0.102	Red Drum
Chromium^a	8	8	0.207	1.02	0.102	Red Drum
Copper^a	20	20	0.453	2.04	0.204	Red Drum
Manganese^a	11	11	0.257	1.02	0.102	Red Drum
Nickel^a	9	9	0.562	2.04	0.204	Red Drum
Zinc	20	0	5.13	2.16 and 1.86	0.216 and 0.186	Red Drum and Sea Trout/Flounder

Notes:

21 saltwater tissue samples were collected and analyzed for metals and mercury.

^a Maximum values were from a single sample

**Appendix Table C-5 Precipitation Results of SRS National Trends Network Station
for Calendar Year 2015**

Analyte	Precipitation Weighted Concentration	Deposition
Calcium (Ca^{2+})	0.055 mg/L	0.75 kg/ha
Magnesium (Mg^{2+})	0.021 mg/L	0.287 kg/ha
Potassium (K^+)	0.019 mg/L	0.260 kg/ha
Sodium (Na^+)	0.144 mg/L	1.971 kg/ha
Ammonium (NH_4^+)	0.147 mg/L	2.01 kg/ha
Nitrate (NO_3^-)	0.492 mg/L	6.73 kg/ha
Chloride (Cl^-)	0.253 mg/L	3.46 kg/ha
Sulfate (SO_4^{2-})	0.441 mg/L	6.04 kg/ha

Note: ha = hectare—a metric unit of area defined as 10,000 square meters.

Negative values are reported in tables in this appendix. Background counts are subtracted from the sample counts. Negative values occur when the background count is greater than the sample count. Background counts reflect naturally occurring radionuclides and cosmic radiation that is detected by laboratory instrumentation.

Appendix Table D-1 Summary of Radioactive Atmospheric Releases by Source

All values under the "Calculated" column through "Totals" column are reported in curies.^a

In the Calculated column, blanks indicate the radionuclide is not present. In the facility (Reactors, Separations, SRNL) columns, a blank indicates the radionuclide was not analyzed. A 0.00E+00 in the facility columns indicates the result was not significant.

Radionuclide	Half-Life ^b	Calculated ^c	Reactors	Separations ^d	SRNL	Total
Gases and Vapors						
H-3 (oxide)	12.3 y	2.24E+03	9.15E+02	1.67E+04		1.99E+04
H-3 (elemental)	12.3 y			1.88E+03		1.88E+03
H-3 Total	12.3 y	2.24E+03	9.15E+02	1.86E+04		2.17E+04
C-14	5700 y	1.57E-07		1.64E-02		1.64E-02
Hg-203	46.6 d	5.22E-10				5.22E-10
Kr-85	10.8 y			3.96E+03		3.96E+03
I-129	1.57E+07 y	2.01E-04		1.89E-03	9.06E-06	2.09E-03
I-131	8.02 d	6.75E-10				6.75E-10
Particles						
Ag-110m	250 d	1.48E-11				1.48E-11
Am-241	432 y	1.12E-05	0.00E+00	2.61E-05		3.73E-05
Am-243	7370 y	4.50E-09				4.50E-09
Ba-133	10.5 y	7.01E-10				7.01E-10
Cd-109	461 d	1.34E-08				1.34E-08
Ce-139	138 d	5.20E-10				5.20E-10
Ce-141	32.5 d	4.94E-11				4.94E-11
Ce-144	285 d	2.00E-08				2.00E-08
Cm-244	18.1 y	2.83E-07	0.00E+00	8.54E-07		1.14E-06
Co-57	272 d	4.96E-10				4.96E-10
Co-60	5.27 y	4.96E-07	0.00E+00	0.00E+00	0.00E+00	4.96E-07
Cs-134	2.06 y	4.31E-07				4.31E-07
Cs-137	30.2 y	1.25E-03	0.00E+00	7.80E-03	0.00E+00	9.05E-03
Eu-152	13.5 y	1.47E-09				1.47E-09
Eu-154	8.59 y	3.56E-07				3.56E-07
Eu-155	4.76 y	1.18E-07				1.18E-07
F-18	110 m	4.00E-02				4.00E-02
Fe-55	2.74 y	1.17E-08				1.17E-08
Mn-54	312 d	3.78E-10				3.78E-10
Nb-94	2.03E+04 y	2.42E-07				2.42E-07
Nb-95	35.0 d	3.63E-07				3.63E-07
Ni-59	1.01E+05 y	5.76E-11				5.76E-11
Ni-63	100 y	5.46E-09				5.46E-09
Np-237	2.14E+06 y	1.62E-06	0.00E+00	8.79E-08		1.71E-06
Pa-233	27.0 d	1.42E-06				1.42E-06

Radionuclide	Half-Life ^b	Calculated ^c	Reactors	Separations ^d	SRNL	Total
Particles						
Pb-212	10.6 h	8.43E-07				8.43E-07
Pm-147	2.62 y	2.89E-06				2.89E-06
Pm-148m	41.3 d	1.90E-12				1.90E-12
Pr-144	17.3 m	2.00E-08				2.00E-08
Pu-236	2.86 y	5.55E-10				5.55E-10
Pu-238	87.7 y	3.14E-05	4.72E-10	8.01E-06		3.94E-05
Pu-239	2.41E+04 y	4.34E-05	0.00E+00	6.09E-05		1.04E-04
Pu-240	6560 y	7.73E-06				7.73E-06
Pu-241	14.4 y	2.07E-04				2.07E-04
Pu-242	3.75E+05 y	2.16E-06				2.16E-06
Ra-226	1600 y	2.48E-07				2.48E-07
Ra-228	5.75 y	2.29E-07				2.29E-07
Rh-106	29.8 s	1.19E-08				1.19E-08
Ru-103	39.3 d	5.11E-10				5.11E-10
Ru-106	374 d	3.04E-06				3.04E-06
Sb-125	2.76 y	1.18E-06				1.18E-06
Sb-126 ^e	12.4 d	1.70E-07				1.70E-07
Se-75	120 d			1.94E-07		1.94E-07
Se-79	2.95E+05 y	4.90E-09				4.90E-09
Sm-151	90 y	2.89E-06				2.89E-06
Sn-113	115 d	6.27E-10				6.27E-10
Sn-123	129 d	6.66E-12				6.66E-12
Sn-126	2.30E+05 y	1.70E-07				1.70E-07
Sr-85	64.8 d	6.00E-10				6.00E-10
Sr-89	50.5 d	5.99E-10				5.99E-10
Sr-90	28.8 y	3.34E-05	2.30E-09	1.53E-04		1.87E-04
Tc-99	2.11E+05 y	1.06E-06				1.06E-06
Te-127	9.35 h	1.04E-11				1.04E-11
Te-129	69.6 m	1.05E-12				1.05E-12
Th-228	1.91 y	1.26E-10	8.29E-10			9.55E-10
Th-229	7340 y	1.60E-09				1.60E-09
Th-230	7.54E+04 y	1.43E-10	7.68E-09			7.82E-09
Th-231	25.5 h	2.12E-04				2.12E-04
Th-232	1.41E+10 y	4.79E-12	2.17E-09			2.18E-09
Tl-208	3.05 m	1.41E-06				1.41E-06
U-232	68.9 y	6.04E-09				6.04E-09
U-233	1.59E+05 y	4.21E-10				4.21E-10
U-234	2.46E+05 y	6.11E-07	2.41E-09	1.02E-04		1.03E-04
U-235	7.04E+08 y	8.41E-09	0.00E+00	6.33E-06		6.34E-06
U-236	2.34E+07 y	3.01E-08				3.01E-08
U-238	4.47E+09 y	2.08E-07	1.99E-09	1.48E-04		1.48E-04

Radionuclide	Half-Life ^b	Calculated ^c	Reactors	Separations ^d	SRNL	Total
Particles						
Y-88	107 d	4.58E-10				4.58E-10
Y-90 ^e	64.1 h	3.34E-05	2.30E-09	1.53E-04		1.87E-04
Y-91	58.5 d	7.98E-10				7.98E-10
Zn-65	244 d	9.56E-10				9.56E-10
Zr-95	64.0 d	1.22E-07				1.22E-07
Unidentified alpha ^f	N/A	3.94E-05	0.00E+00	1.21E-05	0.00E+00	5.15E-05
Unidentified beta ^f	N/A	2.17E-03	5.17E-05	9.05E-04	1.73E-06	3.13E-03
TOTAL		2.24E+03	9.15E+02	2.25E+04	1.08E-05	2.57E+04

Notes:

^a One curie equals 3.7E+10 becquerels^b ICRP 107, *Nuclear Decay Data for Dosimetric Calculations* (2008)^c Estimated releases from unmonitored sources. Beginning in 2016, individual isotope annual releases below 1E-12 Ci (1 pCi) are no longer reported in this table and, therefore, not used in the dose calculations.^d Includes separations, waste management, and tritium processing facilities^e Daughter products (Sb-126 & Y-90) in secular equilibrium with source terms (Sn-126 & Sr-90, respectively). In MAXDOSE/POPDOSE, they are included in the source term and their ingrowth is included in their parents' source term.^f For dose calculations, unidentified alpha and beta releases are assumed to be Pu-239 and Sr-90, respectively.

Appendix Table D-2 Summary of Air Effluent DOE DCS Sum of Fractions

Facility (Sampling Location)	Radionuclides Included in the DCS Sum of Fractions	DCS Sum of Fractions
A Area (791-A Sandfilter Discharge)	I-129	3.71E-04
C Area (C-Area Main Stack [148'])	H-3 (oxide)	1.73E+00
F Area (235-F Sandfilter Discharge)	U-234, U-238, Pu-238, Pu-239, Am-241	1.14E-03
F Area (291-F Stack Isokinetic)	Sr-89/90, I-129, Cs-137, U-234, U-235, Np-237, U-238, Pu-238, Pu-239, Am-241, Cm-244	6.66E-01
F Area (772-4F Stack)	U-234, U-238, Pu-238, Pu-239, Am-241	1.43E-03
H Area (291-H Stack Isokinetic)	H-3 (oxide), C-14, Kr-85, Sr-89/90, I-129, Cs-137, U-234, U-235, Np-237, U-238, Pu-238, Pu-239, Am-241	4.11E-01
K Area (K-Area Main Stack [148'])	H-3 (oxide)	1.30E+01
K Area (KIS Facility)	Sr-89/90, Th-228, Th-230, Th-232, U-234, U-238, Pu-238	5.05E-03
L Area (L-Area Disassembly)	H-3 (oxide)	2.31E+01
L Area (L-Area Main Stack [148'])	H-3 (oxide)	1.56E+01
Tritium (232-H (200ft))	H-3 (elemental), H-3 (oxide)	2.30E+01
Tritium (233-H)	H-3 (elemental), H-3 (oxide)	1.92E+00
Tritium (234-H)	H-3 (elemental), H-3 (oxide)	2.20E+01
Tritium (238-H)	H-3 (oxide)	3.23E+01
Tritium (264-H)	H-3 (elemental), H-3 (oxide), Se-75	6.48E+00

Note: DOE-STD-1196-2011, Derived Concentration Technical Standard

Appendix Table D-3 Summary of Tritium in Environmental Air

All concentrations are in pCi/m³. Bolded minimum and maximum concentration results were reported as detected. Minimum and maximum concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large.

The results at the following locations were all not detected: 25-Mile Radius (Aiken Airport and the Control Location–Hwy 301 @ State Line)

Location	Number of Samples	Mean Conc. (std. dev.)	Minimum Conc. (std. dev.)	Maximum Conc. (std. dev.)
Onsite				
Burial Ground North	26	1.64E+02 (1.62E+00)	3.81E+01 (6.74E+00)	3.68E+02 (1.04E+01)
Site Perimeter				
Allendale Gate ^a	26	2.00E+00 (6.67E-01)	-6.84E+00 (2.55E+00)	9.81E+00 (4.63E+00)
Barnwell Gate	26	1.06E+01 (8.32E-01)	-6.68E+00 (5.36E+00)	1.73E+02 (3.39E+00)
D Area	26	5.17E+00 (7.93E-01)	-2.56E+00 (3.32E+00)	2.38E+01 (4.45E+00)
Darkhorse @ Williston Gate	26	5.11E+00 (8.19E-01)	-5.03E+00 (6.26E+00)	2.92E+01 (4.38E+00)
East Talatha	26	5.38E+00 (8.35E-01)	-1.94E+00 (1.91E+00)	2.04E+01 (5.47E+00)
Green Pond	26	4.51E+00 (8.15E-01)	-3.51E+00 (5.66E+00)	1.29E+01 (6.94E+00)
Highway 21/167	26	3.72E+00 (8.50E-01)	-6.16E+00 (5.54E+00)	1.98E+01 (5.50E+00)
Jackson	26	4.38E+00 (8.65E-01)	-6.54E+00 (4.65E+00)	1.79E+01 (5.25E+00)
Patterson Mill Road	26	3.06E+00 (9.59E-01)	-7.11E+00 (5.31E+00)	1.73E+01 (4.95E+00)
Talatha Gate	26	4.49E+00 (7.87E-01)	-5.81E+00 (5.39E+00)	1.43E+01 (5.30E+00)
25-Mile Radius				
Augusta Lock and Dam 614	26	2.75E+00 (7.96E-01)	-8.57E+00 (4.97E+00)	1.59E+01 (4.94E+00)

Note:

^aThere were two detected results. However, neither was the maximum measured value.

Appendix Table D-4 Summary of Tritium in Rainwater

Samples were collected approximately every 4 weeks at each of 13 locations. All concentrations are in pCi/L. Twelve samples were collected from each location during 2016. Bolded minimum and maximum concentration results were reported as detected. Minimum and maximum concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large. The results at the following locations were all not detected: Site Perimeter (Allendale Gate, Barnwell Gate, Darkhorse @ Williston Gate, Patterson Mill Road) and 25-Mile Radius (Augusta Lock and Dam 614 and Highway 301 @ State Line). The Highway 301 @ State Line location is the control location.

Location	# of Detected Results	Mean Conc. (std. dev.)	Minimum Conc. (std. dev.)	Maximum Conc. (std. dev.)
Onsite				
Burial Ground North	11	2.24E+03 (5.67E+01)	-1.06E+02 (1.57E+02)	6.92E+03 (2.83E+02)
Site Perimeter				
D Area	1	1.19E+02 (4.11E+01)	-3.11E+02 (1.66E+02)	4.81E+02 (1.51E+02)
East Talatha	1	6.23E+01 (4.01E+01)	-3.00E+02 (1.66E+02)	4.05E+02 (1.47E+02)
Green Pond	1	1.16E+02 (4.05E+01)	-1.41E+02 (1.33E+02)	8.03E+02 (1.41E+02)
Highway 21/167	1	4.43E+01 (3.96E+01)	-1.82E+02 (1.31E+02)	2.62E+02 (5.21E+01)
Jackson	1	1.06E+02 (4.01E+01)	-2.27E+02 (1.29E+02)	4.89E+02 (1.50E+02)
Talatha Gate	1	1.10E+02 (4.01E+01)	-2.66E+02 (1.60E+02)	3.89E+02 (1.27E+02)
25-Mile Radius				
Aiken Airport	1	1.02E+02 (4.11E+01)	-2.02E+02 (1.33E+02)	4.57E+02 (1.48E+02)

Appendix Table D-5 Summary of Radionuclides in Soil

Samples are collected annually from 18 locations. Bolded values are detected results. Values not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large.

The following locations are sampled: F Area (2000 feet West), H Area (2000 ft East), Z Area (#3), Burial Ground Locations (643-26E-2 and Burial Ground North), Plant Perimeter Locations (Allendale Gate, Barnwell Gate, D Area, Darkhorse @ Williston Gate, East Talatha, Green Pond, Highway 21/167, Jackson, Patterson Mill Road, and Talatha Gate) and 25-Mile Radius Locations (Aiken Airport, August Lock and Dam 614, and Highway 301 @ State Line). The Highway 301 @ State Line is the control location.

All Co-60 and Np-237 results were not detected; thus, they were not reported in this table.

Radionuclide	# of Detected Results	Control - HWY 301 Conc. (pCi/g)	Location of Minimum Conc.	Minimum Conc. (pCi/g)	Location of Maximum Conc.	Maximum Conc. (pCi/g)
Cs-137	17 of 18	1.34E-01	Burial Ground (643-26E-2)	-4.51E-03	Allendale Gate	4.27E-01
Sr-89/90	2 of 18	3.24E-02	Z-Area #3	-4.76E-02	Aiken Airport	2.56E-01
U-234	18 of 18	2.00E+00	Allendale Gate	4.43E-01	Highway 301 @ State Line	2.00E+00
U-235	18 of 18	9.62E-02	Green Pond	1.71E-02	Highway 301 @ State Line	9.62E-02
U-238	18 of 18	2.10E+00	Allendale Gate	3.97E-01	Highway 301 @ State Line	2.10E+00
Pu-238	5 of 18	4.08E-04	Darkhorse @ Williston Gate	-1.24E-04	F Area (2000 Feet West)	3.32E-02
Pu-239	18 of 18	8.92E-03	Jackson	2.29E-03	F Area (2000 Feet West)	4.86E-02
Am-241	16 of 18	2.26E-03	Burial Ground (643-26E-2)	-9.95E-06	D-Area	9.84E-03
Cm-244	1 of 18	3.22E-04	Barnwell Gate	-3.41E-04	Jackson	1.97E-03
Gross Beta	15 of 18	8.57E+00	Barnwell Gate	2.95E+00	D Area	1.57E+01
Gross Alpha	18 of 18	1.16E+01	Aiken Airport	1.89E+00	Burial Ground North	2.29E+01

Appendix Table D-6 Summary of Radionuclides in Grassy Vegetation

Samples are collected annually from 14 locations. Bolded values are detected results. Values not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large. All results for Co-60, U-235, Np-237, Pu-238, Pu-239, Cm-244 and Gross alpha were not detected; thus, not reported in this table.

The following locations are sampled: Control (Highway 301 at the SC/GA State line), Onsite location (Burial Ground North), Site Perimeter locations (Allendale Gate, Barnwell Gate, D Area, Darkhorse @ Williston Gate, East Talatha, Green Pond, Highway 21/167, Jackson, Patterson Mill Road, Talatha Gate), and 25-Mile Radius Locations (Aiken Airport and the Augusta Lock and Dam 614). Samples are collected annually.

Radionuclide	# of Detected Results	Control (Highway 301) Conc. (pCi/g)	Location of Minimum Conc.	Minimum Conc. (pCi/g)	Location of Maximum Conc.	Maximum Conc. (pCi/g)
H-3	3 of 14	3.62E-02	D-Area	-1.54E-02	Burial Ground North	2.24E+00
Cs-137	9 of 14	1.45E-01	Burial Ground North	-1.76E-02	Allendale Gate	5.46E-01
Sr-89/90	14 of 14	1.01E-01	Burial Ground North	7.05E-02	Highway 21/167	6.14E-01
U-234	14 of 14	2.92E-03	Darkhorse @ Williston Gate	1.15E-03	Aiken Airport	1.20E-02
U-238	14 of 14	2.57E-03	Patterson Mill Road	7.86E-04	Jackson	1.22E-02
Am-241	1 of 14	9.14E-05	Aiken Airport	-5.73E-05	Augusta Lock and Dam 614	7.84E-04
Tc-99	14 of 14	2.25E-01	Talatha Gate	1.57E-01	Augusta Lock and Dam 614	9.57E-01
Gross Beta	14 of 14	1.23E+01	Highway 21/167	4.76E+00	Augusta Lock and Dam 614	1.56E+01

Appendix Table D-7 Summary of Radionuclides in Foodstuffs

Samples of five foodstuffs are collected annually from five regions surrounding SRS. Beef, greens, and fruit are collected each year. There are six foodstuffs that are collected on a rotating three-year cycle. Wheat and cabbage were the rotational crop samples collected in 2016.

Units are in pCi/g. Bolded minimum and maximum concentration results were reported as detected. Minimum and maximum concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large.

Food Type	Nuclide	Number of Samples	Number of Results > Detection Limit	Mean Sample Conc.	Minimum Sample Conc.	Maximum Sample Conc.
Beef	Cs-137	5	1	3.51E-03	2.70E-04	1.46E-02
	U-234	5	4	8.99E-05	5.00E-05	1.23E-04
	U-238	5	4	7.94E-05	1.74E-05	1.27E-04
	Gross Beta	5	5	2.55E-00	2.22E+00	2.86E+00
H-3, Co-60, Np-237, Pu-238, Pu-239, Am-241, Cm-244, Sr-89,90, U-235, Tc-99 and gross alpha were not detected in beef						
Greens	Cs-137	5	4	1.40E-02	3.78E-03	2.31E-02
	Sr-89,90	5	5	2.52E-01	1.91E-01	3.27E-01
	U-234	5	4	1.63E-02	4.81E-04	4.57E-02
	U-235	5	1	6.19E-04	-6.92E-05	2.24E-03
	U-238	5	4	1.60E-02	5.68E-04	4.70E-02
	Tc-99	5	4	5.04E-01	1.85E-01	1.02E+00
	Gross Beta	5	5	3.32E+01	2.78E+01	3.81E+01
H-3, Co-60, Np-237, Pu-238, Pu-239, Am-241, Cm-244 and gross alpha were not detected in greens						
Fruit (watermelon)	Gross Beta	5	5	5.30E-01	4.49E-01	6.46E-01
H-3, Cs-137, Co-60, Np-237, Pu-238, Pu-239, Am-241, Cm-244, Sr-89,90, U-234, U-235, U-238, Tc-99 and gross alpha were not detected in fruit						
Wheat	Cs-137	5	1	4.02E-03	1.14E-03	1.02E-02
	U-234	5	5	2.15E-03	1.03E-03	5.68E-03
	U-238	5	5	2.04E-03	7.70E-04	5.68E-03
	Np-237	5	1	3.35E-04	1.96E-04	6.97E-04
	Gross Beta	5	5	4.05E+00	3.86E+00	4.27E+00
H-3, Co-60, Pu-238, Pu-239, Am-241, Cm-244, Sr-89,90, U-235, Tc-99 and gross alpha were not detected in wheat.						

Food Type	Nuclide	Number of Samples	Number of Results > Detection Limit	Mean Sample Conc.	Minimum Sample Conc.	Maximum Sample Conc.
Cabbage	H-3	5	1	3.87E-02	-6.11E-03	1.11E-01
	Cs-137	5	5	2.75E-02	2.15E-02	3.35E-02
	Sr-89,90	5	5	1.41E-01	4.08E-02	2.78E-01
	U-234	5	4	1.75E-02	5.08E-04	9.11E-02
	U-235	5	1	6.59E-01	-1.14E-04	3.00E-03
	U-238	5	5	1.72E-02	-1.32E-04	9.41E-02
	Am-241	5	1	8.61E-05	-1.09E-04	5.95E-04
	Cm-244	5	1	1.15E-04	0.00E+00	3.78E-04
	Tc-99	5	3	1.64E-01	3.35E-02	2.55E-01
	Gross Beta	5	5	2.19E+01	1.51E+01	3.11E+01
Co-60, Np-237, Pu-238, Pu-239 and gross alpha were not detected in cabbage. Uranium series was reanalyzed to confirm this year's elevated, outside of the historical trend, results. The reanalyzed results were comparable with the original results. All results were retained. Thus, there are 10 reported values for U-234, U-235, and U-238 for the 5 cabbage samples. Each sample had at least one of the two results with a detected result.						

Appendix Table D-8 Summary of Radionuclides in Dairy

SRS collects cow's milk samples from dairies located in communities surrounding the Site. The number listed in parentheses after the state in which the dairies are located, indicates the number of dairies that provide samples to SRS from that state.

Bolded minimum and maximum concentration results were reported as detected. Minimum and maximum concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large. All Co-60 results were not detected, thus, not reported in this table.

Location	Nuclide	Number of Samples	Number of Results > Detection Limit	Mean Sample Conc. (pCi/L)	Minimum Sample Conc. (pCi/L)	Maximum Sample Conc. (pCi/L)
SC-Dairies (4)	Cs-137	16	0			
GA-Dairies (4)	Cs-137	16	1	1.42E+00	-3.89E-03	3.92E+00
SC-Dairies (4)	Sr-90	16	1	4.08E-01	-6.27E-01	9.84E-01
GA-Dairies (4)	Sr-90	16	2	1.48E-01	-7.16E-01	1.33E+00
SC-Dairies (4)	H-3	16	1	4.19E+01	-3.65E+02	4.41E+02
GA-Dairies (4)	H-3	16	1	6.08E+01	-1.53E+02	2.92E+02

Appendix Table D-9 Radiation in Liquid Release Sources

All values under the three Areas columns and the “Totals” column are reported in curies.

Tritium is the main contributing radionuclide in Liquid Sources releases. Although the remaining radionuclides are contributors, their contributions in liquid source releases are minimal.

In the facility (Reactor, Separations, SRNL) columns, a blank indicates the radionuclide was not analyzed. A 0.00E+00 in the facility columns indicates the result was not significant.

All Co-60 results were not detected; thus, they were not reported in this table.

Radionuclide	Half-Life	Reactors	Separations ^a	SRNL	Totals
H-3 ^b	12.3 y	2.40E+02	4.28E+02	0.00E+00	6.68E+02
C-14	5700 y		5.82E-04	0.00E+00	5.82E-04
Sr-90	28.8 y	0.00E+00	1.95E-02		1.95E-02
Tc-99	2.11E+05 y		1.88E-02	0.00E+00	1.88E-02
I-129	1.57E+07 y		1.82E-02	0.00E+00	1.82E-02
Cs-137 ^c	30.2 y	0.00E+00	1.78E-02	0.00E+00	1.78E-02
U-234	2.46E+05 y		3.29E-02	3.79E-05	3.29E-02
U-235	7.04E+08 y		1.04E-03	1.20E-06	1.04E-03
U-238	4.47E-09 y		3.68E-02	2.65E-05	3.68E-02
Np-237	2.14E+06 y		2.78E-06		2.78E-06
Pu-238	87.7 y		2.57E-04	2.91E-06	2.60E-04
Pu-239	2.41E+04 y		1.28E-05	8.50E-07	1.37E-05
Am-241	432 y		1.80E-03		1.80E-03
Cm-244	18.1 y		1.54E-04		1.54E-04
Alpha ^d	N/A	2.59E-03	1.35E-03	3.74E-04	4.31E-03
Beta-Gamma ^e	N/A	1.03E-01	4.84E-03	5.76E-04	1.08E-01
				Sum	6.68E+02

Notes:

^a Includes separations, waste management, and tritium processing facilities.

^b The tritium release total, which includes direct + migration releases, is used in the dose calculations for SRS impacts.

^c Depending on which value is higher, the Cs-137 release total is based on concentrations measured in RM 118.8 fish or on the actual measured effluent release total from the Site. Refer to chapter 6 (Dose) for more information.

^{d,e} For dose calculations, unidentified alpha and beta/gamma releases are assumed to be Pu-239 and Sr-90, respectively.

Appendix Table D-10 Summary of Liquid Effluent DOE DCS Sum of Fractions by Facility

Facility (sampling location)	Radionuclides Included in the Sum of Fractions	DCS Sum of Fractions
A Area (TB-2 Outfall at Road 1A)	H-3, C-14, Co-60, I-129, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Tc-99	1.59E-03
F Area (F-013 200-F Cooling Basin)	H-3, Co-60, Sr-89/90, I-129, Cs-137, U-234, U-235, Np-237, U-238, Pu-238, Pu-239, Am-241, Cm-244, Tc-99	4.56E-03
F Area (F-05)	H-3, C-14, Co-60, Sr-89/90, I-129, Cs-137, U-234, U-235, Np-237, U-238, Pu-238, Pu-239, Am-241, Cm-244, Tc-99	5.87E-03
F Area (FM-3 F-Area Effluent)	H-3, C-14, Co-60, Sr-89/90, I-129, Cs-137, U-234, U-235, Np-237, U-238, Pu-238, Pu-239, Am-241, Cm-244, Tc-99	1.96E-03
F-Tank Farm (F-012 281-8F Retention Basin)	H-3, Co-60, Sr-89/90, I-129, Cs-137, U-234, U-235, Np-237, U-238, Pu-238, Pu-239, Am-241, Cm-244, Tc-99	5.64E-03
H Area (FM-1C H-Area Effluent)	H-3, C-14, Co-60, Sr-89/90, Cs-137, U-234, U-235, Np-237, U-238, Pu-238, Pu-239, Am-241, Cm-244	7.85E-03
H Area (H-004)	H-3, Co-60, Sr-89/90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239	8.89E-03
H-ETP (U3R-2A ETP Outfall at Road C)	H-3, C-14, Co-60, Sr-89/90, Cs-137, U-234, U-235, Np-237, U-238, Pu-238, Pu-239, Am-241, Cm-244	4.52E-01
H-Tank Farm (H-017 281-8H Retention Basin)	H-3, Co-60, Sr-89/90, I-129, Cs-137, U-234, U-235, Np-237, U-238, Pu-238, Pu-239, Am-241, Cm-244, Tc-99	2.18E-02
H-Tank Farm (HP-52 H-Area Tank Farm)	H-3, Co-60, Sr-89/90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Am-241, Cm-244	8.31E-04
K Area (K Canal)	H-3, Co-60, Sr-89/90, Cs-137	2.92E-04
L Area (L-07)	H-3, Co-60, Sr-89/90, Cs-137	3.35E-04
S Area (S-004)	H-3, Co-60, Sr-89/90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239	6.53E-03
Tritium (HP-15 Tritium Facility Outfall)	H-3, Co-60, Sr-89/90, Cs-137	6.45E-03

Appendix Table D-11 Summary of Radionuclides in Sediments

Sediment samples are collected annually. SRS collected sediment samples at 8 Savannah River locations and 27 onsite streams, basins, ponds, or swamp discharge locations. This table presents a summary for the analytes detected for the sediment samples collected at the 35 locations categorized as river, stream or stormwater basin. Each table includes the respective control location concentration, whether detected or not, as well as the maximum value of the river, stream, and stormwater basin samples. Bolded concentration results were reported as detected. Concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large. All results for Co-60 were not detectable. Np-237 was not detected in any river samples, but was detected in stream and stormwater basin samples. Radionuclides not detected in a type of waterbody (river, stream, or stormwater basin) are not reported in that table.

The following locations are the sampling locations: Controls (River Mile 160.5 and Upper Three Runs Creek (U3R)-1A Treadway Bridge RD 8-1), Savannah River Locations (River Miles 118.7, 129, 134.0, 150.2, 151, 152.1, and 157.2), SRS Storm Basin locations (E-005, E-006, E-004, -003, POND 400, E-002, E-001, and Z Basin), and SRS Stream locations (FM-2 at Road 4, FM-3A Below F-Area Effluent, Four Mile A-7A (Beaver Pond), Four Mile Creek Swamp Discharge, Four Mile Creek at Road A-7, L3R-1A at Road B, L3R-2 Sediment, McQueens Branch (MCQBR) at Monroe Road, MCQBR downstream of Z-Basin, Pen Branch Swamp Discharge, SC-2A 1 mile above Road B, SC-4 Steel Creek at Road A, TB-5 Near Road C, Tinker Creek 1, U3R-4 Sediment, RM 150.4 Sediment, River Mile 160.0 Sediment, and R-Area Sediment.

The streams and stormwater basins have the same control location, U3R-1A Treadway Bridge RD 8-1.

River Sediment Results			
Radionuclide	Control Conc. (pCi/g)	Location of Maximum Result	Maximum Conc. (pCi/g)
Cs-137	3.73E-02	RM-150.2 Below Four Mile Creek	6.95E-01
Sr-89/90	1.41E-01	RM-134.0 Below Little Hell Landing	1.62E-01
U-234	1.84E+00	RM-150.2 Below Four Mile Creek	2.09E+00
U-235	9.14E-02	RM-150.2 Below Four Mile Creek	9.49E-02
U-238	1.76E+00	RM-150.2 Below Four Mile Creek	1.88E+00
Pu-238	2.31E-04	RM-150.2 Below Four Mile Creek	2.78E-03
Pu-239	0.00E-00	RM-157.2 Upper 3 Runs Mouth	4.46E-03
Am-241	4.32E-03	RM-160.5 Demier Landing	4.32E-03
Cm-244	8.03E-04	RM-150.2 Below Four Mile Creek	2.29E-03
Gross B	2.02E+01	RM-151 R-3A Above Vogtle	2.37E+01
Gross A	7.49E+00	RM-157.2 Upper 3 Runs Mouth	1.78E+01

Stream Sediment Results			
Radionuclide	Control Conc. (pCi/g)	Location of Maximum Result	Maximum Conc. (pCi/g)
Cs-137	1.45E-01	Z Basin	2.92E+03
Sr-89/90	7.51E-02	Four Mile A-7A (Beaver Pond)	8.65E-01
U-234	1.84E+00	TB-5 Near Road C	6.30E+00
U-235	1.14E-01	TB-5 Near Road C	2.76E-01
Np-237	0.00E+00	Z Basin	2.80E-02
U-238	2.03E+00	TB-5 Near Road C	6.38E+00
Pu-238	1.02E-03	FM-2 at Road 4	9.97E-01
Pu-239	9.62E-03	Four Mile A-7A (Beaver Pond)	2.84E-01
Am-241	3.22E-03	Four Mile A-7A (Beaver Pond)	2.67E-01
Cm-244	0.00E+00	Four Mile A-7A (Beaver Pond)	2.18E-01
Gross B	4.86E+01	Z Basin	2.51E+03
Gross A	5.62E+01	U3R-1A Treadway Bridge RD 8-1	5.62E+01

Stormwater Basin Sediment Results			
Radionuclide	Control Conc. (pCi/g)	Location of Maximum Result	Maximum Conc. (pCi/g)
Cs-137	1.45E-01	POND 400	3.76E-01
Sr-89/90	7.51E-02	E-06	2.49E-01
U-234	1.84E+00	POND 400	2.11E+00
U-235*	1.14E-01	U3R-1A Treadway Bridge RD 8-1	1.14E-01
Np-237	0.00E+00	SWDF Basin South (E-001)	3.54E-03
U-238	2.03E+00	EAV Basin North (E-004)	2.07E+00
Pu-238	1.02E-03	SWDF Basin South (E-001)	3.05E-01
Pu-239	9.62E-03	POND 400	2.73E-01
Am-241	3.22E-03	EAV Basin South (E-003)	7.59E-02
Cm-244	0.00E+00	SWDF Basin South (E-001)	5.92E-03
Gross B*	4.86E+01	U3R-1A Treadway Bridge RD 8-1	4.86E+01
Gross A*	5.62E+01	U3R-1A Treadway Bridge RD 8-1	5.62E+01

Note:

* The control location, a Site stream (U3R-1A Treadway Bridge RD 8-1), is the maximum result.

Appendix Table D-12 Summary of Radionuclides in Drinking Water

Units are in pCi/L. Bolded minimum and maximum concentration results were reported as detected. Minimum and maximum concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large.

Samples at the Treatment Plants are collected monthly. These samples are analyzed for tritium, Co-60, Cs-137, gross alpha and gross beta. For the Treatment Plants samples, all results for Co-60 and Cs-137 were below detection limits; and thus, not presented in the table below. One onsite location is collected quarterly. All other onsite locations are collected annually. For the annual and quarterly samples, all results for tritium, Co-60, Cs-137, Sr-89/90, U-235, Pu-238, Pu-239 and Cm-244 were below detection limits; and thus, not presented in the table below. The treatment plant samples are analyzed for tritium, Co-60, Cs-137, gross alpha and gross beta.

Treatment Plants—Finished Water Summary

Nuclides		Tritium		
Locations	Number of Samples	Mean Conc.	Minimum Conc.	Maximum Conc.
BJWSA Purrysburg WTP	12	2.14E+02	9.35E+01	3.41E+02
N. Augusta Public Water Works	12	6.98E+01	5.46E-04	1.76E+02

Nuclides		Gross Beta			Gross Alpha		
Locations	Number of Samples	Mean Conc.	Minimum Conc.	Maximum Conc.	Mean Conc.	Minimum Conc.	Maximum Conc.
BJWSA Purrysburg WTP	12	1.62E+00	7.35E-01	2.25E+00	5.15E-02	-7.78E-02	2.27E-01
N. Augusta Public Water Works	12	1.85E+00	1.55E+00	2.33E+00	9.24E-02	-6.30E-02	2.78E-01

Onsite Location Summary—Quarterly Samples

Nuclides		Gross Beta			Gross Alpha		
Location	Number of Samples	Mean Conc.	Minimum Conc.	Maximum Conc.	Mean Conc.	Minimum Conc.	Maximum Conc.
782-3A quarterly	4	1.84E+00	7.03E-01	2.56E+00	1.93E+00	5.70E-01	2.86E+00

Onsite Location Summary—Annual Samples

	Nuclides	U-234	U-238	Am-241	Gross Beta	Gross Alpha
Location	Number of Samples	Conc.	Conc.	Conc.	Conc.	Conc.
617-G	1	2.30E-02	1.53E-02	1.77E-03	1.29E+00	5.38E-01
681-3G Dom. Water Faucet	1	4.95E-03	1.32E-02	2.45E-03	2.62E+00	1.32E+00
704-16G	1	1.28E-02	1.97E-02	8.30E-03	1.70E+00	2.09E+00
709-1G	1	2.78E-02	3.38E-02	4.00E-03	9.51E-01	1.50E-01
737-G	1	5.54E-03	1.54E-02	8.16E-03	1.36E+00	1.51E-01
782-3A (annual)	1	3.76E-02	5.46E-02	4.22E-03	Quarterly, See above	Quarterly, see above
905-112G Well	1	2.73E-02	5.22E-02	3.59E-03	1.45E+00	6.49E-01
905-113G Well	1	4.86E-02	2.95E-02	1.05E-02	1.55E+00	1.00E+00
905-125B	1	5.30E-02	8.73E-02	5.78E-03	1.76E+00	1.62E+00
905-67B	1	2.43E-02	2.60E-02	4.05E-03	7.97E-01	1.14E+00

Appendix Table D-13 Summary of Radionuclides in Freshwater Fish

Units are in pCi/g. Bolded minimum and maximum concentration results were reported as detected. Minimum and maximum concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large. All Co-60, I-129, and gross alpha results were nonsignificant and thus, not reported in this table.

The analyte mean is set to zero if all composite values per fish species at a single location are less than the MDL or the uncertainty is large. Three composite samples were analyzed for each fish type from each location.

Tritium (H-3) (Edible)									
	Bass			Catfish			Panfish		
Location	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.
Augusta L&D	0.00E+00	2.22E-02	4.46E-02	0.00E+00	5.00E-03	1.65E-02	0.00E+00	4.08E-02	5.19E-02
Upper Three Runs Creek River Mouth	0.00E+00	-4.00E-03	2.24E-02	7.16E-02	4.68E-02	1.09E-01	9.30E-02	5.11E-03	1.57E-01
Four Mile Creek River Mouth	2.44E-01	7.81E-02	5.49E-01	0.00E+00	6.65E-02	7.84E-02	1.31E-01	5.57E-02	2.66E-01
Steel Creek River Mouth	1.90E-01	6.62E-02	3.76E-01	1.12E-01	1.67E-02	2.08E-01	4.94E-02	1.04E-02	7.68E-02
Lower Three Runs Creek River Mouth	1.43E-01	1.40E-01	1.45E-01	4.70E-02	2.31E-02	8.11E-02	7.59E-02	2.54E-02	1.16E-01
Hwy 301 Bridge Area	9.72E-02	8.30E-02	1.09E-01	0.00E+00	-1.69E-02	4.51E-02	0.00E+00	2.15E-02	5.86E-02

Cs-137 (Edible)									
	Bass			Catfish			Panfish		
Location	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.
Augusta L&D	5.19E-02	2.06E-02	1.11E-01	2.51E-02	1.16E-02	4.00E-02	1.93E-02	8.86E-03	3.59E-02
Upper Three Runs Creek River Mouth	1.20E-01	3.84E-02	2.19E-01	2.93E-02	2.06E-02	3.97E-02	1.72E-02	1.03E-02	3.05E-02
Four Mile Creek River Mouth	1.57E-01	9.78E-02	2.69E-01	5.20E-02	2.86E-02	8.27E-02	1.08E-01	5.03E-02	2.12E-01
Steel Creek River Mouth	1.15E-01	9.76E-02	1.40E-01	7.25E-02	5.76E-02	9.32E-02	5.81E-02	3.11E-02	9.54E-02
Lower Three Runs Creek River Mouth	1.43E-01	4.08E-02	2.86E-01	1.14E-01	8.43E-02	1.45E-01	1.78E-01	3.89E-02	4.14E-01
Hwy 301 Bridge Area	3.77E-02	3.03E-02	4.24E-02	2.48E-02	1.72E-02	3.03E-02	1.26E-02	1.08E-02	1.52E-02

Sr-89/90 (Edible)									
	Bass			Catfish			Panfish		
Location	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.
Augusta L&D	0.00E+00	6.73E-04	9.03E-04	0.00E+00	1.29E-03	2.70E-03	6.51E-03	2.52E-03	9.76E-03
Upper Three Runs Creek River Mouth	2.07E-03	7.95E-04	3.35E-03	0.00E+00	-3.11E-04	1.82E-03	0.00E+00	1.45E-03	3.32E-03
Four Mile Creek River Mouth	6.78E-03	4.59E-03	9.22E-03	2.34E-03	-7.62E-04	5.54E-03	5.33E-03	3.41E-03	8.57E-03
Steel Creek River Mouth	0.00E+00	9.08E-04	2.21E-03	1.80E-03	-1.46E-04	3.92E-03	0.00E+00	7.86E-04	4.49E-03
Lower Three Runs Creek River Mouth	2.58E-03	4.00E-04	4.11E-03	2.10E-03	1.39E-03	3.27E-03	0.00E+00	9.00E-04	1.97E-03
Hwy 301 Bridge Area	1.83E-03	3.81E-04	4.19E-03	0.00E+00	1.15E-03	1.88E-03	0.00E+00	1.42E-03	5.00E-03

Sr-89/90 (Nonedible)									
	Bass			Catfish			Panfish		
Location	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.
Augusta L&D	7.58E-01	6.35E-01	9.22E-01	7.41E-01	7.05E-01	7.84E-01	8.25E-01	6.97E-01	8.97E-01
Upper Three Runs Creek River Mouth	7.30E-01	5.70E-01	9.05E-01	7.36E-01	6.05E-01	8.81E-01	8.55E-01	6.22E-01	1.15E+00
Four Mile Creek River Mouth	2.28E+00	9.22E-01	4.57E+00	1.01E+00	7.84E-01	1.32E+00	1.65E+00	1.26E+00	1.93E+00
Steel Creek River Mouth	6.43E-01	4.32E-01	7.73E-01	6.21E-01	4.70E-01	8.59E-01	9.72E-01	7.92E-01	1.20E+00
Lower Three Runs Creek River Mouth	6.34E-01	4.65E-01	8.24E-01	8.77E-01	6.41E-01	1.15E+00	7.86E-01	6.81E-01	9.00E-01
Hwy 301 Bridge Area	6.73E-01	6.03E-01	7.08E-01	6.25E-01	4.68E-01	7.30E-01	7.30E-01	6.73E-01	8.41E-01

Tc-99 (Edible)									
	Bass			Catfish			Panfish		
Location	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.
Augusta L&D	4.52E-02	1.78E-02	8.22E-02	0.00E+00	3.08E-02	5.51E-02	0.00E+00	2.00E-02	4.89E-02
Upper Three Runs Creek River Mouth	0.00E+00	-9.73E-03	5.46E-02	5.86E-02	4.97E-02	7.65E-02	0.00E+00	4.24E-02	6.92E-02
Four Mile Creek River Mouth	9.80E-02	7.57E-02	1.26E-01	7.08E-02	5.05E-02	1.09E-01	6.60E-02	3.73E-02	9.59E-02
Steel Creek River Mouth	0.00E+00	2.56E-02	6.19E-02	0.00E+00	-1.07E-02	6.19E-02	0.00E+00	6.86E-03	2.81E-02
Lower Three Runs Creek River Mouth	0.00E+00	1.15E-02	2.97E-02	0.00E+00	3.27E-03	5.32E-02	0.00E+00	3.14E-02	6.00E-02
Hwy 301 Bridge Area	0.00E+00	1.12E-02	5.97E-02	0.00E+00	7.70E-03	4.22E-02	0.00E+00	2.14E-02	3.57E-02

Gross Beta (Edible)									
	Bass			Catfish			Panfish		
Location	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.
Augusta L&D	2.80E+00	2.62E+00	3.00E+00	2.95E+00	2.81E+00	3.16E+00	1.78E+00	1.45E+00	2.02E+00
Upper Three Runs Creek River Mouth	2.92E+00	2.46E+00	3.35E+00	2.96E+00	2.64E+00	3.22E+00	2.50E+00	2.31E+00	2.67E+00
Four Mile Creek River Mouth	2.74E+00	2.62E+00	2.89E+00	3.25E+00	3.03E+00	3.57E+00	2.46E+00	2.35E+00	2.61E+00
Steel Creek River Mouth	2.53E+00	2.32E+00	2.78E+00	2.65E+00	2.55E+00	2.76E+00	2.04E+00	1.85E+00	2.31E+00
Lower Three Runs Creek River Mouth	2.67E+00	2.44E+00	3.14E+00	2.89E+00	2.67E+00	3.19E+00	2.27E+00	1.94E+00	2.78E+00
Hwy 301 Bridge Area	2.50E+00	2.31E+00	2.76E+00	2.84E+00	2.78E+00	2.89E+00	2.28E+00	1.82E+00	2.62E+00

Appendix Table D-14 Summary of Radionuclides in Saltwater Fish

Bolded minimum and maximum concentration results were reported as detected. Minimum and maximum concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large. Results of all samples for Co-60, Cs-137, Tc-99, I-129, Sr-89/90 (in flesh), and gross alpha were below method detection limits.

All saltwater fish are collected at the location designated as River Miles 0–8 (mouth of Savannah River).

Analyte	Marine Mullet				Red Drum			
	Number of Samples	Mean (pCi/g)	Minimum (pCi/g)	Maximum (pCi/g)	Number of Samples	Mean (pCi/g)	Minimum (pCi/g)	Maximum (pCi/g)
H-3	3	0.00E+00	-7.22E-03	2.11E-02	3	0.00E+00	2.37E-02	4.76E-02
Sr-89/90 Nonedible	3	2.82E-01	2.41E-01	3.11E-01	3	0.00E+00	-8.68E-02	2.44E-01
Gross Beta	3	2.47E+00	2.35E+00	2.53E+00	3	1.56E+00	1.23E+00	1.76E+00

Analyte	Sea Trout			
	Number of Samples	Mean (pCi/g)	Minimum (pCi/g)	Maximum (pCi/g)
H-3	2	5.52E-02	3.62E-02	7.41E-02
Sr-89/90 Nonedible	2	0.00E+00	1.26E-01	2.19E-01
Gross Beta	2	1.76E+00	1.74E+00	1.78E+00

Appendix Table D-15 Summary of Radionuclides in Shellfish

Bolded minimum and maximum concentration results were reported as detected. Minimum and maximum concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large. All Co-60, Cs-137, I-129, and Tc-99 results were not detected; thus, not reported in this table.

All shellfish are collected at the location designated as River Miles 0-8 (at the mouth of Savannah River).

The species of shellfish collected in 2016 were shrimp and crab. Insufficient volume of shrimp was collected to perform the Tc-99 analyses. Thus, only the crab sample was analyzed for Tc-99.

Nuclide	Number of Samples	Number of Results > Detection Limit	Mean Concentration (pCi/g)	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)
Sr-89/90	2	1	5.66E-03	3.32E-03	8.00E-03
Gross B	2	2	8.34E-01	4.38E-01	1.23E+00
Gross A	2	1	3.10E-01	1.43E-01	4.76E-01

Appendix Table D-16 Summary of Radionuclides in Wildlife

Bolded concentration results were reported as detected. Concentrations not bolded indicate the result was less than the analytical method detection limit or the uncertainty is large. All Co-60 results were below detection limits, and thus are not reported in this table.

Sample Type	Nuclide	Number of Samples	Number of Results > Detection Limit	Mean Sample Conc. (pCi/g)	Minimum Sample Conc. (pCi/g)	Maximum Sample Conc. (pCi/g)
Deer Flesh: Regular Hunts	Cs-137	42	42	2.64E+00	4.59E-01	1.18E+01
Deer Flesh: Roadside Removal	Cs-137	75	75	1.21E+00	1.31E-01	7.20E+00
Hog Flesh	Cs-137	3	3	7.78E-01	3.03E-01	1.14E+00
Deer Flesh: Regular Hunts	Sr-89/90	42	4	2.44E-03	-1.40E-03	1.09E-02
Hog Flesh	Sr-89/90	3	0	3.22E-03	2.89E-03	3.57E-03
Deer Bone: Regular Hunts	Sr-89/90	42	42	3.83E+00	1.93E+00	6.73E+00
Hog Bone	Sr-89/90	3	3	2.08E+00	1.62E+00	2.50E+00

Appendix Table E-1 Summary of Documents that Report Groundwater Monitoring Data

Document Title	Submittal Frequency
Data Report for the C-Area Groundwater (CAGW) Operable Unit	Annual
K-Area Burning/Rubble Pit (131-K) and Rubble Pile (631-20G) (KBRP), L-Area Burning/Rubble Pit (131-L), Gas Cylinder Disposal Facility (131-2L) and L-Area Rubble Pile (131-3L) (LBRP), and P-Area Burning/Rubble Pit (131-P) (PBRP) Operable Units Combined Groundwater Monitoring Report Sampling Summary	Annual
Annual Comprehensive TNX Area Groundwater Monitoring and Remedial Action Effectiveness Interim Report	Annual
R-Area Groundwater Effectiveness Monitoring Report in Support of R-Area Operable Unit	Annual
2016 Effectiveness Monitoring Report (EMR) for Monitored Natural Attenuation (MNA) at the L-Area Southern Groundwater (LASG) Operable Unit	Biennial
Five-Year Remedy Review Report for Savannah River Site Operable Units	Phased - Annual
D-Area Groundwater Operable Unit	Annual
Groundwater Mixing Zone Report for the D-Area Oil Seepage Basin	Annual
Groundwater Mixing Zone Sampling Summary Report for the R-Reactor Seepage Basin, 108-4R Overflow Basin Operable Unit	Biannual
488-4D Class Two Landfill Midyear Groundwater Monitoring Report	Biannual
632-G C&D Class Two Landfill Groundwater Monitoring Report	Biannual
N-Area Heating Oil (NHO) Plume Groundwater Monitoring Report	Annual
Z-Area Saltstone Disposal Facility Groundwater Monitoring Report	Biannual
288-F Class Two Landfill Annual Groundwater Monitoring Report	Biannual
Interim Sanitary Landfill (Class Three) Annual Groundwater Monitoring Report	Biannual
Annual M-Area and Metallurgical Laboratory Hazardous Waste Management Facilities Groundwater Monitoring and Corrective Action Report	Annual
Annual Corrective Action Report for the F-Area Hazardous Waste Management Facility, the H-Area Hazardous Waste Management Facility, and the Mixed Waste Management Facility	Annual
Performance Evaluation Report for the M-Area Inactive Process Sewer Lines (MIPSL) (081-M) Operable Unit	Annual
Performance Evaluation Report for the A-Area Burning/Rubble Pit (731-A, 731-1A) and Rubble Pit (731-2A) and the Miscellaneous Chemical Basin/Metals Burning Pit (731-4A, 731-5A) Operable Unit	Annual
Effectiveness Monitoring Report (EMR) for the Monitored Natural Attenuation (MNA) at the Chemicals, Metals, and Pesticides (CMP) Pits Operable Unit	Annual
Biennial Effectiveness Monitoring Report (EMR) for Monitored Natural Attenuation (MNA) at the C-Area Burning/Rubble Pit (131-C) and Old C-Area Burning/Rubble Pit (NBN) Operable Unit	Biennial

Document Title	Submittal Frequency
Scoping Summary for the General Separations Area Eastern Groundwater Operable Unit	Annual
Scoping Summary for the General Separations Area Western Groundwater Operable Unit	Annual
Performance Evaluation Report for the A-Area Miscellaneous Rubble Pile (731-6A) Operable Unit	Annual
SRS Annual Environmental Report	Not applicable ^a

Note:

^a The SRS Annual Environmental Report is not submitted to the regulatory agencies as a regulatory requirement. The report is a publicly available document. The Annual Environmental Report summarizes information on offsite wells and onsite wells that are not included in regulatory submittals.

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.

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—Existing in the surrounding area. Completely enveloping.

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.

Area Completion Project—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.

Atomic Energy Agency—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.

audit—A systematic evaluation to determine the conformance to quantitative specifications of some operational function or activity.

B

Background control location—A sampling point that is not impacted by SRS operations.

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.

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.

Biobased products—Products derived from plants and other renewable agricultural, marine, and forestry materials that provide an alternative to conventional petroleum-derived products.

Biopreferred® —A program the U.S. Department of Agriculture (USDA) manages to increase the purchase and use of biobased products. The program's purpose is to spur economic development, create new jobs and provide new markets for farm commodities. For more information, please see the [USDA website](#).

biota—Plant and animal life.

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.

canyon—Two facilities located at SRS where nuclear materials are chemically recovered and purified. They are called “canyons” because of their similarity to how a canyon looks, open space with high wall-like mountains on either side of a valley.

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.

categorical exclusion—Categories of actions that do not individually or cumulatively have a significant effect on the human environment and for which, therefore, neither an environmental assessment nor an environmental impact statement is required.

Central Savannah River Area—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.

chlorocarbons—Compounds of carbon and chlorine, or carbon, hydrogen, and chlorine, such as carbon tetrachloride, chloroform, tetrachloroethylene, etc. They are among the most significant and widespread

environmental contaminants. Classified as hazardous wastes, chlorocarbons may have a tendency to cause detrimental effects, such as birth defects.

cleanup—Actions taken to deal with release or potential release of hazardous substances. This may mean complete removal of the substance; it also may mean stabilizing, containing, or otherwise treating the substance so that it does not affect human health or the environment.

closure—Control of a hazardous waste management facility under Resource Conservation and Recovery Act requirements.

compliance—Fulfillment of applicable requirements of a plan or schedule ordered or approved by government authority.

composite—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”).

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 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.

contaminant pathway—The way contaminants move and settle in the environment after release from operating facilities to the air and water.

continuous assessment—Evaluation of a program or employee carried out on a fixed interval (e.g. weekly, monthly, annually)

control chart—A graph of some measurement plotted over time or sequence of sampling, together with control limit(s) and, usually, a central line and warning limit(s). Control charts provide a graphical representation of accuracy and precision, a long-term mechanism for self-evaluation of analytical data, and an assessment of analytical capability of the laboratory analyst.

control standard—A standard prepared independently of and run with the calibration. It is used to verify the accuracy of the calibration.

cool roof—A thick white rubber-type roof that lowers the temperature of standard roofs from about 150 degrees Fahrenheit to 100 degrees or less.

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 dioxide, nitrogen

oxides, and lead. The Environmental Protection Agency 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 (μ Ci)**— 10^{-6} Ci, one-millionth of a curie; 3.7×10^4 disintegrations per second.
- **picocurie (pCi)**— 10^{-12} Ci, one-trillionth of a curie; 0.037 disintegrations per second.

D

DCS sum of fractions—The sum of the ratios of the average concentration of each radionuclide to its corresponding DCS value. (See below for definition of DCS-derived concentration standard.)

decay (radioactive)—Spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide, or into a different energy state of the same radionuclide.

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 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.

derived concentration standard (DCS)—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). The guides for radionuclides in air and water are given in U.S. Department of Energy Derived Concentration Technical Standard (DOE-STD-1196-2011) (DOE 2011).

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.

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.

DOECAP—A comprehensive audit program for contract laboratories with the intent of conducting consolidated audits to eliminate redundant audits previously conducted independently by DOE field element sites and to achieve standardization in audit methodology, processes, and procedures.

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).
- **equivalent dose**—Product of the absorbed dose (rad) in tissue and a radiation weighting factor. Equivalent dose is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).
- **effective dose**—Sum of the dose equivalents received by all organs or tissues of the body after each one has been multiplied by an appropriate tissue weighting factor.
- **committed effective dose**—Is the effective dose integrated over time, usually 50-years. Committed effective dose is expressed in units of rem (or sievert).
- **collective dose**—Sum of the effective dose of all individuals in an exposed population within a 50-mile (80-km) radius, and expressed in units of person-rem (or person-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.

drinking water standards—Federal primary drinking water standards, both proposed and final, as set forth by the 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—A release of treated or untreated water or air from a pipe or a stack to the environment. Liquid effluent flows into a body of water such as a stream or lake. Airborne effluent (also called emission) discharges into the atmosphere.

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 to members of the public, and demonstrating compliance with applicable standards.

emission—A release of a gas.

ENERGY STAR®—A U.S. Environmental Protection Agency program that helps businesses and individuals save money and protect the climate through energy efficiency. For more information, please visit the [ENERGY STAR website](#).

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 the 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 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.

EPEAT—A product database that registers products based on the devices' ability to meet various criteria developed and agreed upon by diverse stakeholders to address the full lifecycle of an electronic product. This system ensures all products listed in the EPEAT database truly represent environmental leadership. For more information, please visit the [EPEAT website](#).

exception (formerly "exceedance")—Term used by the Environmental Protection Agency and the South Carolina Department of Health and Environmental Control that denotes a report value is more than the 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.

exclusion or exclusion device—Material or equipment used for wildlife control. These devices may be used to deter animal use of an area, to provide a method of collecting animals, or to provide a means of exit for an animal.

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—The way that a person could be impacted from releases of radionuclides into the water and air.

F

fallout—The settling to the ground of airborne particles ejected into the atmosphere from the earth by explosions, eruptions, forest fires, etc. or from human production activities such as found at nuclear facilities.

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 duplicate—An independent sample collected as closely as possible to the same point in space and time as the original sample. The duplicate and original are two separate samples taken from the same source, stored in separate containers, and analyzed independently.

fiscal year—An established period of time when an organization's annual financial records start and end. In the federal government, this period is from October 1 to September 30.

G

global fallout—Radioactive debris from atmospheric weapons tests that has been deposited on the earth's surface after being airborne and cycling around the earth.

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).

gross alpha and beta releases—The total alpha-emitting and beta-emitting activity determined at each effluent location.

ground shine—Exposure to gamma radiation produced by radioactive materials on the ground surface is called ground shine and it contributes to external dose.

groundwater—Water found underground in cracks and spaces in soil, sand, and rocks.

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.

hazardous waste—Any waste that is a toxic, corrosive, reactive, or ignitable material that could affect human health or the environment.

I

International Organization for Standardization (ISO)—Creates documents that provide requirements, specifications, guidelines, or characteristics that can be used consistently to ensure that materials, products, processes, and services are compatible with their purpose. For more information, please visit the [ISO website](#).

Intralaboratory checks—Compare performance within a laboratory by analyzing duplicate and blind samples throughout the year.

isotope—Each of two or more forms of the same element that contain equal numbers of protons but different numbers of neutrons in their nuclei, and hence differ in relative atomic mass but not in chemical properties; in particular, a radioactive form of an element.

L

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

low-level waste—Waste that includes protective clothing, tools, and equipment that have become contaminated with small amounts of radioactive material.

lower limit of detection—Smallest concentration/amount of an analyte that can be reliably detected in a sample at a 95% confidence level.

M

manmade radiation—Radiation from sources such as consumer products, medical procedures, and nuclear industry.

MAPEP—A laboratory comparison program that tracks performance accuracy and tests the quality of environmental data reported to DOE.

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.

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 non-beneficial element. Human poisoning due to this highly toxic element has been clinically recognized.

migration—Transfer or movement of a material through the soil or groundwater.

minimum detectable concentration (radionuclides)—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.

minimum detectable concentration (chemicals)—Smallest amount or concentration of a chemical that can be distinguished in a sample by a given measurement system at a given confidence level.

mixed waste—Waste that has both hazardous and radioactive components.

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

organic—Of, relating to, or derived from living organisms (plant or animal).

outfall—Place where treated or untreated water flows out of a pipe to mix with water from a water body, such as a stream or lake.

P

parameter—Analytical constituent; chemical compound(s) or property for which an analytical request may be submitted.

passive device—A device that does not require a source of energy for its operation.

PCB bulk product waste—Waste derived from products manufactured to contain PCBs in a non-liquid state at 50 ppm or greater. Typical examples are caulk, paint, and sealants.

performance evaluation (PE) sample—A sample, the composition of which is unknown to the analyst, that is provided to test whether the analyst/laboratory can produce analytical results within specified performance limits.

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 water originating at a waste source (e.g., a hazardous waste disposal site). It extends downward and outward from the waste source.

plume shine—Exposure to gamma radiation from airborne radioactive materials is called plume shine (sometimes called cloud shine or sky shine) and it contributes to external dose.

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.

practical quantitation—The lowest level a laboratory can quantify with 99% confidence.

precision—A estimate of the degree to which a set of observations or measurements of the property, usually obtained under similar conditions agree. It is a data quality indicator.

priority I finding—Documents a deficiency that is of sufficient magnitude to potentially render the audited facility unacceptable to provide the affected service to DOE.

priority II finding—Documents a deficiency that is not of sufficient magnitude to render the audited facility unacceptable to provide services to DOE.

process sewer—Pipe or drain, generally located underground, used to carry off either process water or waste matter, or both.

proficiency testing—An evaluation of a laboratory's performance against pre-established criteria by means of inter-laboratory comparison. It is also known as comparative testing.

purge—To remove water prior to sampling, generally by pumping or bailing.

Q

quality assurance (QA)—An integrated system of management activities involving planning, implementation, documentation, assessment, reporting, and quality improvement to ensure quality in the processes by which products are developed.

quality control (QC)—A set of activities for ensuring quality in products by identifying defects in the actual products.

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.

reference person—A hypothetical age and gender averaged individual that is a combination of human (male and female) physical and physiological characteristics arrived at by international consensus for the purpose of standardizing radiation dose calculations.

RCRA/CERCLA Units—Units subject to the remedial action process established in the Federal Facilities Agreement.

Regional Screening Level (RSL)—The risk-based concentration derived from standardized equations combining exposure assumptions with toxicity data.

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 times 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 sites contaminated with waste due to historical activities.

representative person—A hypothetical individual receiving a dose that is representative of the more highly exposed individuals in the population.

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.

retention basin—Unlined basin used for emergency, temporary storage of potentially contaminated cooling water from chemical separations activities.

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 an analyte.

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.

significant analytical result—Indicates that the result is statistically significant or is at or above the detection limit of the applicable radioanalytical method, or both.

Silvex— A herbicide and a plant growth regulator. It has been banned for use as a herbicide in the United States since 1985.

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 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.

splits or split sample—Two or more representative portions taken from a single sample and analyzed by different analysts or laboratories. Split samples are used to replicate the measurement of the parameters of interest.

SRS Community Reuse Organization (SRSCRO)—A nonprofit organization charged with developing and implementing strategy to diversify the economy in the five South Carolina and Georgia counties surrounding the Site. For more information, please see the [SRSCRO website](#).

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.

statistical data evaluation—A collection of methods used to process large amounts of data and report overall trends.

stormwater runoff—Surface streams that appear after precipitation.

Superfund—See Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

surface water—Water that has not penetrated below the surface of the ground.

T

tank farm—Interconnected underground tanks used for storage of high-level radioactive liquid wastes.

temperature—Thermal state of a body, considered with its ability to communicate heat to other bodies.

terrestrial—Living on or growing from the land.

thermoluminescent dosimeter (TLD)—A passive device that measures the exposure from ionizing 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.

translocation—The deliberate movement of organisms from one site for release in another. It must be intended to yield a measurable conservation benefit at the levels of a population, species or ecosystem, and not only provide benefit to translocated individuals.

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.

tritium—Elemental form of the radioactive isotope of hydrogen and occurs as a gas.

tritium oxide—Water in which the tritium isotope has replaced a hydrogen atom. Stack releases of tritium oxide typically occur as water vapor.

turbidity—Measure of the concentration of sediment or suspended particles in solution.

U

unidentified alpha and beta releases—The unspecified alpha and beta releases that are conservatively 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. Unidentified alpha and beta releases also include naturally occurring radionuclides, such as uranium, thorium, radon progeny, and potassium-40.

utility water—Once-through non-contact cooling water, recirculated non-contact cooling water, boiler blowdown, steam condensate, air conditioning condensate, and other uncontaminated heating, ventilation and air conditioning or compressor condensates.

V

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 DOE facilities.

waste unit—A particular area that is or may be posing a threat to human health or the environment. Waste units range in size from a few square feet to tens of acres and include basins, pits, piles, burial grounds, landfills, tank farms, disposal facilities, process facilities, and groundwater contamination.

waste stream—Waste material generated from a single process or from an activity that is similar in material, physical form, isotopic makeup and hazardous constituents.

WaterSense®—A U.S. Environmental Protection Agency partnership that offers ways to increase water efficiency through products and services. For more information, please visit the [U.S. EPA website](#).

water table—Planar, underground surface beneath which earth materials, such as soil or rock, are saturated with water.

Waters of the State—Surface or underground water within the jurisdiction of the state, as defined in the South Carolina Pollution Control Act.

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, swamp, bog, Carolina bay, floodplain bottom, where land is covered by shallow water at least part of the year and is characterized by somewhat mucky soil.

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Appendix G References

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Appendix H

Units of Measure

Symbol	Name	Symbol	Name
Temperature		Concentration	
°C	degrees Celsius	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	Conductivity	
Length		µmho	micromho
cm	centimeter	Radioactivity	
ft	foot	Ci	curie
in	inch	cpm	counts per minute
km	kilometer	mCi	millicurie
m	meter	µCi	microcurie
mm	millimeter	pCi	picocurie
µm	micrometer	Bq	becquerel
Mass		Radiation Dose	
g	gram	mrad	millirad
kg	kilogram	mrem	millirem
mg	milligram	Sv	sievert
µg	microgram	mSv	millisievert
Area		µSv	microsievert
mi ²	square mile	R	roentgen
ft ²	square foot	mR	milliroentgen
Volume		µR	microroentgen
gal	gallon	Gy	gray
L	liter		
mL	milliliter		

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	<i>Système International</i>	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-US	0.945	L	L	1.057	liq qt-US
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}	μ Ci	μ Ci	10^6	pCi
pCi/L (water)	10^{-9}	μ Ci/mL (water)	μ Ci/mL (water)	10^9	pCi/L (water)
pCi/m ³ (air)	10^{-12}	μ Ci/mL (air)	μ Ci/mL (air)	10^{12}	pCi/m ³ (air)



SAVANNAH RIVER SITE

Savannah River Nuclear Solutions, LLC – Aiken, South Carolina