Chapter 7 Groundwater Management Program

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/Steed 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).

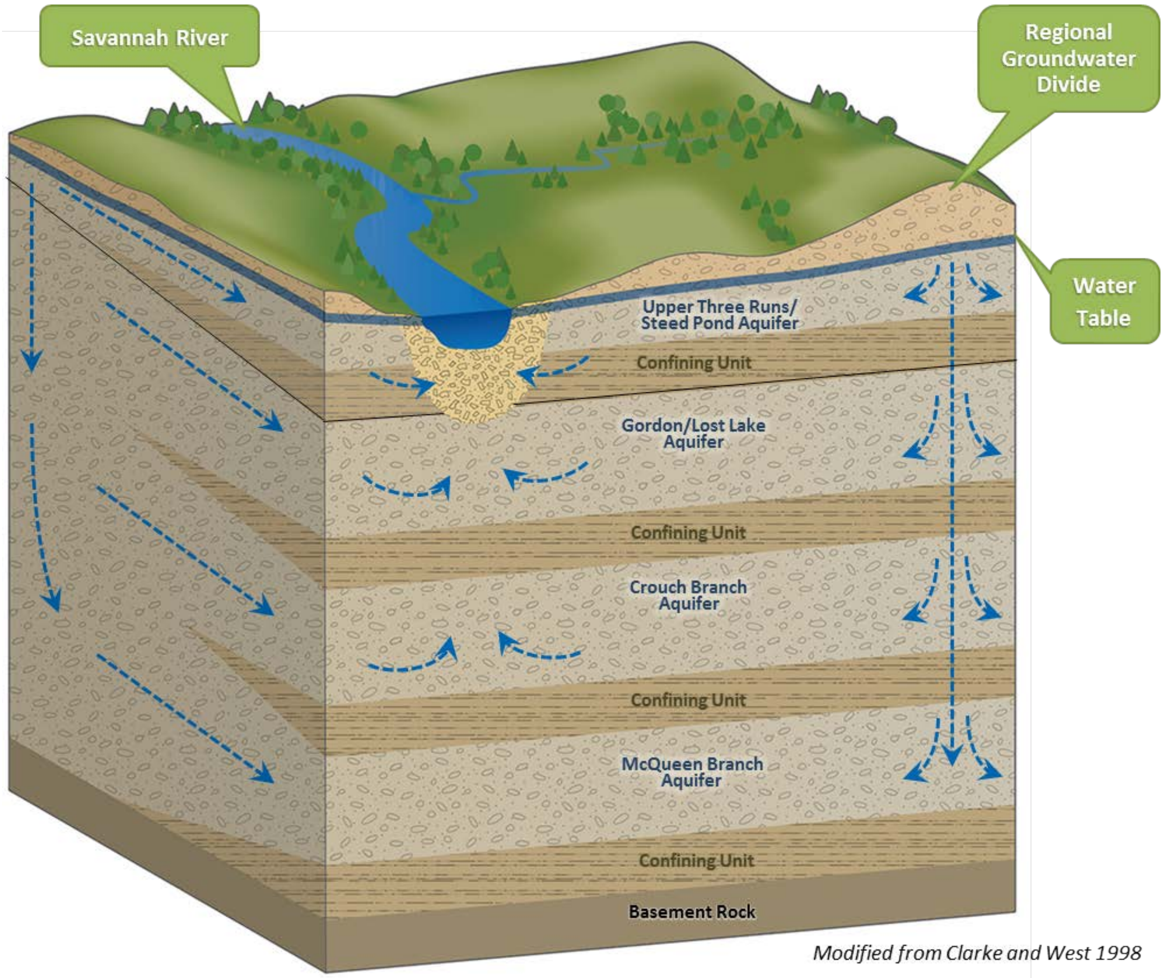

Figure 7-1 Groundwater at SRS

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

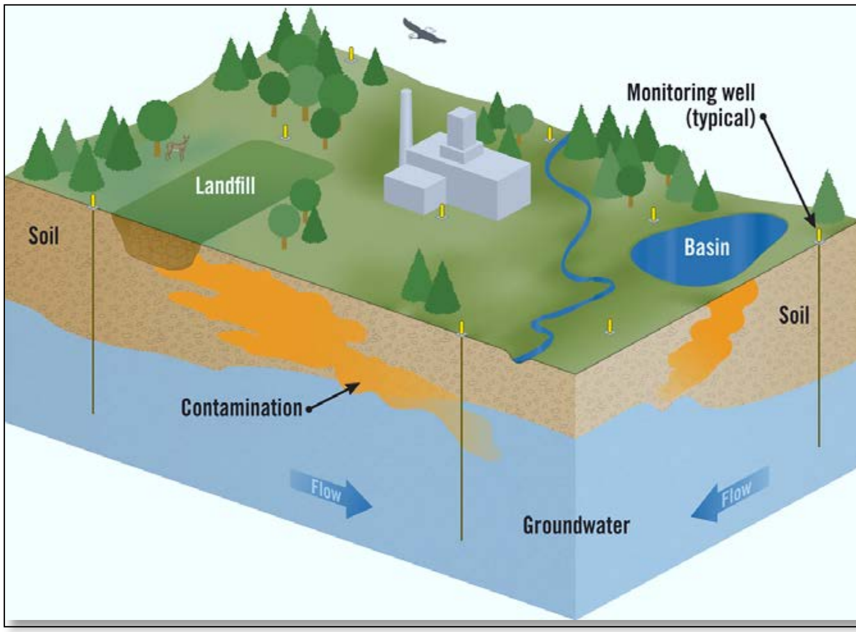

Figure 7-2 How Contamination Gets to Soil and Groundwater

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)

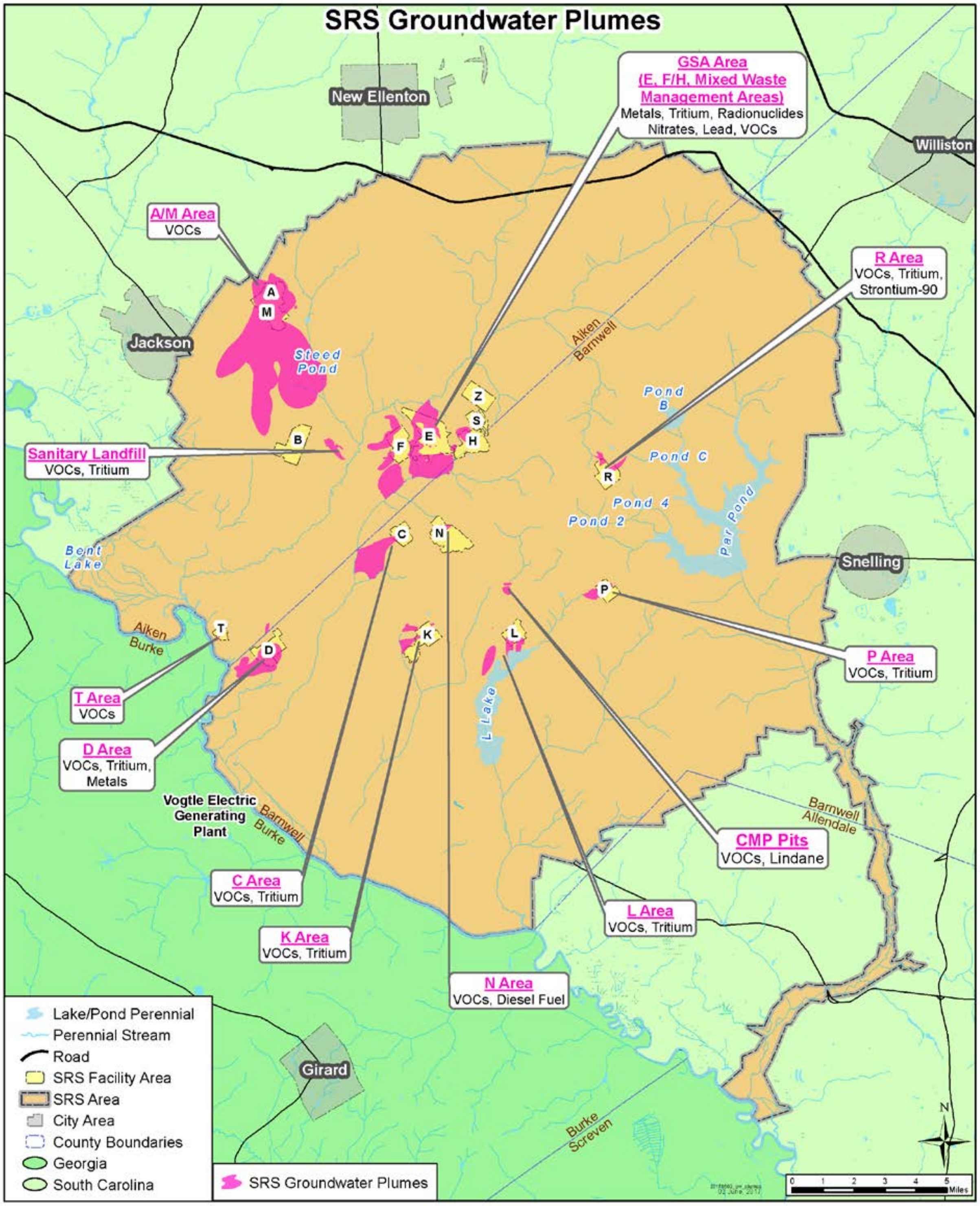

Figure 7-3 Groundwater Plumes at SRS

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.

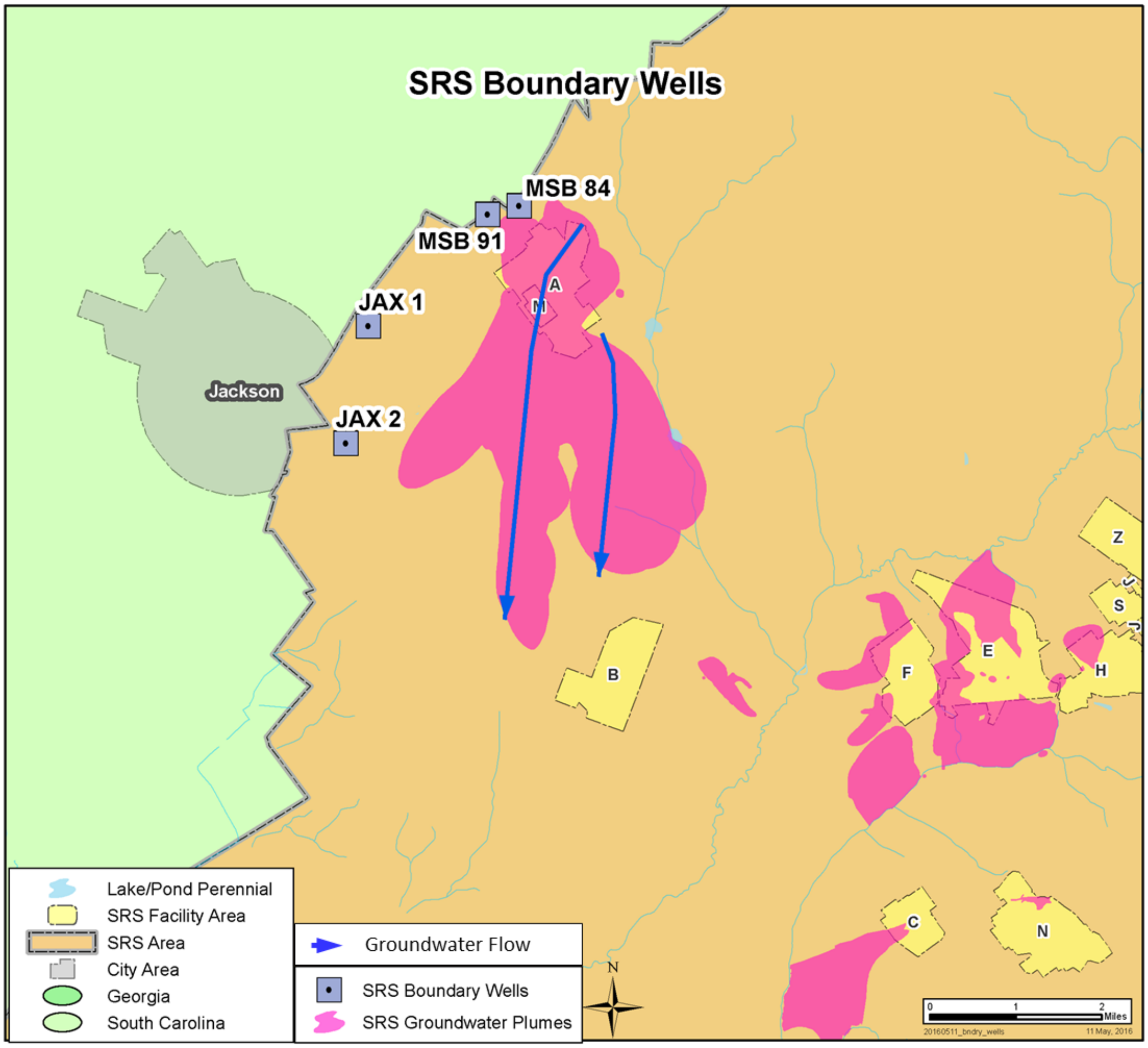

Figure 7-4 Location of Site Boundary Wells at SRS—Between A/M Areas and Jackson, South Carolina

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.

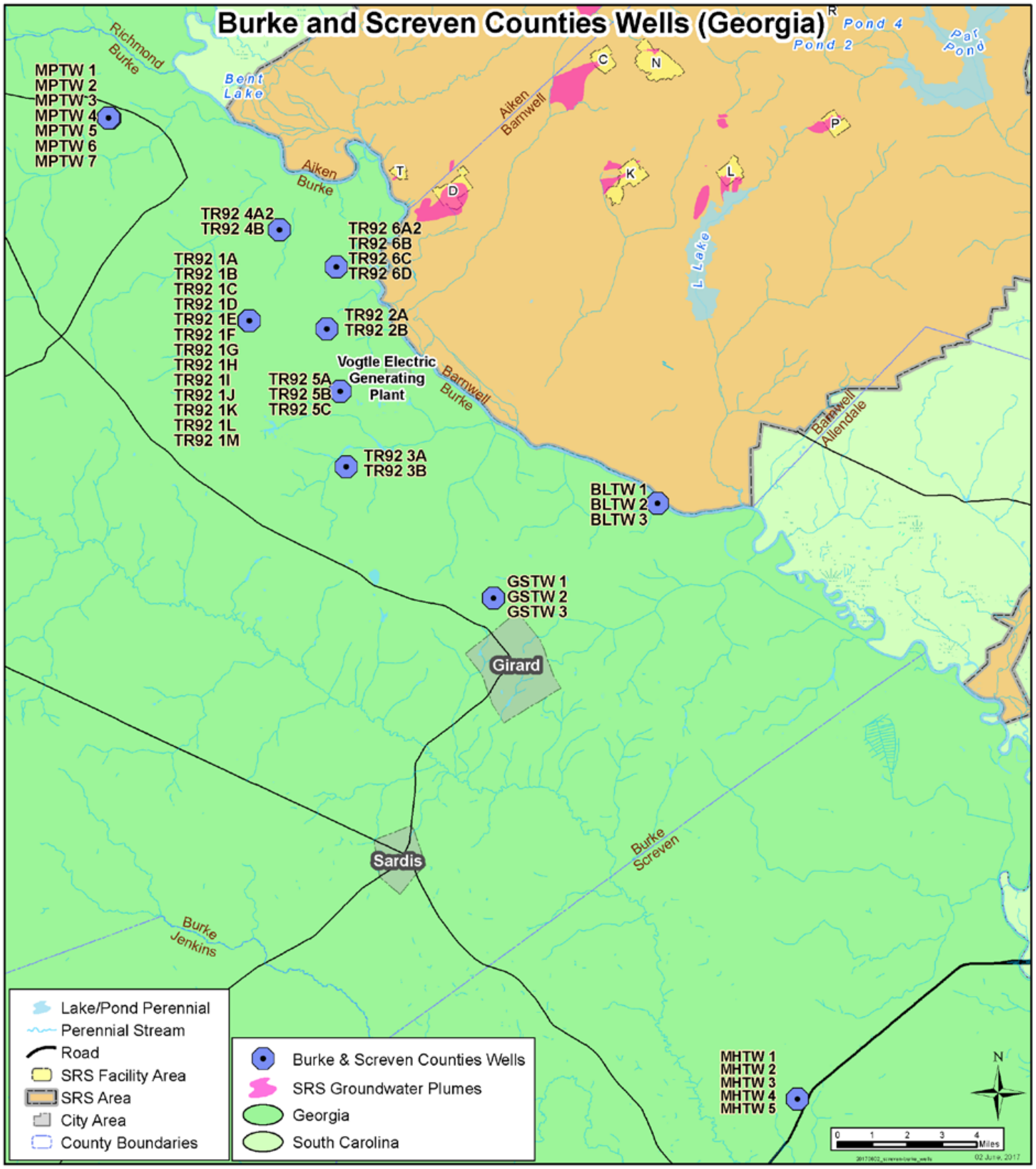

Figure 7-5 Location of Monitoring Wells Sampled for Tritium in Burke and Screven Counties, Georgia

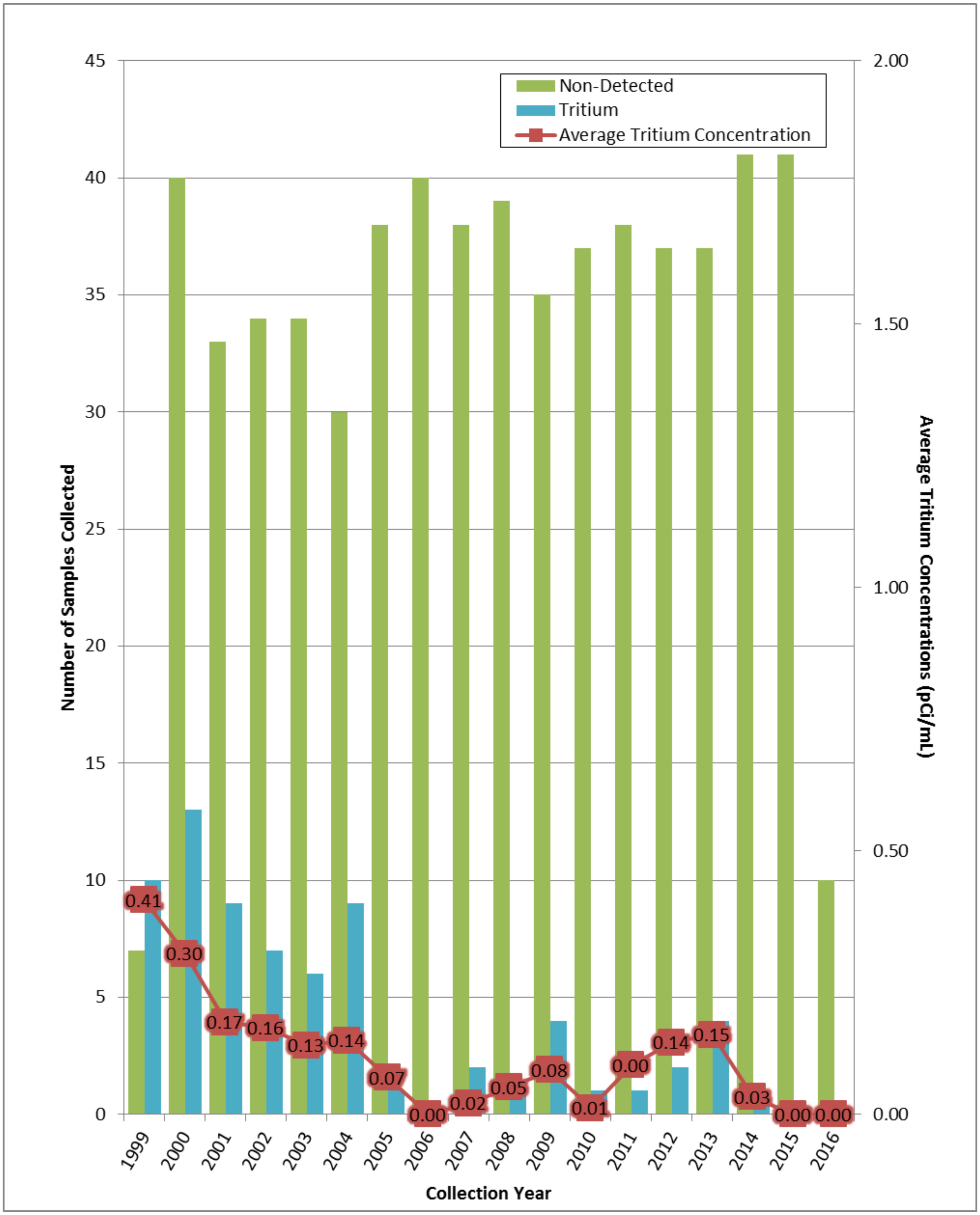

Figure 7-6 Tritium Concentration in Wells Sampled in Burke and Screven Counties, Georgia

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.